TOWARDS ENVIRONMENTAL HISTORICAL NATIONAL ACCOUNTS FOR OIL PRODUCERS:

METHODOLOGICAL CONSIDERATIONS AND ESTIMATES FOR VENEZUELA AND MEXICO OVER THE 20TH CENTURY.

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For the Degree of Doctor of Philosophy
London School of Economics and Political Science
University of London
2002

Abstract

Environmental accounting literature reminds us that prosperity can be ephemeral if it is built on depletion of natural resources. Traditional national accounting practice ignores the loss of natural resources. According to standard environmental accounting, this produces exaggerated income, encourages unsustainable levels of consumption and is misleading when assessing the economic prospects of resource extracting countries.

While the historiography of oil-extracting countries departs from entirely different concepts and methods, it contains plenty of arguments that resemble those of the environmental accountants. This thesis shows how Mexican and Venezuelan scholars have discussed the concept of national wealth, the ephemeral prosperity delivered by oil depletion and the biases that oil cash introduced in the perceptions of their countries' economic performance. Nonetheless the arguments in the historiography lack quantitative support for the most part.

The dissertation connects these previously disparate literatures and explores the resulting synergies. A priori, it seems that environmental accounting provides the tools for quantifying the hitherto qualitative observations of the historiography of two countries with very different strategies regarding the depletion of their natural resources. While Mexico approximates very closely the theoretical case of a closed economy, Venezuela has been considered the textbook example of a resource-export-driven economy. In the end, history proves to be an excellent laboratory for an ex-post analysis of the concepts, models and methods of environmental accounting.

This study contributes to the surprisingly small amount of comparative historical studies of the oil industries and the economic histories of Venezuela and Mexico. The most important conclusion derived from the comparative analysis of the theoretical models of environmental accounting is that the competing methods available in the literature seem to apply to different scenarios. Furthermore, the results of the thesis show that the role of technological change in sustaining the historical levels of consumption is substantial since the terms of trade did not improve in the continuous way needed to rescue economies from declining levels of consumption. This is an important finding because gains from trade have now been included in some environmental accounting models but technological change is left out. Overall, the thesis is an examination of the tractability and usefulness of environmental accounting as a tool of economic analysis over the long run.

TABLE OF CONTENTS

TABLE OF CONTENTS

List of Figures

List of Tables

List of maps

List of Abbreviations

API	American Petroleum Institute (usually refers to oil gravity)
BCV	Banco Central de Venezuela
Blvs	Bolivars
ECLA	Economic Commission for Latin America
HVP	Hotelling Valuation Principle
INEGI	Instituto Nacional de Estadística Geografía e Informática (Mexico)
mll or mill	Millions
MMH	Ministerio de Minas e Hidrocarburos (Venezuela, Ministry of Mines and Hydrocarbons)
OPEC	Organisation of Petroleum Exporter Countries
PDVSA	Petróleos de Venezuela S.A. (national Venezuelan oil company)
PEMEX	Petróleos Mexicanos (national Mexican oil company)
PODE	Petróleos y otros Datos Estadisticos (annual Venezuelan publication of oil related data)
SNA	System of National Accounts
SEA	Satellite Environmental Accounts
SEEA	System of Integrated Economic and Environmental Accounts
UNSTAT	United Nations Statistical Office
$	US dollars

Acknowledgements

This research has only been possible thanks to the financial, academic and personal support I received from a number of institutions and individuals. I am truly indebted to all of them.

The London School of Economics, the Economic and Social Research Council, the Economic History Society, the Institute of Historical Research, all in the United Kingdom, and Fundación Cultural Forum Filatélico and the Fulbright Commission in Spain, provided me financial support at different stages of the dissertation.

Prof. N. Crafts bears the responsibility for converting me to economic history and provided intellectual challenge, constructive criticism, openness, administrative support, encouragement and reliability in a way that made working with him a privilege. The Economic History Department at LSE supplied the best possible environment to start a research career. Thanks to all those at LSE (and elsewhere) who have commented on my work while in progress, particularly Dudley Baines, Oscar Calvo-Gonzalez, Albert Carreras, Guillaume Daudin, Larry Epstein, Regina Grafe, Kai Kaiser, Tim Leunig, Colin Lewis, Mary Morgan and P.K. O'Brien. I am particularly grateful to my examiners, M.Weale and R. Thorp, whose comments contributed to improve the final version of the thesis. Bernardo Duggan provided crucial help with corrections and Marco Zambon with the mathematics.

I would not have embarked on postgraduate research without the encouragement of Leandro Prados de la Escosura and James Simpson at Universidad Carlos III de Madrid. Leandro also made possible my fieldwork in Mexico. I am grateful to Marco Palacios and Pilar Gonzalbo for their support while at El Colegio de Mexico, to the staff of the Biblioteca del Banco de Mexico and Biblioteca Central de Petróleos Mexicanos for their assistance, and to Ivan Pliego and María Hoppested for their generous hospitality. Both the Mexican and the Venezuelan side of this research benefited from the library of the Oxford Institute for Energy Studies. There, Juan Carlos Boué and Bernard Mommer shared their knowledge and archival material on PEMEX and Venezuelan oil industry and economy. Special thanks to Absdrúbal Baptista for providing me with his latest data set and publications. The last stage of this PhD was completed while being visiting scholar at UC Berkeley, thanks to the facilities of the Institute of Business and Economic Research and the Economics Department and to the support of Prof. B. Eichengreen.

My friends, fellow students and office mates have been one of the most important sources of support and inspiration. The courage and success of Regina, Gabi, Jerome and Guillaume have been a real inspiration for following their footsteps. Without their example and encouragement the task would have been close to impossible to complete. Ryma Sefedjely borne me more than anyone else, yet Ivan, Pilar, Anna, Teresa, Geeta, Ignacio, Joerg and Daniel also made the dark days lighter. Finally, none of this would have been possible without the unconditional support of my family. Indeed, this work is dedicated to them.

Introduction

This thesis combines concepts from economic history and environmental accounting to develop what has been called environmental historical national accounts. It examines the tractability and usefulness of environmental accounting as a tool of economic analysis over the long run. The experiences of Venezuela and Mexico during the twentieth century are scrutinised in the light of environmental accounting methods. Environmental accounting is expected to be relevant to the economic histories of Venezuela and Mexico given the weight that natural resources, particularly oil, have had in the economic development of both countries in the twentieth century. Below, we pose six basic questions regarding this research. Why is environmental accounting relevant to economic history? What are the primary issues being researched? Why focus on oil depletion? Why these two oil producers? What are the advantages of undertaking environmental accounting over the long run? Finally, what are the implications of the thesis?

Why is environmental accounting relevant to economic history?

In the first place, the estimation and analysis of long-term economic performance and its different methods of measurement are central to the study of economic history. Economic historians have made a huge effort to construct historical series of income and output for almost every country.[1] National accounts, and the gross domestic product (GDP) in particular, have become the central tool for analysing economic change and the different patterns of development within and between countries, helping us to understand the present and to plan better for the future. However, thanks to the literature on environmental accounting, recognition is growing that national income has never been accurately calculated for economies based on natural resources. According to this literature, ignoring the loss of natural resources, via degradation or depletion, in calculations of national income and output can mask the destruction of resources available to a country behind the false appearance of a growing national economy.[2] An economy can consume more (i.e. grow) as a result of an improvement of its productivity,

[1] Among others S. Kuznets, *Income and Wealth series* (Cambridge, 1951) ; P. Deane, and W.A. Cole, *British Economic Growth, 1688-1959: Trends and Structure*. University of Cambridge.Department of Applied Economics. Monographs, Vol. 8 (Cambridge, 1959).; K. Ohkawa, *Capital stock : estimates of long term economic statistics of Japan since 1868* (Tokyo, 1966); C. Feinstein, *National Income, Expenditure and Output of the United Kingdom, 1855-1965* (Cambridge, 1972) ; L. Prados de la Escosura, *De Imperio a Nación : el crecimiento económico español (1730-1930)* (Madrid, 1988) *A. Baptista, Bases Cuantitativas de la Economía Venezolana, 1830-1989 (Caracas, 1991).*

[2] P. Dasgupta and K.G. Mäler, 'The Environment And Emerging Developing Issues', in *Proceedings Of The World Bank Annual Conference On Development And Economics 1990* (New York, 1991), p.101.

or it can consume more from an increasingly rapid depletion of natural resources. Consider, as an extreme hypothetical case, a country that lives simply on exporting its exhaustible resources and importing consumption goods with the export revenue. Assume, too, that resources are costless to extract and that other than extraction there is no domestic production. The income of this country, as historically measured, could be large, and it would even be seen to be rising. However, when measured as suggested by some approaches to environmental accounting, its income would be nil. Environmental accountants argue that in the case of resource-based economies 'traditional accounting practices exaggerated income, encouraged unsustainable levels of consumption and obscured the necessity to implement greatly needed policy adjustments'.[3] *A priori,* this adjustment seems to be important for a number of countries which resemble, for some part of their economic histories, the hypothetical 'country' mentioned above.

What are the primary issues being researched?

The principal concern here is the quantification of the claims of environmental accounting; or in other words, to what extent environmental historical national accounts diverge from traditional national accounts. Standard historical GDP series, like those of Maddison or Hofman, generally used as a starting point for the analysis of the historical economic performance of most countries, fail to recognise the special characteristics of income generated by resource-led economies.[4] If the allegations of environmental accounting were correct, these traditional statistics would yield misleading analyses for economies heavily reliant on natural resource exploitation. Economic historians recognise that our knowledge of national income, output and wealth is not static. In fact, our historical estimates are constantly under revision, new indices are constructed, new data are included, new techniques are applied to the old data, etc. All of which results in amendments to previous conclusions and, in some cases, new interpretations. This research fits within that spirit of constant revision of income measures. This is

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[3] S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy, et al. (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989), p.10. It is fair to notice that it is not only the environmental literature that argues along these lines. Studies on rentier states, that is oil producer countries, put forward similar concerns about national income accounts yet from a complete different perspective. See for instance, H. Mahdavy, 'The Patterns and Problems of Economic Development in Rentier States: the Case of Iran', in Cook (ed.), *Studies in the Economic History of the Middle East* (Oxford, 1970) and R. Stauffer, *Accounting for "Wasting Assets". Income Measurement for Oil and Mineral-Exporting Rentier States*, Vol. 25 (Vienna, 1984).

[4] A. Maddison, *Monitoring The World Economy, 1820-1992* (Paris, 1995) ; A.A. Hofman, *The Economic Development of Latin America in the Twentieth Century* (Cheltenham, UK, 2000).

particularly important for Latin America countries since it is widely recognised that its 'quantitative economic history remains to be done for the most part.'[5]

Why focus on oil depletion? Why these two oil producers?

The divergence from traditional income measures 'is more important for countries where non-renewable resources are being run down.'[6] Among non-renewable resources it is hard to think of a natural resource that shapes economies more than oil has done throughout the twentieth century. In addition to its non-renewable nature and the unarguable relevance of oil receipts for oil producer economies, the fact that oil exploitation has occurred for over a century justifies the choice of two oil producers for testing the usefulness of environmental accounts in historical terms.

Mexico and Venezuela have been oil producers since the dawn of the oil era. Mexico started commercial production in 1901 and was the world's greatest oil exporter and second producer by 1921. Venezuela replaced Mexico in this position during the inter-war years. Chapter 1 shows that both countries relied on oil as their major source of income and engine of development at different times in their histories. The fact that they followed opposite paths in their pioneer oil politics is also relevant to the issue being investigated. While Mexico nationalised its oil industry by 1938 and followed an inward-looking strategy of depleting the oil just to the extent necessary to fulfil domestic requirements, Venezuela adopted a pure export-oriented strategy, leaving her oil in foreign hands until 1976. After almost forty years of looking at each other with a mixture of criticism and wonder, defending their own exploitation strategy as the best possible, Mexico and Venezuela ended the twentieth century as state-owned medium-sized oil exporters.

Venezuela's exploitation policy resembles more closely the hypothetical 'country', mentioned above, living simply from exporting its non-renewable resources and importing consumption goods with the export revenue, whereas Mexico's conservationist approach fits better with the 'productive' (but closed) economy, at least during the period 1938-1976. *A priori*, following the premises of environmental accounting, Venezuela's traditional income estimates will diverge further from environmentally adjusted estimates than will those of Mexico for that period. Yet the main question in this context is whether

[5] From the introduction of J.H. Coatsworth and A.M. Taylor (eds.), *Latin America and the World Economy since 1800* (Cambridge, MA, 1999)
[6] S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy, et al. (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989), p.10.

environmental accounting is useful when classifying these two strategies in terms of their efficiency and their implications for long run sustainable development.

What is also relevant is that Mexicans and Venezuelans of different epochs were not unaware of the ephemeral prosperity embodied in their resource-driven economies, as Chapter 3 demonstrates. The literature on oil producers is plenty of arguments that resemble those of the environmental accountants. In the case of Venezuela, it has been argued that 'due to the nature of oil revenues an increasing gap opened between the real production capacity and its earning and expenditure possibilities'.[7] Also it has been stated that 'after decades of consuming more than they produced, to restore balance, Venezuelans' real incomes and consumption would have to decline'.[8] For their part Mexicans feared that a misleading and ephemeral prosperity would have taken place in the country if production had continued at the pace of the early years of the twentieth century. The arguments of the historiography are mostly supported by qualitative rather than quantitative evidence. Contemporaries lacked the concepts and tools that environmental accounting offers for quantifying their arguments. Environmental historical accounts have the potential to fill this quantitative gap.

What are the advantages of undertaking environmental accounting over the long run?

In principle, it is economically sound to adjust conventional national output and income measures for the depletion of environmental assets, particularly of non-renewable resources. More than two decades of work on environmental accounting have shown, however, that there are significant obstacles to the construction of accurate estimates of augmented national income and output. In addition to the conceptual issues, the most daunting obstacles are problems involved in estimating quantities of stocks and flows and providing monetary valuation.[9] This research does not escape these problems. A good deal of the work presented in the following chapters concerns the elaboration of the data series needed. The construction of consistent time-series data is one of the contributions of the thesis. It is argued that 'a national programme of environmental accounting should be long-term because the statistics required take a long time to be developed and the

[7] A. Uslar Pietri, 'Los males del petróleo', *El Nacional* (1985) 28th April. The increasing disparity between consumption and production in a country such as Venezuela is also referred by B. Mommer and A. Baptista, 'El Petróleo En Las Cuentas Nacionales: Una Proposicón', *Working Paper IESA* 10 (1983), p.3. Furthermore, it has also been argued that resource-abundant economies grow more slowly precisely because they are likely to be living beyond their means since the natural resource allows the economy to afford extraordinary (unsustainable) consumption possibilities. F. Rodriguez and J.D. Sachs, 'Why do resource-abundant economies grow more slowly?', *Journal of Economic Growth* 4 (1999), p. 278.
[8] M. Naim and A. Pinango (eds.), *El caso Venezuela: una ilusión de armonía* (Caracas, 1974).
[9] W.D. Nordhaus and E.C. Kokkenlenber (eds.), *Nature's Numbers: Expanding the U.S. National Economic Accounts to Include Environment* (Washington D.C., 1999), p.44.

analysis of some environmental effects may require long time series'.[10] The data series developed in the thesis also permit the quantitative comparison of the sharp contrasts between the Mexican and Venezuelan oil industries in terms of basic indicators such as production, exploration policies, labour and capital costs, fiscal policies, etc.

Environmental accounting can also benefit from the long-run approach of this research. History provides an excellent laboratory for an ex-post analysis of the concepts, models and methods of environmental accounting, because it has been recognised that 'it is necessary not only to develop more comprehensive models, but also to devote more effort to verification of these models through ex-post comparisons of predictions with observed results.'[11] Indeed, this research aims to fill 'the gap between the considerable progress made towards resolving basic theoretical issues and the lack of agreement on the empirical side about the most appropriate methods for making specific adjustments'.[12] It is here where the repeated testing in different national contexts becomes crucial. In principle, the exercises of evaluation in Chapters 4 and 5 have the objective of comparing the different depletion strategies followed by Mexico and Venezuela. Yet they also confront the shortcomings of the theory and the abstractions of the methods with historical facts and figures, making evident some new gaps between theory and practice of environmental accounting that do not appear in shorter term exercises.

What are the implications of the thesis?

If environmental accounting premises are correct, some of the issues raised in the historiography regarding the ephemeral prosperity of Mexico and Venezuela will finally find a quantitative support. In the process, the oil industries of Mexico and Venezuela are empirically compared for the first time over the whole of the twentieth century. This quantitative comparison can shed some light on the political and ideological claims that historically have been made by both sides regarding their chosen strategy of depletion. These analyses are of fundamental importance for the comparative economic history of the two countries.

In addition, by providing a quantitative measure of the contribution of environmental resources, environmental accounting in historical terms also opens a door for further

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[10] P. Bartelmus, E. Lutz, et al., 'Environmental Accounting : an operational perspective', in Serageldin and Steer (eds.), *Valuing The Environment: proceedings of the First Annual International Conference On Environmentally Sustainable Development held at the World Bank, September 30-October 1, 1993* (Washington D.C., 1993),p.177.

[11] A.M. Freeman, *The Measurement of Environmental and Resource Values: Theory and Methods* (Resources for the Future, Washington D.C., 1993), p.14.

[12] J.R. Vincent, 'Green accounting: from theory to practice', *Environment and Development Economics* 5 (2000), p.23.

explorations in other debates in economic history. The thesis will help to assess the appropriateness of traditional national accounts for oil producers and for resource driven economies in general. This will surely contribute to the ongoing debate regarding the concept of national income and its measures. Growth accounting could also gain from environmental accounting. In one of his seminal articles, Moses Abramovitz admits that his measures of convergence do not allow for variation in the richness of countries' natural resources in relation to their populations, since productivity measures reflect differences in natural resource availability as well as levels of technology.[13] This problem could be addressed if differences in natural resource endowments were taken into account in a standardised manner. Hence, broader economic history controversies can profit from environmental historical accounting.

The methodological considerations contribute to the evolution of environmental economics by showing inconsistencies, improving definitions, qualifying methods and conventions, etc. If these tools turn out to be useful in historical perspective, it will generate greater confidence in the implementation of future policies based upon their use. Oil stocks and flows, values and depreciation estimates derived from the thesis are major items within the environmental accounts of Mexico and Venezuela. They will be of use for those attempting the more ambitious objective of producing a complete set of environmental historical national accounts including all the other natural resource depletion, damages to flora, fauna and ecosystems plus pollution for Mexico and Venezuela. These historical series can also serve as benchmarks for comparison with other oil- producing countries. Therefore, the results of this research will be useful for those currently working on the generation of environmental accounts.

The analysis of different economic strategies and their impact on development and environmental depletion measures can yield new questions for the long-term sustainable growth debate. Consequently, the results obtained could have implications for political planning over the use of the environment.

[13] M. Abramovitz, 'Catching up, forging ahead and falling behind', *Journal of Economic History* 46 (1986) 2, pp.392-393.

[14] Some enquiry on this direction is present in M. Rubio, 'Resource-Led Growth Failure: Faulty Policies and Misleading Performance Indicators, a Proposition', in *75th Annual Conference of the Economic History Society. New Researchers Papers* (Glasgow, 2001).

The structure of the thesis

The thesis is organised in the following manner. Chapter 1 provides the historical background to the experiences of Mexico and Venezuela, both in relation to oil and to their economic performances during the twentieth century. It demonstrates that, despite the deep contrasts between both countries, there are many links between the Venezuelan and Mexican histories.

Chapter 2 presents the theoretical framework of environmental accounting. The Chapter starts with a definition of 'environment', paying particular attention to non-renewable resources, the part that most closely relates to this research. Three ways of accounting for the environment in national accounts are then introduced. The analysis of the concepts of income and depreciation in national accounts concludes the first half of the chapter. As methodological considerations are the main concern of this chapter, the second half is devoted to the theoretical exposition of the methods of evaluation that will be used later on. More crucially it presents the concept of resource rent on which all the methods rely.

Chapters 3 and 4 provide further insight regarding the history, the historiography and the statistics of the oil industry in both countries yet under different perspectives. Chapter 3 presents in more depth the different approaches to oil exploitation in each country. It demonstrates that the concerns the environmental literature has put together throughout the 1990s can be traced back to the early days of the petroleum industry. The historical qualitative sources show that Venezuelans and Mexicans of all epochs have recognised the special characteristics of oil receipts and the risks of ephemeral prosperity that they entailed. The chapter also shows the lack of appropriate quantification of the value of oil depletion and its impact on traditional indicators of economic performance.

Chapter 4 seeks to calculate the resource rent. It discusses not only the data, but also the most suitable ways of using the available information. It provides sensitivity analysis and produces series of resource rents for Mexico and Venezuela for most of the twentieth century. In the process, the chapter compares the two oil industries in terms of costs, profits, labour, etc. The contrasting production strategies translate into very different rent results.

Chapter 5 puts together the ideas and results of previous chapters, in order to estimate the value of oil resources and its depreciation according to the different methods. This chapter represents the contribution of economic history to environmental accounting. It proves that the theoretical assumptions underlying the methods are crucial to the results, and that variation from the restricted scenario for which the methods are constructed changes both the values obtained and the expected biases of the methods. The results of the chapter generate more questions than answers, but improve understanding of the methods of evaluation by analysing known and previously ignored strengths and weakness.

The adjustments to traditional national accounts are carried on in Chapter 6. The first part of the chapter is devoted to the adjustment at the GDP level and the impact of such adjustment to the growth and performance portrayed in Chapter 1. Nevertheless, the core of environmental accounting literature opts for the correction of the net income. In this chapter the results of the previous chapters are used to elucidate the main claims of environmental accounting: did traditional indicators exaggerate income? Did traditional indicators encourage unsustainable levels of consumption? The answer to these questions is produced in a sequence of three exercises that connect the findings of the previous chapters. The results of this chapter also respond to some of the unanswered questions of the historiography: was there a gap between the production and the consumption capacity of the Venezuelan economy? Was correct the belief of the Mexican government of the early part of the twentieth century was that even if Mexico had continued to exploit the oil fields and exporting the resource it would not have contributed to higher income levels? The last section of the chapter responds these questions using the results of this and earlier chapters.

The conclusion summarises the main findings of the thesis and points to a research agenda for economic historians, environmental accountants and policy-makers.

In the Appendices the sources and data series are described and discussed.

'Of all the self-mutilating theories adopted by Latin American governments, none has lasted as long as the idea that countries grow rich by exploiting what lies under their soil, rather than through the hard work of adding value to goods and services. This myth has proved particularly potent when it comes to oil'.[1]

Chapter 1

The Historical Setting: A Century of Oil in Mexico and Venezuela

It is somewhat surprising not to find many comparative historical studies of either the oil industries or the economic histories of Venezuela and Mexico. The comparative studies that are available appeared either in the first half of the century or in the post-oil boom crisis.[2] It is true that most monographs about Venezuela start by emphasising the little attention that the country has attracted historically.[3] According to Goodman,

[1] 'Energy in Latin America. Even oil is growing less sacred'. In *The Economist.* (1996).

[2] M. Acosta Saignes, *Petróleo en México y Venezuela* (México D.F., 1941) does a comparative study of the evolution and development of the petroleum exploitation in Mexico and Venezuela with a clear opposition to companies and the policies followed by the Venezuelan government of the early half of the century. M. Matos Romero, *Venezuela y México ante el Imperialismo* (Maracaibo, 1939) compares the ill effects of the imperialist penetration in both countries particularly in Venezuela.

For the post-oil boom crisis period see Kaplan M. (coordinador), A.R. Brewer-Carías and otros, *Petróleo y desarrollo en México y Venezuela.* (Mexico D.F., 1981).More recently I.F. Palacio Solano, *América Latina: el estigma del petróleo. México, Ecuador y Venezuela* (México, D.F, 1996). Outside the oil industry A. Gilbert, 'Self-Help Housing During Recession', in Abel and Lewis (eds.), *Welfare, Poverty and Development in Latin America* (Oxford, 1993) compares the welfare effects of the 1980s crisis. For its part, E.A. Baloyra, 'Oil Policies and Budgets in Venezuela, 1938-1968', *Latin America Research Review* 9 (1974) 2, follows a methodology previously used to analyse the political evolution of the Mexican Revolution to analyse Venezuela's government expenditures. It is an exceptional case where a study of Mexico is applied to Venezuela. A notable exception is also J.F. Thynne, 'British Policy On Oil Resources 1936/1951: With Particular Reference To Mexico, Venezuela And Persia' (DPhil Dissertation, London School of Economics, 1995).

[3] See for example the prefaces or introductions to the following monographs L.W. Goodman, J. Mendelson Forman, M. Naim, et al. (eds.), *The lessons of the Venezuelan experience* (Washington D.C., 1995); J.D. Martz and D.J. Myers (eds.), *Venezuela: The democratic experience* (New York, 1986); M. Naim, *Paper, Tigers and Minotaurs. The politics of Venezuela's Economic Reforms* (Washington, D.C., 1993); J. Ewell, *Venezuela.A Century of Change* (London, 1984) and F. Coronil, *The magical state: Nature, money, and modernity in Venezuela* (Chicago and London, 1997).

in scholarly terms, 'Venezuela had the least interesting combination of characteristics - exceptional and unexciting without being a likely model for others. It was too exceptional to be included in multi-country comparative studies of political or economic development, and it offered insufficient attraction as single case to lure many students'.[4] In contrast, Mexico enjoys one of the largest historiographies of the continent.

This chapter outlines the historical evolution of the Mexican and Venezuelan economies and their oil industries during the twentieth century. It will demonstrate that, despite the deep contrasts between the two countries, particularly regarding their oil policies throughout the century, there are many links between the Venezuelan and Mexican histories. It provides the historical background to the analysis and estimates that will follow in the thesis. Chapters 3 and 4 provide further insight regarding the history, the historiography and the statistics of the oil industry in both countries. The final section of this chapter sketches the economic performance of both countries throughout the century according to their GDP and GDP per capita. It also makes a first enquiry into whether these statistics are misleading indicators of the actual economic performance of Mexico and Venezuela during the twentieth century.

1.1 A Century of Oil

A Common Heritage

In the case of oil, the common link between Mexico and Venezuela can be traced back to the Spanish heritage. Virtually all defenders of the policies of Latin American governments in regard to subsoil mineral wealth have begun their defence with a reference to the heritage from Spanish law that determined that the sovereignty of the subsoil rests in the Nation.[5] In other words, the property of the subsoil remains with

[4] Goodman, Mendelson Forman, Naim, et al. (eds.), *The lessons of the Venezuelan experience*, p.4.

[5] Some examples for the Mexican case are México. Cámara de Diputados (by M. de la Peña), *Estudio jurídico, político y económico sobre el Art 27 constitucional* (México D.F., 1921), M. Manterola, 'Legislación fiscal especial sobre petróleo y derivados', *Revista de Hacienda* 1 (1938) 6, A. Garcia Robles, *La Question du Petrole au Mexique et le Droit International* (Paris, 1939).
Venezuelan also justified their right to grasp part of the benefits from the companies starting from this very same principle. Law related works were very prominent in the earliest stages of the oil industry development, see for instance: J.J.Abreu, 'Sobre la exoneración de los derechos de importación', *Revista de Fomento* (December 1938) 7; A. Planchard Burguillos, 'Comentarios a la legislación venezolana de hidrocarburos', *Revista de Fomento* (1938) 7; R.Gonzalez Miranda, , *Estudios acerca del régimen legal del petróleo en Venezuela*. Colección de Estudios Jurídicos, Vol. XXI (Caracas, 1954).Venezuela. Ministry of Mines and Hydrocarbons, 'The petroleum industry and its fiscal obligations in Venezuela by A. Parra', in *1st Venezuelan Petroleum Congress organised by the Venezuelan Society of Petroleum Engineers* (Caracas, 1962), T.E. Carrillo Batalla, 'La distribución del ingreso fiscal petrolero entre gastos corrientes y gastos de inversión', in *La evaluación de la inversión del ingreso fiscal petrolero en*

the Nation, regardless of the owner of the surface. This practice in Spanish legal history was first codified in the early fourteenth century, when Alfonso XI decreed that all mines of any metal and their produce were property of the Crown and were not to be worked without licence or grant.[6] The Mexican mineral code of 1884 broke with this principle for 25 years, changing it to the unity of the surface and subsoil of the Anglo-Saxon tradition. In 1910 Mexico reverted to the Spanish principle. This institutional arrangement is the main common historical feature of the petroleum industries of the two countries, since it entitled the nation (i.e. the government) to benefit from the exploitation of the natural resources that lay underneath its soil by the mere principle of ownership. Yet their histories are linked in more ways than by their institutional heritage. When reviewing the evolution of the oil industry in both countries and the main themes of the historiography, the bonds become at least as apparent as the contrasts.

A Similar Departure (1900s-1930s)

At the dawn of the twentieth century, Venezuela and Mexico based their economies on the primary sector, as did most of the rest of Latin America. Agriculture and mining (Venezuelan coffee and Mexican non-precious metals –copper, lead, zinc, silver, not as yet oil) accounted for most of the productive effort and exports of both countries.[7] There was relatively little artisan industry of the type to be found virtually everywhere in Latin America by the turn of the century. Two long dictatorships, Porfirio Díaz (1876-1911) in Mexico and Juan Vicente Gómez (1908-1935) in Venezuela, brought, in their time, the political stability that encouraged foreign investors to explore the countries' oil. The oil industry added to the 'export-led' pattern of the early part of the century, just displacing some traditional products such as coffee and cacao in

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Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965] (Caracas, 1968), D. Bendahan, *La Legislación Venezolana sobre Hidrocarburos* (Caracas, 1969).

[6] M. Rippy, *Oil and The Mexican Revolution* (Leiden, 1972), p.1. The first four chapters of this book review the different laws regarding minerals in Mexico.

[7] The following works provide good insight into the economic history of the early part of the twentieth century. For Venezuela see: C.R. Silva, 'Bosquejo histórico del desenvolvimiento de la economía venezolana en el siglo XX', in Mendoza (ed.), *Venezuela Moderna: Medio siglo de historia 1926-1976* (Caracas, 2nd ed., 1979); T.E. Carrillo Batalla, *El desarrollo del sector manufacturero industrial de la economía venezolana* (Caracas, 1962); J. Salazar-Carrillo, *Oil and Development in Venezuela During the Twentieth Century* (London, 1994). For Mexico: Cárdenas, E. (compliador), *Historia Económica de México (5 Vols)*, Lecturas edited by P. Brazdresch, Vol. 64 (México, D.F., 1992-1994); Colegio de México, *Estadísticas económicas del Porfiriato: comercio exterior de México, 1877-1911* (México D.F., 1960); Colegio de México, Seminario de Historia Moderna de México, *Estadísticas económicas del Porfiriato: fuerza de trabajo y actividad económica por sectores* (México D.F, 1965); S.H. Haber, *Industry and Underdevelopment. The Industrialisation of Mexico, 1890-1940* (Stanford, 1989); C.W. Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth* (London, 1970).

Venezuela and silver in Mexico. Their growth performances during this period are described as high but yet unstable (see Table 1-1.4 below).[8]

It could be said that, for the first part of this history, Venezuela was the recipient of Mexican oil policies, whereas for the second part, Venezuelan conduct affected the Mexican situation. It is an historical fact that the Mexican oil industry developed before Venezuela's. The development of the oil industry in the south of the United States and the similarity of its coastal area to that of northern Mexico attracted world-wide attention in the first two decades of the century.[9] Literally hundreds of oil companies were organised to exploit the Mexican subsoil.[10] From 1901 to 1911, around 25 million barrels of oil were exported from Mexico without the payment of a penny in taxes.[11] Nevertheless, between 1914 and 1920, the foreign enclaves, especially the oil industry, stood out as islands of prosperity in the sea of destitution caused by the Mexican Revolution.[12] The oil industry and the revival of mining in the 1920s helped to soften the immediate economic hardship of the Revolution.[13]

Mexico's first great oil boom peaked in 1921; by then, the country had become the major oil exporter in the world. During those years, Mexican oil production accounted for almost a quarter of the world's oil production.[14] Nevertheless, the changes initiated by the Revolution –the rise of economic nationalism- started to become evident by the 1920s. The consequence for the oil industry was the decline of production and the shift of investment elsewhere, chiefly to Venezuela.[15]

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[8] R. Thorp, *Progress, Poverty and Exclusion. An Economic History of Latin America in the 20th Century* (New York, 1998), p.16.

[9] The modern oil industry began when the first producing well was drilled in Titusville, Pennsylvania, United States in 1859.

[10] Some 447 companies existed in Mexico in 1919, but only 24 produced in exportable quantities Rippy, *Oil and The Mexican Revolution* , pp. 137, fnt.18.

[11] Ibid, p.137 quoting an official Mexican publication.

[12] A. Knight, 'The Political Economy of Revolutionary Mexico, 1900-1940', in Abel and Lewis (eds.), *Latin America, Economic Imperialism and the State: The Political Economy of The External Connection form Independence to the Present* (London, 1992), p.295.

[13] Thorp, *Progress, Poverty and Exclusion. An Economic History of Latin America in the 20th Century* , p.68. Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth* initially demonstrated this.

[14] J. Noriega, *Influencia de los hidrocarburos en la industrialización de México*, Vol. 3 (México D.F., 1944), p.211.

[15] J.C. Brown, 'Why Foreign Oil Companies Shifted Production from Mexico to Venezuela during the 1920s', *American Historical Review* (1985) 90.

Table 1.1- 1: Nominal investment in Latin America by the US and the UK in 1913 and 1929 (US dollars per capita)

	US investment		UK investment	
	1913	1929	1913	1929
Argentina	5.22	52.70	243.17	184.61
Brazil	2.11	14.47	49.11	42.98
Chile	4.33	91.96	95.87	90.57
Colombia	0.40	36.46	6.96	5.32
Peru	7.76	27.08	29.50	25.28
Uruguay	4.29	40.76	206.0	138.21
Mexico	36.30	41.92	42.53	-
Venezuela	1.15	55.34	15.83	31.45

Sources: Elaborated from investment data by R. Thorp, 'Economy, 1914-1929', in Bethell (ed.), *Latin America Economy and Society 1870-1930* (Cambridge, 1989) p.64 except for Mexico, data on direct foreign investment from G. Gereffi and P. Evans, 'Transnational corporations, dependent development, and state policy in the semiperiphery: a comparison of Brazil and Mexico', *Latin America Research Review* 26 (1981) 3, p.36 and P. Evans and G. Gereffi, 'Foreign Investment and Dependent Development: Comparing Brazil and Mexico', in Hewlett and Weinert (eds.), *Brazil and Mexico: Patterns in Late Development* (Philadelphia, 1982), p.128 .Population from A. Maddison, 'Economic and Social Conditions in Latin America,1913-1950', in Urrutia (ed.), *Long-term Trends in Latin American Economic Development* (Washington, D.C., 1991), p.8

Until the end of 1922, the development of the Venezuelan petroleum industry was restricted. Despite the big number of oil concessions, no great deposits had been found. On 14 December 1922, the blowout of well Los Barrosos N°2 in the La Rosa area showed Venezuela's great oil potential to the world. It produced an estimated 100,000 barrels every 24 hours for nine consecutive days. It started a rush into Venezuelan oil.[16] Table 1.1-1 shows how Venezuela passed from being one of the Latin American countries with the lowest foreign investment per capita in 1913 to become the largest per capita recipient of US funds by 1929. In Venezuela, as in Mexico in the previous decades, three companies –Standard Oil, Shell and Gulf- controlled the majority of output.

The development of the oil industry in Venezuela benefited from the definitive take-off of the oil industry at world level during those years. Engines used diesel oil more and more often; oil replaced coal in ships and other engines; aeronautics were born; automobiles began to be produced on a large scale. In addition, the Mexican

[16] Data from A.R. Martínez, *Venezuelan Oil Development and Chronology* (London, 1989), p.39-41.

Revolution and its aftermath discouraged foreign investment in Mexican oil. Furthermore, Venezuela applied the most liberal oil policy of the continent. Exploration and operation rights were fixed at very low rates. 'From 1878 to 1920 the government granted 1312 contracts for oil exploitation. Most of which belonged to foreign companies'.[17]

A huge per-well production volume after 1922; low transport costs;[18] low political risk factors (an all-powerful dictator and a docile labour force); [19] and 'the best petroleum law in the world' combined to give Venezuela an important international cost advantage. The combination of those factors led Venezuela to replace Mexico as the world's largest oil exporter in 1928. By 1930 Venezuela was also the world's second largest producer after the United States, while Mexico had fallen to the seventh position.

In both countries, the literature of this first period is dedicated to the development of the industry and to the somehow difficult relationships established between the foreign companies and the governments. [20] More specific concerns in the Mexican case are the role of the workers and to the links between oil and the Revolution.[21] The different perspectives taken from inside and outside the country are readily observable within

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[17] W.M. Sullivan, 'Situación económica y política durante el período de Juan Vicente Gómez, 1908-1935', in John Boulton Foundation (ed.), *Política y economía en Venezuela,1810-1976* (Caracas, 1976), p.258.

[18] Most of the fields were situated in the Ea stern Shore of Maracaibo Lake. Lake and ocean tankers were used. They were able to transport huge amounts of crude at a very low cost.

[19] Military ruled Venezuela from 1899, when General Castro's army took Caracas, up to 1958 when Betancourt returned to power as constitutional president, except for a three year period between 1945 to 1948, when military shared power with the Acción Democrática party.

[20] The first chapters of the following books, provide a good review of the initial stages of the Mexican industry: G. Grayson, *The Politics of Mexican Oil* (Pittsburgh, 1980); J. López Portillo, *El petróleo de México* (México D.F., 1975); G.A. Menéndez, *Doheny, el cruel* (México D.F., 1958); E.W. Owen, *Trek of the Oil Finders: A History of Exploration for Petroleum* (Oklahoma, 1975); *PEMEX, (Petróleos Mexicanos) (ed.), La Industria Petrolera en México : una Crónica (México D.F., 1988)*, Vol. 1 and Chapter 8 in Rippy, *Oil and The Mexican Revolution* .
For the initial stages of Venezuela's oil industry it is worth looking at: Arnold et al., *The First Big Oil Hunt: Venezuela 1911-1916* (New York, 1960); E. Lieuwen, *Petroleum In Venezuela: A History*, Vol. 47 (Berkeley, 1954);Martínez, *Venezuelan Oil Development and Chronology* ; P.E. Mejía Alarcón, *La industria del petróleo en Venezuela* (Caracas, 1972); McBeth, *Juan Vicente Gomez And The Venezuelan Oil Industry, 1908-1935* (Oxford, 1983); Sullivan, 'Situación económica y política durante el período de Juan Vicente Gómez, 1908-1935' .
For Mexican governments relation with the companies see the first chapter of A.J. Bermudez, *The Mexican National Petroleum Industry: A case study in Nationalisation* (Stanford, 1963) and also D.C. Baldridge, *Mexican Petroleum and the United States-Mexican relations, 1919-1923* (London, 1987). Once again Lieuwen, *Petroleum in Venezuela: A History* is useful for Venezuela. See also his E. Lieuwen, 'The politics of energy in Venezuela', in Wirth (ed.), *Latin American Oil Companies and the Politics of Energy* (London, 1985).

[21] For oil workers issues see V. Novelo, *La difícil democracia de los petroleros* (México, D.F., 1991); R. Ramirez Heredia, *La otra cara del petróleo* (México, D.F., 1979); S.L. Adleson, 'The Cultural Roots of the Oil Workers' Unions in Tampico1910-1925", in Brown and Knight (eds.), *The Mexican Petroleum Industry in the Twentieth Century* (Austin, 1992). In relation with the Revolution see for example, J.C. Brown, *Oil and Revolution in Mexico* (Oxford, 1993) and Rippy, *Oil and The Mexican Revolution* .

this early period. From the foreigners' perspective, the companies were responsible for the development of the country's market for the use of fuel, converting the economy to this modern source of industrial energy; for the expansion of production and refining of petroleum products for exports and for the overall improvement of the financial situation of the country and the generation of infrastructure. Nonetheless, the hosts did not view the petroleum industry developed by foreigners as an unmitigated blessing. They accused the wealthy companies of financing reactionary political movements, dividing and repressing the workers, extracting the nation's non-renewable resources, and subordinating domestic needs to the international interest, making huge profits in the process.[22] In Venezuela, the arguments remained mostly unchanged for most of the century. As for Mexico, the controversy turned to a different issue after 1938.

Different Paths (late 1930s-early1970s)

Whatever the wording -Mexicans tend to refer to it as 'the nationalisation', whereas foreigners just call it 'the expropriation'-, the decision implemented by the Mexican government on 18 March 1938 of taking over foreign companies' assets and the cancellation of their rights represented the appendix to a nationalist process rooted in the Revolution.[23] Simultaneously, it also constituted an early precedent to the nationalisation of most oil industries across the world throughout the century and one of the first government commitments to state enterprise in Latin America. As Maddison recalls, state enterprise was still minimal in the Western World by the 1930s, except in Mexico.[24] Therefore, the decision generated a heated controversy in a world where the state played no economic role as yet. Nonetheless, the important issue for our discussion is that 1938 marks the beginning of the Mexican inward-looking strategy, which implied cutting down of oil production just to the level of internal demand, the decision to eliminate exports and the reduction of exploration activity. These main aspects of Mexican oil policy remained basically unchanged for almost 40 years.

[22] Brown, *Oil and Revolution in Mexico*, p.1.
[23] Ibid, and also Rippy, *Oil and The Mexican Revolution*.
[24] The Mexican government not only created PEMEX (Petroleos Mexicanos, the national company in charge of Mexican oil since 1938 and for the rest of the twentieth century), but the Federal Electricity Commission in 1937, and also forced foreign companies out of the insurance sector. In 1942, the government participated in the Altos Hornos steel plant, and in 1943 it created a fertilizer company. In other countries, policy also began to move in that same direction during the Second World War. Maddison, 'Economic and Social Conditions in Latin America, 1913-1950', p.15.

The literature on the causes, justification, process and consequences of expropriation-nationalisation is, by far, the largest among that dedicated to the Mexican oil industry.[25] From the American side, 'the expropriation' has no causes, no economic justification and terrible consequences for the Mexican economy.[26] The long and laborious process to reach a final settlement between the government and the companies also contributed to additional material in the literature.[27] But for many years afterwards, Mexican oil occupied an anonymous position within the country's literature, barely mentioned outside PEMEX's regular reports to the government and the nation. If oil did reappear as a topic from time to time, it was just in reappraisals of the nationalisation.[28]

The Mexican expropriation of foreign companies' property caused enough turmoil in oil spheres for some voices to demand a similar action in Venezuela. During the late 1930s and the early 1940s, the shadow of nationalism rose strongly in Venezuela.[29] Congressional opposition to the foreign companies was already considerable in 1937. A small vociferous group of leftists in the Chamber of Deputies agitated for partial nationalisation. The companies feared the worst when the government, early in 1938, announced a suspension of the granting of concessions. Yet, the overall impression in Venezuela regarding nationalisation was that:

> 'A solution as extreme as Mexico's was out of question. The relative importance of petroleum in Venezuela was far greater. Mexico produced one-fourth as much, had five times as many people, and had a more diversified economy. In sparsely settled Venezuela, where petroleum stifled agriculture

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[25] For causes and consequences of the nationalisation it is worth looking at the following books: J.C. Brown and A. Knight (eds.), *The Mexican Petroleum Industry in the Twentieth Century* (Austin, 1992); J. Silva Herzog, *Mexico y su Petróleo. Una Lección para América* (Buenos Aires, 1959); L. Meyer, *Mexico and the United States in the Oil Controversy. 1917-1942* (Mexico, 1972); L. Meyer and I. Morales, *Petróleo y Nación (1900-1987). La política petrolera en México* (México, D.F, 1990); For an official view see México. Secretaría de Patrimonio Nacional, *El Petróleo de México* (México D.F., 1940 1st ed., 1963) and J. Silva Herzog, *Historia de la Expropiación de las Empresas Petroleras* (México D.F., 1964). For a more radical perspective against the American see: J. Basurto, *El Conflicto Internacional en Torno al Petróleo de México* (México D.F., 1976).
For a plain justification see Garcia Robles, *La Question du Petrole au Mexique et le Droit International.*

[26] Among others, the obvious interested party Standard Oil Company, *The Reply to Mexico* (New York, 1940) but also W.C. Gordon, *The Expropriation of Foreign-Owned Property in Mexico* (Washington D.C, 1941) and R.B. Gaither, *Expropriation in Mexico. The Facts and the Law* (New York, 1940).

[27] 'Mexico's unsolved problem'. In *The Petroleum Press Service.* (London, 1941); M. Manterola, 'La Situación Actual de la Industria del Petróleo en México', *Revista de Economía* IV (1941) 16; Standard Oil Company, *Present Status of the Mexican Oil "Expropriations"* (New York, 1940); Standard Oil Company, *The Reply to Mexico* .

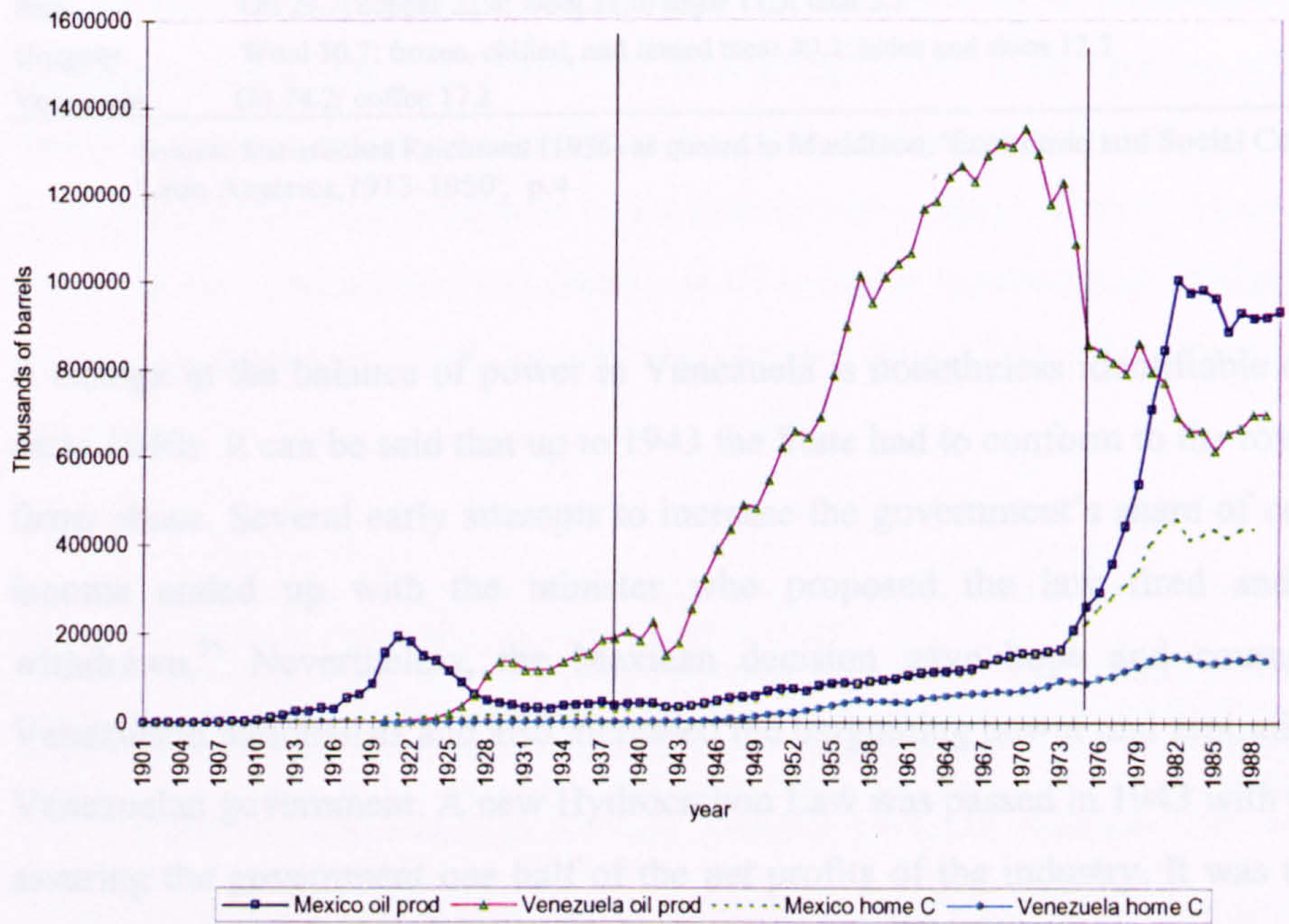
[28] The following texts reappraise the nationalisation from different perspectives. Bermudez, *The Mexican National Petroleum Industry: A case study in Nationalisation;* J.R. Powell, *The Mexican Petroleum Industry 1938-1950* (Berkeley, 1956); Silva Herzog, *Historia de la Expropiación de las Empresas Petroleras,1917-1942*; Basurto, *El Conflicto Internacional en Torno al Petróleo de México* .

[29] An extremely well documented summary of facts is presented by Lieuwen, *Petroleum In Venezuela: A History* in his Chapter 6, 'Controversy, 1935-1941', pp 72-89. The rest of the paragraph is based on the information provided on those pages.

and domestic industry, where the government depended on oil for most of its income, and where petroleum dollars paid for imported food, expropriation was asking for disaster'.[30]

The review of the quantitative evidence confirms these views. Figure 1.1-1 shows not only the enormous difference in production between the two countries, but also the different size of the internal market for oil. Table 1.1-2 shows that, while Venezuela's population is the size of Cuba's, Mexico is one of the biggest countries in Latin America. The dependence of the Venezuelan economy on oil can hardly be exaggerated. Table 1.1-3 shows that, as early as 1929, over two-thirds of the Venezuelan exports were oil exports, a figure only comparable with Brazil's dependence on coffee on at that time, while Mexico's exports were much more varied almost a decade before the nationalisation.

Figure 1.1- 1: Oil production and home consumption in Mexico and Venezuela. 1901-1989 (thousand barrels)



Note: vertical lines mark the Mexican nationalisation of the oil industry in 1938 and the Venezuelan nationalisation in 1976. Data series and sources listed in Appendix A

[30] Opinions expressed in the following diaries and dates: *Critica,* June 23, 1937; *Ahora,* May 5, 1938; *Excelsior* (Maracaibo edition), March 16, 1937, as quoted in Ibid., p. 76-77, footnote 23.

Table 1.1- 2: Population of Latin America, 1913-1985 (thousands).

	Argentina	Brazil	Chile	Colombia	Cuba	Mexico	Peru	Uruguay	Venezuela	9-country Total
1913	7,653	23,660	3,463	4,885	2,469	14,930	4,507	1,165	2,590	65,322
1929	11,592	32,894	4,306	7,131	3,742	16,290	5,576	1,570	2,927	86,028
1938	13,724	39,480	4,915	8,688	4,427	18,991	6,372	1,829	3,685	102,111
1950	17,150	51,942	6,091	11,597	5,516	27,376	7,630	2,239	5,145	134,686
1965	22,283	80,403	8,510	18,488	7,810	43,500	11,470	2,693	9,119	204,276
1973	25,189	99,836	9,856	22,571	9,036	56,481	14,350	2,821	11,844	251,984
1980	28,237	118,518	11,104	25,892	9,720	69,655	17,290	2,908	14,930	298,254
1985	30,557	133,966	12,070	28,620	10,090	77,938	19,700	3,010	17,216	333,167

Source: Maddison, 'Economic and Social Conditions in Latin America, 1913-1950', p.8

Table 1.1-3: Commodity Composition of Latin American Exports, 1929. (Percentages of total exports).

Argentina	Wheat 29.2; maize 17.6; frozen, chilled, and tinned meat 12.8; linseed oil 12.6
Brazil	Coffee 71.0
Chile	Nitrates 42.1; copper 40.4
Colombia	Coffee 60.6; petroleum 21.3
Cuba	Sugar 79.5
Mexico	Silver 20.6; other minerals 47.0
Peru	Oil 29.7; copper 22.4; wool 21.0; sugar 11.5; lead 5.1
Uruguay	Wool 30.7; frozen, chilled, and tinned meat 30.2; hides and skins 12.7
Venezuela	Oil 74.2; coffee 17.2

Source: Statistisches Reichsamt (1936) as quoted in Maddison, 'Economic and Social Conditions in Latin America,1913-1950', p.4

A change in the balance of power in Venezuela is nonetheless identifiable during the early 1940s. It can be said that up to 1943 the State had to conform to the royalties that firms chose. Several early attempts to increase the government's share of companies' income ended up with the minister who proposed the law fired and the law withdrawn.[31] Nevertheless, the Mexican decision gave hope and courage to the Venezuelan nationalists and also increased the bargaining power and aspirations of the Venezuelan government. A new Hydrocarbon Law was passed in 1943 with the aim of assuring the government one half of the net profits of the industry. It was to rule the

[31] In an attempt to take advantage of the competition for obtaining oil concessions, the Venezuelan government drafted the 1918 law, which raised the royalties from 5 percent to 15 percent. The American government and companies firmly protested. As a consequence the minister who proposed the law was fired, and company lawyers drafted their own law which set royalties at 10 percent. On a further occasion, when the depression induced a fall in the price of crude oil, a new attempt to increase the government's share of oil industry profits was carried out in 1930. A new *reglamento* imposed state fiscal and technical controls over the produces. Shell and Standard officials 'visited' General Gómez, as a result, the *reglamento* was abolished and the minister was fired again. From Lieuwen, *Petroleum In Venezuela: A History* and Venezuela.

industry with small modifications until the nationalisation in 1976. For many of the subsequent years, Venezuela's governments influenced the world's oil market, with their tax and concession policies, probably as no other single country.

The so-called 'anti-imperialist' literature supported the case for nationalisation of Venezuelan oil throughout the early 1940s.[32] It made clear references to the Mexican case along with strong opposition to private companies and the policies followed by the Venezuelan government of the early part of the century. In all, the main concern of this literature was the analysis of the distortions that oil was introducing in Venezuela at all levels: political, social and economic. In particular, the displacement of the hitherto most important sector, agriculture, by the petroleum sector was subject to continual consideration.[33] Nevertheless, the main subject among scholars continued to be the relationships between politics and industry.[34] They now concentrated on the level of the royalties that the government should impose on the firms.[35] Whether Venezuela took the advantage that it should from its oil has been the recurrent topic of the Venezuelan literature.[36]

The increasing role of other regions, especially the Middle East, in the production of oil and gas during the 1950s displaced Venezuela from its long-standing privileged position in world markets. Venezuela, producing heavy oil and having a higher per-barrel cost of extraction (around 80 cents), had every reason to fear all-out competition from the Middle East producers (with 20cent/barrel costs). Output quotas were the only way that Venezuela could protect its oil industry against cheap foreign oil.[37] The road to the creation of OPEC in 1960 and the next stage of the oil industry history had just begun.[38]

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[32] Examples of this line of argument are Matos Romero, *Venezuela y México ante el Imperialismo* and Venezuela. The latter represents the communist point of view.

[33] Examples are R.D. Leon, *De agro-pecuario a petrolero* (Caracas, 1944); M. Egaña, *Tres décadas de producción petrolera* (Caracas, 1947); L.F. Calvani, *Nuestro Máximo Problema* (Caracas, 1947). The matter of the conflict oil-agriculture was already present in the previous decade as demonstrated by R.A. Camejo, 'Lineamientos de la Industria del Petróleo en Venezuela', *Revista de Fomento* (1938) 7.

[34] F. Tugwell, *The politics of oil in Venezuela* (Stanford, 1975), J.E. Hartshorn, *Oil Companies and Governments* (London, 1967).

[35] See Chapter 4 in Lieuwen, *Petroleum In Venezuela: A History* ; Mejía Alarcón, *La industria del petróleo en Venezuela* presents representative correspondence and law making of the epoch.

[36] Numerous conferences were organised regarding the use Venezuela should have made of its oil, see for example: T.E. Carrillo Batalla, *La evaluación de la inversión del ingreso fiscal petrolero en Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]* (Caracas, 1968); Mieres, F.(coordinador), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989).

[37] J. Amuzegar, *Managing the Oil Wealth: OPEC's Windfalls and Pitfalls* (London, 1999), p.27.

[38] For the role of Venezuela in the creation of the OPEC, its consequences for the country and the world's oil markets from the Venezuelan perspective, see for instance L. Vallenilla, *Oil: the Making of a New Economic Order. Venezuelan Oil and the OPEC* (New York, 1975); S.G. Rabe, *The road to OPEC*

Economically, the 1950s and 1960s were very prosperous decades overall for both Mexico and Venezuela. The so-called 'Mexican economic miracle' occurred before the rebirth of the petroleum industry, and was characterised by high growth and low inflation.[39] National income in Venezuela also grew rapidly, and the country enjoyed one of the highest per capita growth rates in the world.[40] In Venezuela, the rapid growth on petroleum production did contribute to rapid growth in the rest of the economy.[41] Yet Mexican and Venezuelan strategies regarding the role of oil in their economies differed substantially. The main objective of Pemex was adequate supply of the national market, despite the higher yield that could had been obtained from sales abroad.[42] In contrast, oil cash has been Venezuela's income ever since the advent of the oil era; other sources were relatively small or quickly eliminated.[43]

Times of Reaction (1970s)

Mexican nationalists took pride in their independence compared with the foreign spoliation of national wealth that Venezuela was suffering. Venezuelan nationalists looked with envy at the Mexican ability to exploit their own resources. Whether there was genuine concern for the depletion of oil as such rather than a share in the gains is a different matter. After almost forty years of running in opposite directions, looking at each other with a mixture of wonder and criticism, and each defending its strategy against the other, the shock in oil prices of the early 1970s generated enough disturbances to force the Mexican and Venezuelan governments to redirect their

: *United States relations with Venezuela, 1919-1976* (Austin, Texas, 1982) and section 2.6 in J.C. Boué, *Venezuela. The Political Economy of Oil* (Oxford, 1993).

[39] There is no full agreement among scholars about the 'miracle years' for Mexico. Fitzgerald refers to the period from 1950-65 as so; Hamilton writes that 'a large number of people were left out of the 'Mexican Miracle' from 1940-70'; On her part, Lustig characterises the period 1950s-1973 as of high growth and low inflation. See E.V.K. Fitzgerald, 'Financial constraints upon relative autonomy: the State and capital accumulation in Mexico, 1940-1982', in Anglade and Fortin (eds.), *The State and Capital Accumulation in Latin America. Brazil, Chile, Mexico*, Vol. 1 (London, 1985), p.230; N. Hamilton, 'State-class alliance and conflicts: issues and actors in the Mexican economic crisis', in Hamilton and Harding (eds.), *Modern Mexico. State, Economy and Social Conflict* (London, 1986), p.9 and N. Lustig, 'Equity and growth in Mexico', in Teitel (ed.), *Towards a New Development Strategy for Latin America. Pathways from Hirschman's Thought* (Washington, D.C., 1992), p.221.

[40] J.D. Martz and D.J. Myers, 'The Politics of Economic Development', in Martz and Myers (eds.), *Venezuela: The Democratic Experience* (New York, 1986), p.73. Their closer look to the economic performance of Venezuela describe the period 1953-1957 as one of expansion; the transition to democracy (1958-1963) as one of crisis and the years 1964-1968 as times of stabilisation and growth. For a different periodisation of the Venezuelan economy see Echevarría, O.A., *La economía venezolana, 1944-1994* (Caracas, 1995).

[41] J.A. Hanson, 'Cycles of Economic Growth and Structural Change since 1950', in Martz and Myers (eds.), *Venezuela: The Democratic Experience* (Caracas, 1st ed., 1977), p. 64.

[42] G. Philip, *Oil And Politics In Latin America. Nationalist Movements And State Companies* (Cambridge, 1982), p.336.

policies. Obviously, the changes in strategy can by no means be solely attributed to the sudden price increase of 1973, but it can be taken as the turning point.

The nationalisation of Venezuela's oil industry in 1976 can be considered as the culmination of a very long nationalist process, somehow inspired by Mexico's nationalisation a generation before.[44] In a world already shaken by oil news, the Venezuelan nationalisation of petroleum production did not excite much attention in the international media.[45] There was nothing new about it; the years after the Second World War had witnessed the expansion of the role of the state in the economy, and most of the main oil producing countries had nationalised their industries during the previous decade.[46] Nevertheless, within Venezuela's oil literature, as in Mexico forty years earlier, the nationalisation occupies a prominent place.[47] For its part, Mexico reconsidered its inward-looking strategy. Forced by the pressure of having become a net oil importer during the late 1960s, the increase in exploration investment was generously rewarded with major oil discoveries in the south of the country in 1974. The country's production and exports then experienced an important thrust, putting Mexico's name back in international oil reports.

As shown in Figure 1.1-1 above, the events of the 1970s had major effects on both countries' output levels. The rebirth of the Mexican oil industry coincided with the slowdown in production in Venezuela which was caused by the nationalisation process. Mexico's production regained its 1921 level in 1974, and surpassed that of Venezuela by 1981. As a result, Mexican dependence on oil achieved relatively high levels during this period (see Figures 1.1-2 to 1.1-4 below). However important oil became for Mexico since the mid-1970s, its dependence on oil income never achieved Venezuela's standards. Yet their economies resembled each other more than ever before.

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[43] Thorp, *Progress, Poverty and Exclusion. An Economic History of Latin America in the 20th Century*, p.77.

[44] For an officials review of the first ten years of the Venezuelan national oil industry see: PDVSA, (Petróleos de Venezuela S.A.), *Los primeros diez años de la industria petrolera nacional 1976-1985* (Caracas, 1986).

[45] Goodman, Mendelson Forman, Naim, et al. (eds.), *The lessons of the Venezuelan experience*, p. 4.

[46] Some oil nationalisation dates:1961 Qatar, 1962 Indonesia and Libya, 1967 United Arab Emirates, 1969 Algeria, 1971 Nigeria, 1972 Ecuador (left OPEC in 1992), 1973-75 Gabon. For a review of national oil companies in Latin America see Philip, *Oil And Politics In Latin America. Nationalist Movements And State Companies*.

[47] G. Coronel, *The Nationalisation of the Venezuelan Oil Industry. From Technocratic Success to Political Failure* (Lexington, Massachusetts, 1983); J.F. Petras, M. Morley and S. Smith, *The Nationalisation of Venezuelan Oil* (New York, 1977) and C.E. Baena, 'The politics of oil in Venezuela:

A Common Crisis: 1980s

Events from the mid-1970s to the first half of the 1980s put both economies to the test and, as never before, both governments faced similar problems. High growth rates, this time based on oil revenue in both cases, were now accompanied by inflationary pressures hitherto unknown. The increasing intervention of the state in the economy and expansionary policies, reflected in the raising level of government expenditures, were fuelled by the oil boom optimism. Yet oil windfalls were insufficient to finance the ambitious development projects outlined by both governments. Huge foreign borrowing financed the corresponding deficit.

The fall of oil prices by mid-1981, the macro-economic imbalances, the inconsistency of state policies and the rise of international interest rates were the starting point of what thereafter has been known as the 'debt crisis'. By the mid-1980s, both countries were in the throes of very deep recessions. They saw the price of their principal export plummet and both have experienced substantial declines in gross domestic product. Mexico and Venezuela were also counted among Latin America's largest debtors, both in absolute and per capita terms. The fall in living standards was very marked. The experience of recession was difficult for both countries because, as Table 1.1-4 shows, neither was used to anything but rapid economic growth.[48]

The implementation of orthodox economic programmes, cutting down government expenditures (especially public investment and social expenditures), was able to contain inflation and reduce the deficit. But the period was one of economic stagnation and declining living standards. During the late 1980s and 1990s, oil windfalls were regarded more cautiously and even considered as one of the causes of the 'lost decade'.[49]

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a decision-making analysis of PDVSA's internationalisation policy' (DPhil dissertation, London School of Economics, University of London, 1997).

[48] In fact, the literature often emphasises the sudden shift from boom to crisis that occurred during this period. For the Mexican case see: J.A. Teichman, *Policymaking in Mexico: from Boom to Crisis* (London, 1988); J. Ros, 'Mexico from the Oil Boom to the Debt Crisis: and analysis of policy responses to external shocks, 1978-1985', in Thorp and Whitehead (eds.), *Latin American Debt and Ajustment Crisis* (Oxford, 1987). On Venezuela see: F. Bourguignon, 'Venezuela: Absorption without Growth', in Gelb (ed.), *Oil Windfalls: Blessing or Course?* (Washington, D.C., 1988); Goodman, Mendelson Forman, Naim, et al. (eds.), *The lessons of the Venezuelan experience* ; R. Vaez-Zadeh, 'Oil Wealth and Economic Behavior: the case of Venezuela, 1965-81', *IMF Working Paper*, WP/88/56 (1988, June 30); Mieres, *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]* .

[49] See among others A. Gelb and Associates, *Oil Windfalls, Blessing or Course?* (Washington, D.C., 1988); R.M. Auty, *Resource-based industrialization: sowing the oil in eight developing countries* (Oxford, 1990); ' Putting Mexico together again'. *The Economist*, 4-Feb-95; 'Mexico. Suckled on oil'. *The Economist*, 25-Jul-98; 'Mexico's economy. Miracle or mirage?'. *The Economist*, 11-Apr-98; ' The oil industry. Latin lessons'. *The Economist*, 3-Jan-98; Goodman, Mendelson Forman, Naim, et al. (eds.), *The lessons of the Venezuelan experience* ; T.L. Karl, *The Paradox of Plenty: Oil Booms and Petro-*

In brief, one can divide the history of Mexican oil into three phases. The first goes from the start of commercial crude oil production 1901 to 1938.[50] Within this period, Mexico became the second largest producer of petroleum, after the United States, and the largest oil exporter. The second phase links the expropriation-nationalisation of the oil industry in 1938 with the mid-1970s. In this period, Mexico was producing mainly for its own internal consumption with negligible exports and became a net importer of petroleum by the late 1960s. Finally, the new era of Mexican energy development was launched by major oil discoveries in the south of the country in 1974, and the country's production and exports experienced an important thrust.

As for Venezuela, it is also argued that there were three different periods in its oil industry history. The first was the ultraliberal period, which gave the country the lead in the world's oil exports during in the inter-war period. A second period of emerging nationalism started during the post-war years, which led firstly to the creation of OPEC (1960) and finally to the nationalisation of the industry in 1976. The latter represents the starting point of the last period.

It is not possible however, to identify phases in the pattern of dependence on oil exports in the case of Venezuela (see Figure 1.1-2). Oil exports became the main export product in Venezuela by the late 1920s, and by the 1930s already accounted for 80 percent of total exports. Indeed, from 1933 to 1983 the share was over 90 percent, reaching levels close to 98 percent in the years around 1950. Even after nationalisation in 1976 the share stood at around 95 percent. Only during the last years of the period did the share of oil exports decrease below the 90 percent mark. In contrast, the Mexican oil exports share in total exports, exhibits two peaks separated by a very long period of almost non-existent oil exports. Hydrocarbon exports accounted for half of total exports in 1921 and for more than 70 percent in the early 1980s.

States, Vol. 26 (Berkeley, 1997);Meyer and Morales, *Petróleo y Nación (1900-1987). La política petrolera en México;* Naim, *Paper, Tigers and Minotaurs.The politics of Venezuela's Economic Reforms* ; M. Urrutia, 'Twenty-Five Years of Economic Growth, 1960-1985', in Urrutia (ed.), *Long-Term Trends in Latin American Economic Development* (Inter-American Development Bank, Washington D.C., 1991); A. Uslar Pietri, '¿En qué medida se ha cumplido el vaticinio de Uslar Pietri (*Ahora*, 1936) sobre el parasitismo rentista en la Venezuela petrolera?', in Mieres (ed.), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989).

[50] Bermudez, *The Mexican National Petroleum Industry: A case study in Nationalisation* p.1.

Table 1.1-4: Rate of growth of Latin American GDP 1900-1994, selected periods (average annual compound rate).

	1900-1913			1913-1929			1929-1950			1950-1973			1973-1980			1980-1989			1989-1994			1900-1994		
	a	b	c	a	b	c	a	b◆	c	a	b*	c	a	b♦	c	a	b	c	a	b⅄	c	a	b	c
Argentina	6.4	6.3	6.4	3.5	4.1	3.5	2.5	3.4	2.5	4.0	3.8	3.8	3.0	2.5	2.1	-1.0		-1.0	6.1	1.9	5.9	3.5	3.3	3.3
Brazil	4.5	4.1	3.5	4.7	5.1	3.9	5.0	4.4	4.2	6.9	6.9	6.8	7.2	6.6	6.9	2.3		2.2	0.9	2.4	0.8	5.0	5.5	4.5
Chile	3.7	3.6	3.7	2.9	3.7	2.9	2.2	3.0	2.2	3.6	4.1	3.4	2.8	3.6	3.4	2.9		2.9	6.4	5.4	5.6	3.2	3.3	3.2
Colombia	4.2	4.4	3.9	4.7	4.9	3.9	3.6	3.8	3.6	5.1	5.3	5.2	5.0	5.0	5.0	3.3		3.4	4.3	4.0	3.9	4.4	4.7	4.2
Mexico	2.6	3.4	2.6	0.8	1.4	0.8	4.0	4.2	4.0	6.5	6.5	6.4	6.4	5.5	6.4	1.4		1.4	3.0	1.5	2.7	3.7	5.0	3.7
Venezuela	3.3	2.3	3.3	8.2	9.2	8.2	5.9	4.2	5.9	6.4	5.7	6.3	4.1	4.7	2.5	-0.1		0.2	3.6	2.2	3.5	5.2	5.9	4.9
Six OECD$	2.2			2.2			1.3			5.7			2.3			2.6			1.8			2.8		

Notes:

◆ 1929-1945

* 1945-1972

♦ 1972-1981

⅄ 1981-1996

$ The six OECD countries were France, Germany, Japan, the Netherlands, the United Kingdom, and the United States.

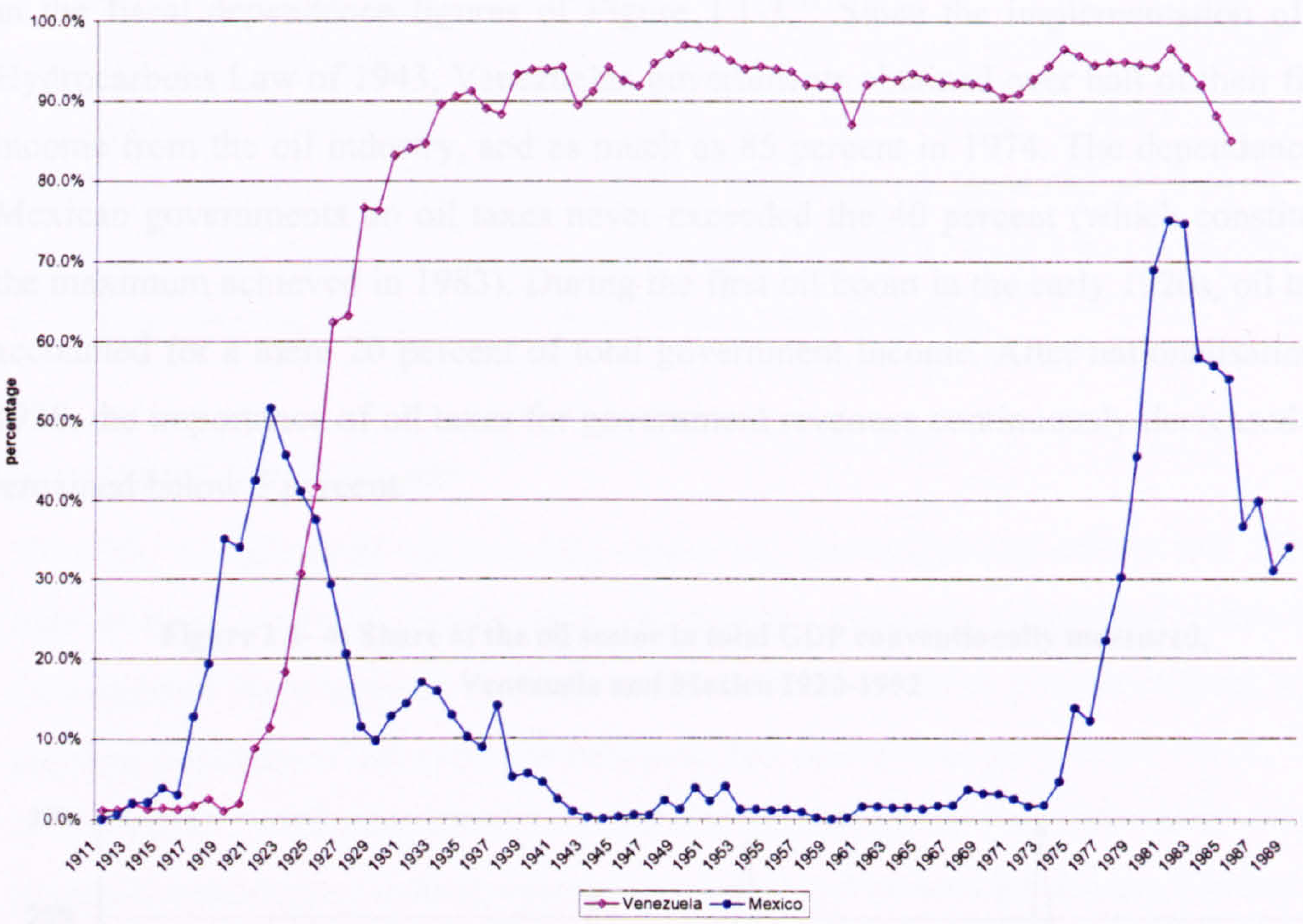
Sources:

a- A.A. Hofman and N. Mulder, 'The Comparative Productivity Performance of Brazil and Mexico, 1950-1994', in Coatsworth and Taylor (eds.), *Latin America and the World Economy since 1800* (Cambridge, MA, 1998), p. 87- Table 3.1

b- Thorp, *Progress, Poverty and Exclusion. An Economic History of Latin America in the 20th Century*, Table 2.1, p.15.

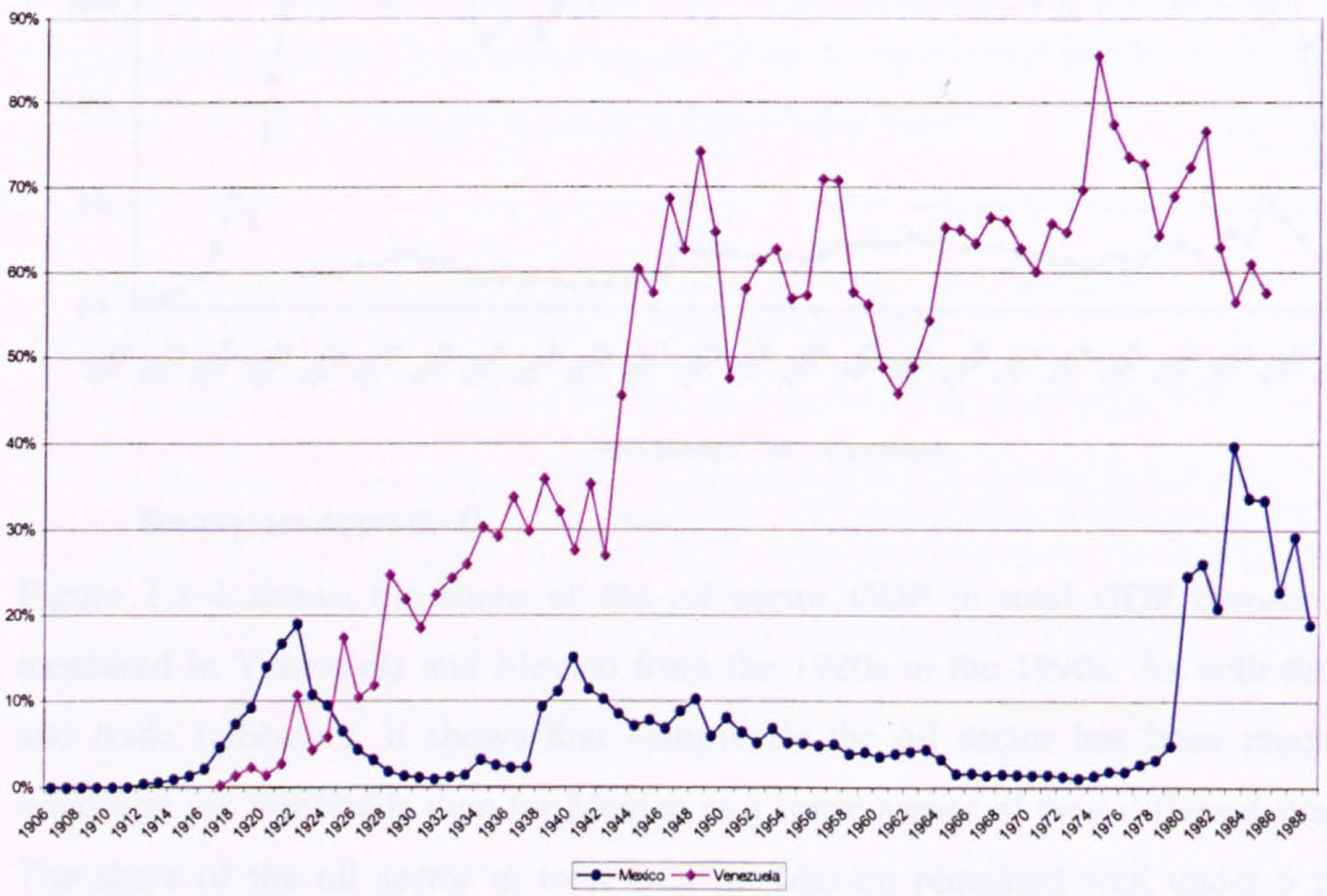
c- calculated from the data in A. Maddison, *Monitoring The World Economy, 1820-1992* (Paris, 1995), pp. 188-189.

Figure 1.1- 2: Oil exports as percentage of total exports by value, Venezuela and Mexico 1911-1989.



Sources: see Appendix B.

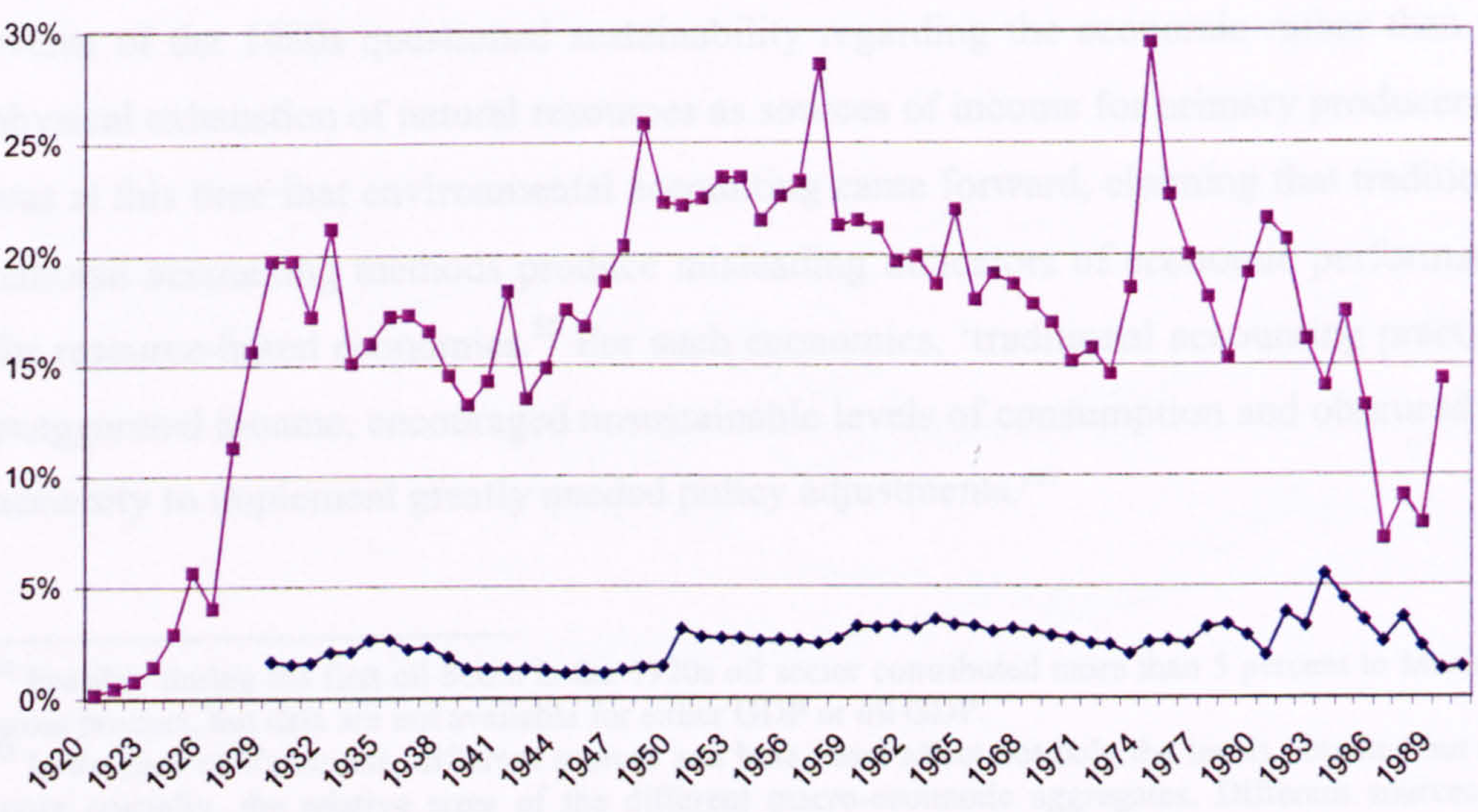
Figure 1.1- 3: Share of oil taxes in government fiscal revenue, Venezuela and Mexico 1911-1989.



Sources: see Appendix C.

The claims about the different phases in Venezuela's oil history are better appreciated in the fiscal dependence figures of Figure 1.1-3.[51] Since the implementation of the Hydrocarbons Law of 1943, Venezuelan governments obtained over half of their fiscal income from the oil industry, and as much as 85 percent in 1974. The dependence of Mexican governments on oil taxes never exceeded the 40 percent (which constituted the maximum achieved in 1983). During the first oil boom in the early 1920s, oil taxes accounted for a mere 20 percent of total government income. After nationalisation in 1938, the importance of oil taxes for government revenues continuously decreased and remained below 5 percent.

Figure 1.1- 4: Share of the oil sector in total GDP conventionally measured, Venezuela and Mexico 1920-1992



Sources: see Appendix D.

Figure 1.1-4 shows the share of the oil sector GDP in total GDP conventionally measured in Venezuela and Mexico from the 1920s to the 1990s. As with the fiscal and trade indicators, it shows that historically the oil sector has been much more important for Venezuela than for Mexico as a consequence of their different strategies. The share of the oil sector in total GDP in Mexico remained well under 5 percent

[51] The emphasis on policy/political phases is especially strong in:R. Espinasa and B. Mommer, 'Venezuelan Oil Policy In The Long Run', in Fesharaki (ed.), *International Issues In Energy Policy, Development And Economics* (Oxford, 1992) and R. Betancourt, *Venezuela: Oil and Politics* (Boston, 1979).

throughout the century.[52] According to these data, the oil sector in Venezuela represented between 15 to 25 percent of the traditional GDP during the twentieth century.[53] The implication of these figures is that the non-oil component of total GDP was calculated to be about 95 percent in Mexico and between 75 and 85 percent in Venezuela. Despite the importance of these contrasts, no historical or contemporary study traces the links between the experiences of Mexico and Venezuela. There is definitely room for a comparative study of these two countries.

1.2 Overall Performance

Possibly, the aftermath of the debt crisis and the reappraisal of the oil windfall phenomenon account partly for increasing concerns regarding sustainable development. Sustainability concerns in terms of the limits to growth imposed by the physical finiteness of the available resources had emerged already in the 1970s. [54] The events of the 1980s questioned sustainability regarding the economic rather than the physical exhaustion of natural resources as sources of income for primary producers. It was at this time that environmental accounting came forward, claiming that traditional national accounting methods produce misleading indicators of economic performance for resource-based economies.[55] For such economies, 'traditional accounting practices exaggerated income, encouraged unsustainable levels of consumption and obscured the necessity to implement greatly needed policy adjustments.'[56]

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[52] Possibly during the first oil boom in the 1920s oil sector contributed more than 5 percent to Mexico's gross product, but data are not available for either GDP or oil GDP.

[53] In the case of Venezuela, different sources and base years affect not only the levels obtained but also more crucially, the relative sizes of the different macro-economic aggregates. Different sources are contrasted in Appendix D.

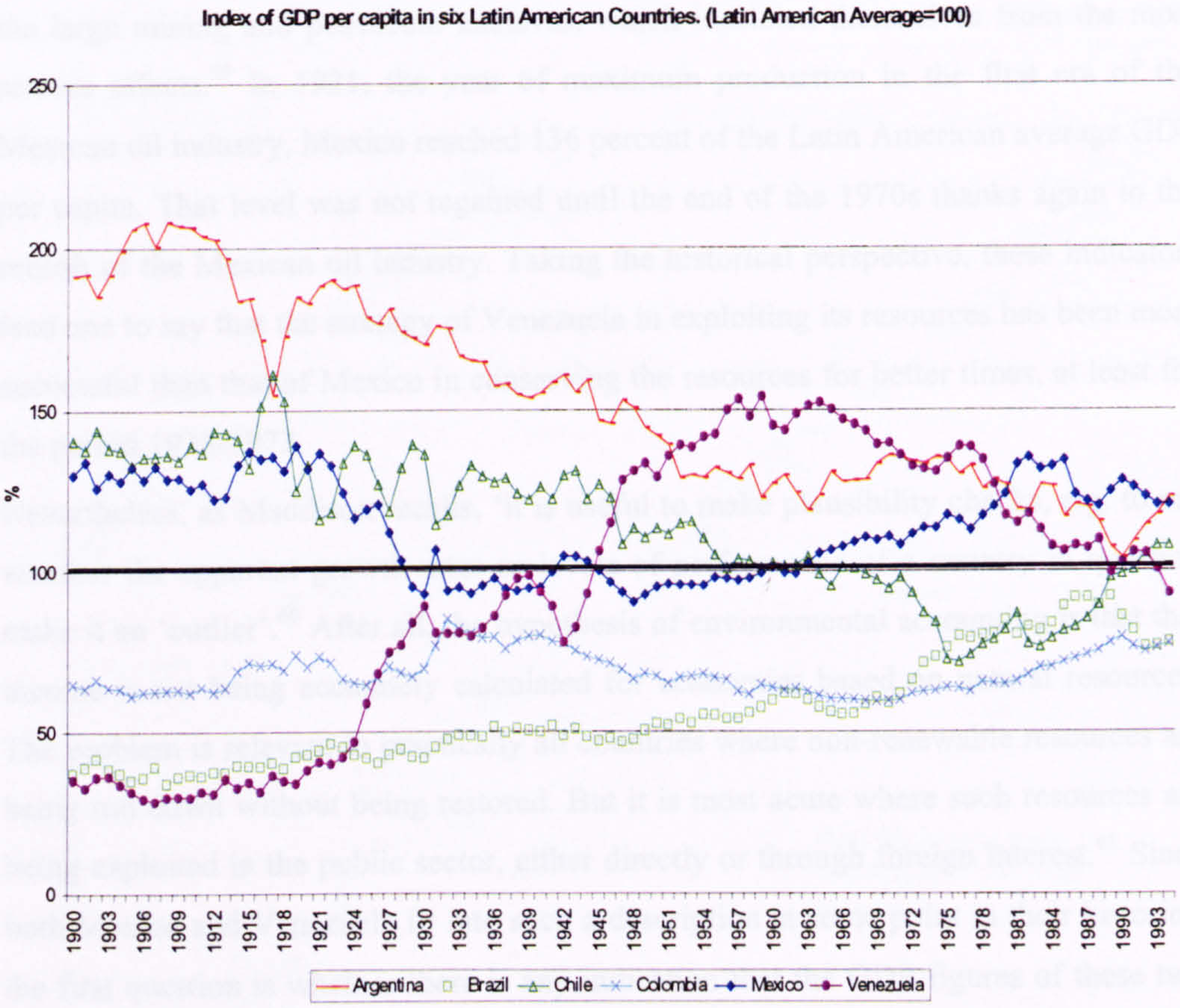
[54] Two obvious references in this tradition are Meadows et al., *The limits of growth* (New York, 1972) and J.W. Forrester, *World Dynamics* (Cambridge, 1971). Some eminent economists produced then insights in environmental issues, among others P. Dasgupta and G. Heal, 'The Optimal Depletion of Exhaustible Resources', *Review of Economic Studies. Symposium on the Economics of Exhaustible Resources* (1974), R.M. Solow, 'The Economics of Resources or the Resources of Economics', *The American Economic Review* 64 (1974) 2; R.M. Solow, ' Intergenerational Equity and Exhaustible Resources', *Review of Economic Studies* (1974) and J. Stiglitz, 'Growth with exhaustible natural resources: efficient and optimal growth paths', *Review of Economic Studies. Symposium on The Economics of Exhaustible Resources* (1974) 41.

[55] Actually, it was not only the environmental literature that argued along these lines. Studies on rentier states, that is oil producer countries, put forward similar concerns about national income accounts yet from a complete different perspective. See for instance, H. Mahdavy, 'The Patterns and Problems of Economic Development in Rentier States: the Case of Iran', in Cook (ed.), *Studies in the Economic History of the Middle East* (Oxford, 1970) and R. Stauffer, *Accounting for "Wasting Assets". Income Measurement for Oil and Mineral-Exporting Rentier States*, Vol. 25 (Vienna, 1984). These approaches are also analysed in passing in Chapter 2.

[56] S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy and Lutz (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989), p.10.

Nevertheless, the economic histories of Mexico and Venezuela are still told in accordance with traditional accounting methods. According to Table 1.1-4 above, Venezuela had the best overall performance in Latin America throughout the twentieth century.[57] In comparative terms, Venezuela started the century with the lowest GDP per capita of the six bigger Latin American countries but by the 1950s it had surpassed them all, as shown in Figure 1.2-1. Furthermore, by 1958 Venezuela had the seventh highest average income in the world, slightly greater than that in the United Kingdom and significantly higher than incomes in France and Germany.[58]

Figure 1.2-1: Index of GDP per capita of six Latin American countries, 1900-1994



Source: based on the GDP per capita produced by A.A. Hofman, *The Economic Development of Latin America in the Twentieth Century* (Cheltenham, UK, 2000), pp.156-157. Latin American average refers to the average GDP per capita of the 6 countries referred.

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[57] A view corroborated in Hofman and Mulder, 'The Comparative Productivity Performance of Brazil and Mexico, 1950-1994', p.87.

[58] D.F., Larson, *The Role of Agriculture in Venezuela's Economic Rise and Decline,* Ref. 682-33, Abstracts of Current projects.1999. Available from: http://econ.worldbank.org.

During most of the first two decades of the century, Venezuelans barely had access to half the GDP per capita of the average Latin American had. In the middle of the century however, Venezuelans enjoyed a GDP per capita fifty per cent higher than the average Latin American. Coming towards the end of the twentieth century, Venezuela's GDP per capita slowly returned to levels closer to the rest of Latin America, and by the 1990s had fallen below the average.

Mexicans commenced the twentieth century with the third biggest GDP per capita of Latin America. For the years of the Revolution it is plausible to think that the relative performance of the country improved thanks in part to the successful performance of the large mining and petroleum enclaves, which insulated themselves from the most serious effects.[59] In 1921, the year of maximum production in the first era of the Mexican oil industry, Mexico reached 136 percent of the Latin American average GDP per capita. That level was not regained until the end of the 1970s thanks again to the rebirth of the Mexican oil industry. Taking the historical perspective, these indicators lead one to say that the strategy of Venezuela in exploiting its resources has been more successful than that of Mexico in conserving the resources for better times, at least for the period 1938-1973.

Nevertheless, as Maddison recalls, 'it is useful to make plausibility checks, e.g. to see whether the apparent growth rates or levels of performance of a country in question make it an 'outlier'.[60] After all, the hypothesis of environmental accounting is that that income is not being accurately calculated for economies based on natural resources. The problem is relevant to practically all countries where non-renewable resources are being run down without being restored. But it is most acute where such resources are being exploited in the public sector, either directly or through foreign interest.[61] Since both Mexico and Venezuela fit into such a description at some point in their histories, the first question is whether there is any indication that the GDP figures of these two countries may be a misleading indicator of their actual performance.

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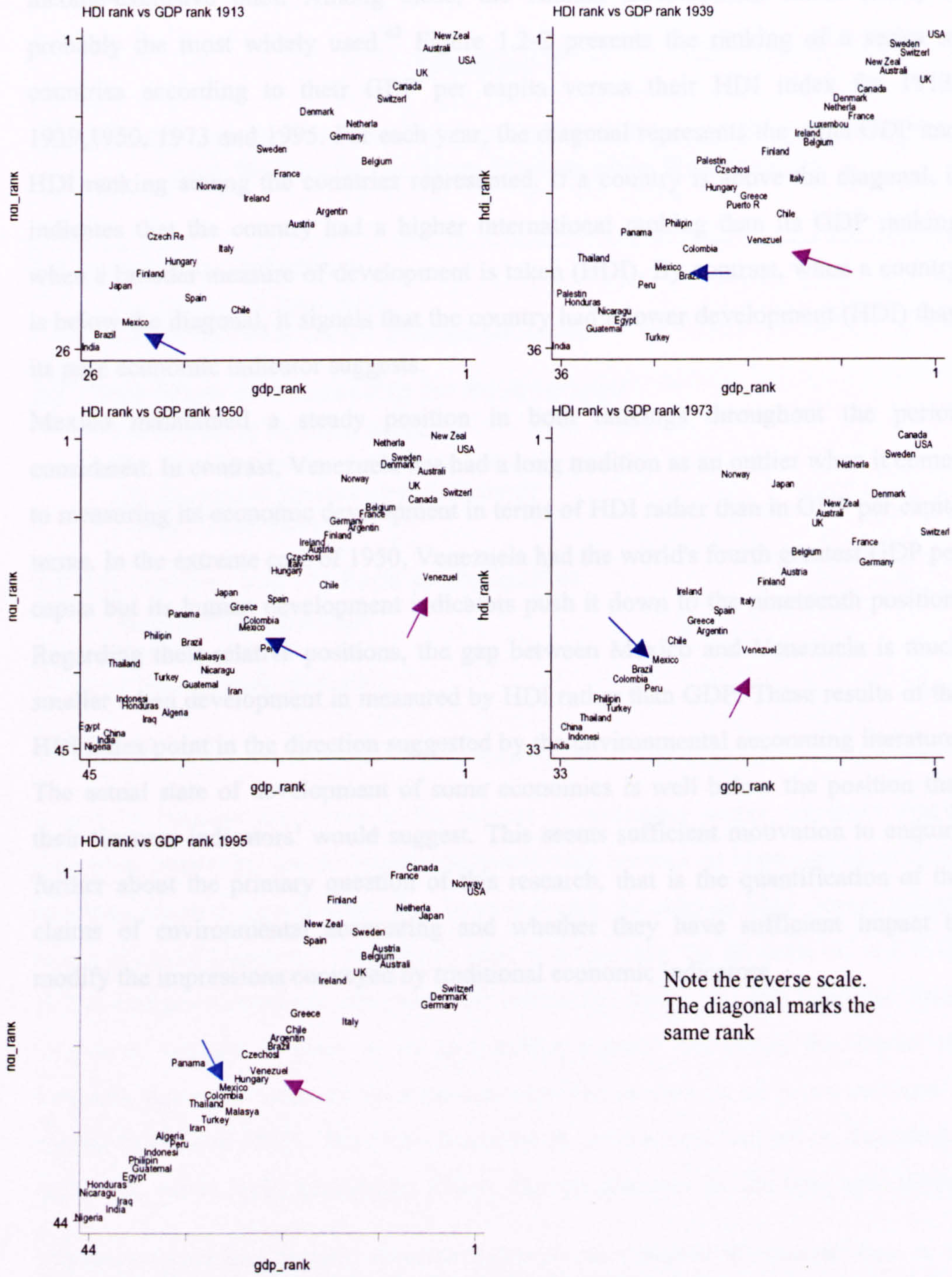
[59] The data in figure 1.2-1Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth* , p.29. See also J.E. Sterrett and J.S. Davis, 'The Fiscal and Economic Condition of Mexico. Report submitted to the International Commitee of Bankers on Mexico'. (New York, 1928).

[60] A. Maddison, *Monitoring The World Economy, 1820-1992* (Paris, 1995), p.125.

[61] El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', p.10.

Figure 1.2-2: GDP per capita ranking V.S. HDI ranking for 1913, 1939,1950, 1973 and 1995 for 36 countries



Sources: Data for 1939 by J. Metzer, *The Divided Economy of Mandatory Palestine*, Vol. 11 (1998), the rest by N.F.R. Crafts, 'The Human Development Index and changes in standards of living: some historical comparisons', *European Review of Economic History* (1997) I.

A preliminary way of enquiring along these lines is to consider indicators other than income-exclusive ones. Among those, the Human Development Index (HDI) is probably the most widely used.[62] Figure 1.2-2 presents the ranking of a series of countries according to their GDP per capita versus their HDI index for 1913, 1939,1950, 1973 and 1995. For each year, the diagonal represents the same GDP and HDI ranking among the countries represented. If a country is above the diagonal, it indicates that the country had a higher international ranking than its GDP ranking when a broader measure of development is taken (HDI). By contrast, when a country is below the diagonal, it signals that the country had a lower development (HDI) than its pure economic indicator suggests.

Mexico maintained a steady position in both rankings throughout the period considered. In contrast, Venezuela has had a long tradition as an outlier when it comes to measuring its economic development in terms of HDI rather than in GDP per capita terms. In the extreme case of 1950, Venezuela had the world's fourth greatest GDP per capita but its human development indicators push it down to the nineteenth position. Regarding their relative positions, the gap between Mexico and Venezuela is much smaller when development in measured by HDI rather than GDP. These results of the HDI index point in the direction suggested by the environmental accounting literature. The actual state of development of some economies is well below the position that their 'income indicators' would suggest. This seems sufficient motivation to enquire further about the primary question of this research, that is the quantification of the claims of environmental accounting and whether they have sufficient impact to modify the impressions conveyed by traditional economic indicators.

[62] The HDI grew out of the general feeling that conventional measures of GDP may not be adequate to capture all the socio-economic changes involved in processes of economic development. See United Nations, *Human Development Report* (New York, 1991)

'Since no complete detailed system for the description of the natural environment exist, it seems that a full system of integrated environmental economic accounts is not attainable at the present time. This situation will not be overcome in the near future. It should not, however, hinder our efforts...'[1]

Chapter 2

The Theoretical Frame: Environmental Accounting Concepts and Methods for Non-Renewable Resources

It may be because economics is the science of allocating scarce resources among competing needs that the environmental assets only become an important issue in the economic research agenda when they become scarce. As early as 1865, Jevons already raised *The Coal Question.*[2] One century later, it turned into 'the oil question' and in the 1970s, eminent economists focused on environmental issues.[3] At that time, the 'limits to growth' seemed to many to be approaching rapidly.[4] However, the debate, the forecasts, the models and the prescriptions subsided as soon as oil prices returned to normal by the mid 1980s. The 1990s literature on environment focused on degradation -pollution, ozone layer, greenhouse effect-, though concerns for the long term remain

[1] European Commission, Eurostat, *European System for the Collection of Economic Data on the Environment (SERIEE) -1994 version* (Brussels, 1994) p.21 paragraph 1028.
[2] W.S. Jevons, *The Coal Question* (Cambridge, 1865).
[3] Among others P. Dasgupta and G. Heal, 'The Optimal Depletion of Exhaustible Resources', *Review of Economic Studies. Symposium on the Economics of Exhaustible Resources* (1974), R.M. Solow, 'The Economics of Resources or the Resources of Economics', *The American Economic Review* 64 (1974) 2 R.M. Solow, ' Intergenerational Equity and Exhaustible Resources', *Review of Economic Studies* (1974) and J. Stiglitz, 'Growth with exhaustible natural resources: efficient and optimal growth paths', *Review of Economic Studies. Symposium on The Economics of Exhaustible Resources* (1974) 41.

central but under a different name: 'sustainable growth'. Nevertheless, it is within this literature that a real interest in measuring the economic significance of the environment finally arose.

The international development organisations, as major users and producers of national accounts, as advisers to developing countries, and as co-ordinators of systematic data collection and exchange, have initiated various efforts to improve the usefulness of environmental data. The Conference of European Statisticians of the Economic Commission for Europe began to investigate the organisation and use of environmental data in 1973. The United Nations Statistical Office (UNSTAT) began working on the problems of organising environmental data in 1974. In 1983 the first of several Environmental Accounting Workshops was held. In late 1984 the UNSTAT presented 'A Framework for the Development of Environment Statistics'.[5]

A number of countries have now prepared environmental accounts including Norway, Canada, The Netherlands, Denmark, France, Japan, Australia, the United States and the United Kingdom.[6] These accounts vary in the aspects that they consider: atmospheric emissions, water, oil and gas depletion, etc. The World Bank, the United Nations, the World Resources Institute and some other international organisations are also involved in the development of environmental accounts, especially in less developed countries.[7] In addition to these efforts, some studies have been carried out as

[4] Two obvious references in this tradition are: Meadows et al., *The limits of growth* (New York, 1972) and J.W. Forrester, *World Dynamics* (Cambridge, 1971).

[5] R.B. Norgaard, 'Linkages between Environmental and National Income Accounts', in Ahmad, Serafy, et al. (eds.), *Environmental accounting for sustainable development: a UNEP-World Bank symposium* (Washington, D.C., 1989), p.54.

[6] The first work on resource valuation is said to have been done in Norway in the 1970s and they were pioneers in natural-resource accounting beginning with oil. France began work in 1978. References can be found in the relevant bodies dealing with national statistics: Australian Bureau of Statistics, Statistics Canada, Statistics Netherlands, Statistics Sweden, INSEE (France), National Office for Statistics (UK), Bureau of Economic Analysis (US). For Japan see K. Oda, K. Arahara, et al., 'Japan: the System of Integrated Environmental and Economic Accounting (SEEA) -trial estimates and remaining issues', in Uno and Bartelmus (eds.), *Environmental Accounting in Theory and Practice*, Vol. 11 (London, 1998). Both J.R. Vincent, 'Green accounting: from theory to practice', *Environment and Development Economics* 5 (2000) and W.D. Nordhaus and E.C. Kokkenlenber (eds.), *Nature's Numbers: Expanding the U.S. National Economic Accounts to Include Environment* (Washington D.C., 1999) provide excellent surveys of the environmental accounting works done by public and private agents.

[7] United Nations, *Concepts and Methods of Environmental Statistics: Statistics of Natural Environment. A Technical Report* (New York, 1991); United Nations, *Integrated Environmental and Economic Accounting*, Vol. XVII (New York, 1993); United Nations, *Integrated Environmental and Economic Accounting: An operational Manual.* (New York, 2000); United Nations. Committee on New and Renewable Sources of energy and on Energy for Development, 'Energy and Sustainable Development: Development of Energy Resources in Developing Countries', *E/C.13/1996/1.* (1996) New York, 12-23 February 1996; World Bank, *Monitoring Environmental Progress: A Report on Work in Progress.* (Washington, D.C., 1995); World Bank, *Monitoring Environmental Progress: Expanding the Measure of Wealth* (Washington, DC, 1996); World Bank, *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development*, Vol. 17 (Washington, D.C., 1997).

doctoral research in universities, such as the study of oil and gas depletion in the United States by T.F. Slaper[8] and on Thailand's deforestation accountancy from 1970 to 1990 by C .W. Sadoff.[9]

Due in part to these efforts, recognition is growing that national income has never been accurately calculated for economies based on natural resources. In consequence, the first steps towards historical environmental national accounting have been taken.[10] It has been argued that income should be gradually adjusted for degradation of petroleum, forestry and fisheries, water quality soil erosion one at a time until our methodologies firm up and the physical basis of our calculation improves.[11] The main reason is that, as section 2.1 of this chapter shows, different environmental assets comprise different economic concepts, adjustments and methods.

The rest of the chapter is organised as follows. Section 2.2 introduces three ways of accounting for the environment in national accounts. The analysis of the concepts of income and depreciation in national accounts set the start of the final section. The methodological considerations are the main concern of this chapter, hence, the second half is devoted to the theoretical exposition of the methods of evaluation that will be used later on. More crucially it presents the concept of resource rent.

[8] T.F. Slaper, 'The Theoretical and Empirical Viability of Measuring the Value of Resource Depletion in the National Accounts: The Case of Oil And Gas in the United States' (DPhil Dissertation, The American University, 1995).

[9] C.W. Sadoff, 'Natural Resource Accounting: A Case Study Of Thailand Forest Management' (DPhil dissertation, University of California, 1993). Many other recent studies are quoted in Chapters 2, 4 and 5.

[10] M. Lindmark, *Towards Environmental Historical National Accounts for Sweden. Methodological Considerations and Estimates for the 19th and 20th Centuries.*, Vol. 21 (1998).

[11] S. El Serafy, 'The Environment as Capital', in Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993) p.19.

2.1 Looking for Definitions

This section endeavours to define and specify the object of measurement. Its main aim is to find a clear definition of exhaustible resources as economic goods. In order to do that, the first step is to clarify concepts about the many ingredients contained in the word 'environment'. 'The environment' will be broken into pieces, to be able to distinguish its economic characteristics. Finally, a small piece -exhaustible resources- will be fully defined, in order to establish its economic characteristics.

Starting in the obvious place, the English dictionary gives the following definition for environment:

' **Environment**: the physical surroundings, conditions, circumstances, etc., in which a person lives [...] **(the environment)** : the totality of the physical conditions on the earth or a part of it'.[12]

Titles such as: '*Valuing the Environment*', '*The Environment and Emerging Developing Issues*' or '*Changing the Face of the Earth: Culture, Environment and History*' could be referring to any aspect of the 'environment'.[13] By definition, they might be talking about whatever physical conditions in whichever part of the earth. Hence, before anything else, we need to specify what aspects concern us: natural resources, water quality, soil erosion, raw materials, nature, exhaustible resources, natural endowment, pollution, the ozone layer, the greenhouse effect, fisheries, forestry, etc. All of these are frequently included in or even replaced by the word 'environment' regardless.

This huge oversimplification undermines most economic approaches to environmental issues. Specific definitions and classification are the first steps that any science must take. Moreover, according to the definition just given, 'the environment' cannot, by any means, be considered as a homogeneous economic entity.

The Different Components

a) Standard Classifications

It is no easy task trying to differentiate the economically different components of the totality of the physical conditions on the earth. In practice, and at this stage of

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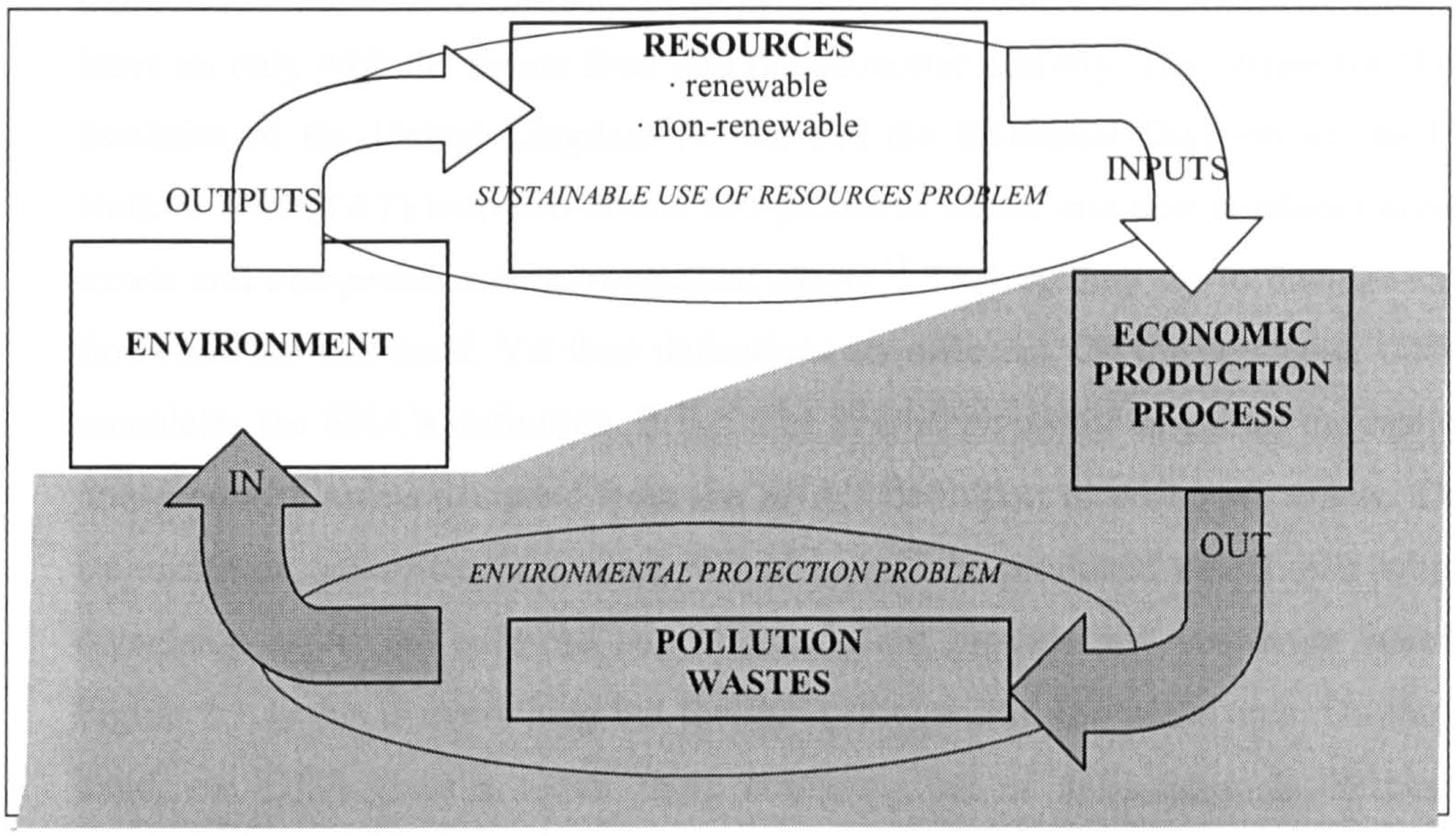
[12] The Oxford Compact English Dictionary, (1996).
[13] I. Serageldin and A. Steer (eds.), *Valuing The Environment* (Washington D.C., 1993), P. Dasgupta and K.G. Mäler, 'The Environment And Emerging Developing Issues', in *Proceedings Of The World Bank Annual Conference On Development And Economics 1990* (New York, 1991), I.G. Simmion, *Changing The Face Of The Earth: Culture, Environment, History* (London, 1989).

development, it might not be easy to choose among different approaches and methodologies.[14] We may first try to identify the elements according to Figure 2.1-1 below.

Figure 2.1-1: Flows between environment and economy



Sources: Own elaboration.

There are several relevant concepts that can be identified from this simple cycle. The environment generates resources (*outputs*), a part of which turn into *inputs* for the economic production process. At the same time, during the production process, waste and pollution are generated and deposited back in the environment.

Let us consider the very simple example of oil extraction within this framework, although the analysis could be applied to most natural resources. Here we can identify four elements: oil reservoirs represent the *outputs* from the environment. Part of these reserves are drilled and oil is stored. This constitutes an *input* for the economic production process. Finally, the pollution and waste generated by the oil industry and its externalities are deposited back in the environment.

A first classification of the components of the cycle is mostly agreed. It is the division between produced and non-produced assets. The former are assets produced by economic activity in previous periods and not yet exhausted.[15] They fall within the grey shadowed area on Figure 2.1-1. They would be fully represented by the outcomes

[14] E. Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993).
[15] C. Bryant and P. Cook, 'Environmental issues and the national accounts', *Economic trends* (1992 Nov) 469 p.102.

of the 'economic production process' box (including pollution and waste). Problems of definition arise with non-produced assets (i.e. 'the environment' box and the flows coming out of it). The United Nations System of National Accounts (SNA) refers to non-produced assets only as *economic assets*, that is, assets over which ownership rights are enforced and which provide economic benefits to their owner.[16] That would leave us only with the *inputs* flow into the economic activity. The Office for National Statistics of the United Kingdom (ONS) and the Statistical Division of the United Nations (UNSTAT) both sub-divide non-produced assets into *non-produced economic assets* and *non-produced environmental assets.*[17] That is, they try to distinguish both flows and the box itself. Yet their definitions are different. On the one hand, UNSTAT completes the SNA's definition. It includes in *environmental assets* all the rest of the non-produced assets excluded from the SNA's definition of *economic assets*. That is, by exclusion, *environmental assets* would be all non-produced assets over which no ownership rights are enforced and which do not provide any economic benefit. In Figure 2.1.1, this is everything but the *input* flow within the white area. On the other hand, the ONS gives a rather more confusing set of definitions. It defines *non-produced economic assets* as natural resources which have been taken into the economic system for use as part of the economic system's productive capacity, or which are managed as an economic resource. *Environmental assets,* according to the ONS's definition, are non-produced assets which are not part of the production process but are affected by it. Moreover, they provide the following examples:

[16] Quoted from P. Bartelmus, E. Lutz and J. van Tongeren, 'Environmental Accounting: an operational perspective', in Serageldin and Steer (eds.), *Valuing The Environment: proceedings of the First Annual International Conference On Environmentally Sustainable Development held at the World Bank, September 30-October 1, 1993* (Washington D.C., 1993), p.163.

[17] Bryant and Cook, 'Environmental issues and the national accounts', p.102. The rest of the discussion on the ONS's definitions is based on this same source and United Nations, *Integrated Environmental and Economic Accounting*, Vol. XVII (New York, 1993).

Table 2.1-1: General classification of produced and non-produced assets

Produced assets	**Non-produced assets**	
	Economic assets	Non economic assets
Buildings, machinery, vehicles, stocks, work in progress...	Proven reserves of oil, gas, coal, Cultivated land☜, Commercial forests ☜, Water in reservoirs, Managed fish stocks, Game reserves	Unproven reserves of oil, gas, coal, etc. Uncultivated land, Natural woodland, Rivers, lakes and coastal waters☜ Ground water, Air, ☜ Eco-systems

Source and notes: own elaboration. '☜' Signals inconsistencies.

Upon closer examination, one realises that some assets could easily fall within different categories, and that there are inconsistencies between and within both classifications. Some of these are indicated in Table 2.1-1. For example, following the UNSTAT classification, cultivated land could be seen as a produced asset being generated by economic activity in previous periods and not yet exhausted. The same could be said of commercial forests if they were just the fruit of commercial reforestation (they become assets produced by economic activity). In the ONS's definition rivers, lakes and coastal water as well as air do not have a price; thus they are considered non-economic assets. However, they enter in the production function.[18] 'In order that a thing should have a price, it must be appropriable, but it is not necessary that a thing should be appropriable (thus, to have a price) for it to be a factor of production'.[19] Hence, following from such a definition, those should be considered factors of production and re-classified as economic assets.

These inconsistencies add to the major problem of these and other classifications: they are too broad. Assets with a different economic nature share the same place. They still do not help to understand environmental resources as economic goods. The example also demonstrates the difficulty of building classifications and definitions. Let us try a reconstruction bearing these considerations in mind.

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[18] The definition of a factor of production 'is that it should make a contribution to production, in the sense that if it were removed, production (or output) would be diminished. Or more usefully, if a part of it were to be removed, production would be diminished ' in J.R. Hicks, *Classics and Moderns*, Vol. 3 (Oxford, 1983), pp. 121-122.

[19] Ibid., parenthesis added.

b) A Personal Attempt

As seen above, one could argue that cultivated land is a produced asset; an oil barrel unsold during the previous year would also be a produced asset. If we base our distinction on the fact of human intervention in produced assets, it would transform all non-produced economic assets into produced assets. However, it could be said that a produced asset goes through several transformations led by human intervention. Then, non-produced assets would be those which suffer very few (if any) transformations by the human hand. Of course, it is still a very open definition, as 'several' and 'very few' transformations remain a matter of subjective appreciation. Nevertheless, it makes the point a bit clearer.

Once within the non-produced assets category, the next step is to differentiate between those that have a direct economic role and the others. Given the two possibilities above, the most manageable seems to be that presented by UNSTAT. It gives two clear criteria to decide what constitutes a non-produced economic asset and what does not. On the one hand, property rights exist and are enforceable over the asset. On the other hand is the issue of benefits to the owner. Let us qualify this second condition, substituting 'benefits' by an 'actual profitable use of the asset at a given point in time'. Hence, the definition of a non-produced economic asset would be a non-produced asset for which property rights and an actual profitable use exist and are enforced at a given point in time. Both must hold simultaneously to apply the definition. By exclusion, the assets that do not satisfy either or both characteristics are non-produced environmental assets. The various implications of this definition will be developed later.

At this point, we have exactly the same degree of disaggregation as the previous two classifications. A further categorisation will divide assets among renewable, restorable and exhaustible. Renewable assets can be re-established in their quality and quantity. Restorable assets can be restored in quality but not in quantity. Exhaustible assets cannot be recovered in quality or quantity once they had been used up. All non-produced assets are suitable for one of the three classes. They are mutually exclusive for individual assets. Nevertheless, they are not absolute categories. Assets can easily change class over time. One can consider the exceptional case where the degradation of a renewable or a restorable resource is no longer recoverable at any price. In such a case, it would turn into an exhaustible asset. Some examples of the different categories are provided in Table 2.1-2.

Table 2.1-2: Specific classification of non-produced assets

PRODUCED	NON-PRODUCED	
Buildings Machinery	ENVIRONMENTAL	ECONOMIC
	RENEWABLE (biota...)	RENEWABLE (commercial forest, fisheries..)
	RESTORABLE (air, water, soil...)	RESTORABLE (certain types of water and soil...)
	EXHAUSTIBLE (mineral and fuel reserves)	EXHAUSTIBLE (commercialised fuels, minerals...)

Source: Own elaboration

Although it might look unimportant, this further step makes an enormous difference when considering the economic characteristics of different non-produced assets. The next section will show this by focusing on the implication of the definitions given when trying to take non-produced assets as economic goods. It will emphasise the analysis of non-produced economic exhaustible assets.

Non-produced Economic Exhaustible Assets

By combining all the definitions above, the definition of non-produced economic exhaustible resources would be:

> An asset which suffers very little (if any) transformation by human intervention, for which property rights and an actual economic profitable use exist and are enforced at a given point in time and which cannot be restored in quality or quantity once it is used.

In relation to Figure 2.1-1, we are only considering a small part of the *input*s flow. Each of the three components of this definition adds some information to the economic treatment one should give exhaustible resources. The small degree of transformation by human intervention tells us something about added values. With little or no transformation, little or no added value is generated. This could be noteworthy when dealing with National Accounts, where added value is precisely what is supposed to be measured.

Some of the most important implications come from the 'economic' definition. First, assets will change category -from environmental to economic and vice versa- over time as property rights and profitable uses appear and disappear. Natural gas was non-economic for a long period of time, with existing property rights but no profitable use. Second, the classification is based on the actual legal and economic status of the assets and not on the nature of the asset itself. This means that not all oil is per se a non-produced economic asset. Assets will change category depending on location. Antarctica's oil will not constitute an economic asset, for it lacks profitable economic use. Some types of soil will have developed property rights and profitable uses, but not others, and so on. In addition, this also reflects the possibility of economic exhaustion of the assets, which turns to be more important than the actual physical exhaustion. Think for instance of the Chilean guano that ceased to have a profitable use when artificial fertilisers become available at the beginning of the twentieth century.

The third component of the definition has some other important implications. In principle, exhaustible assets can only be treated as a stock of goods since receipts from selling minerals, gas or oil cannot be used to recreate them. El Serafy argues that the concept of depreciation, commonly related to capital, cannot apply to assets that cannot be replaced.[20] Indeed El Serafy, treats sales of exhaustible natural assets as sales out of stock and not as production that would account as value added, which they are not.[21] On the contrary, renewable resources can be considered as capital. 'Resource exploitation, particularly if the resource is eventually restored, could then be viewed as a means of 'borrowing' capital when perfect capital markets do not exist. In such a circumstance, exploitation of resources may in fact prove a prudent long-term development strategy'.[22] In response to El Serafy's argument it is sufficient to say that no man-made capital is expected to be restored and replaced to its exact original form. In addition, we have just seen that exhaustible resources have the capacity to become obsolete. Yet capital goods have a different economic treatment from that which is accorded for sales from stocks in National Accounts. This issue reappears in the next section as well as in later chapters.

This section has demonstrated the need for broader specification and economic definition of natural assets. Since the problem we attempt to measure, i.e. the illusion of progress derived from traditional growth measures, is more relevant to countries where non-renewable resources are being run down we shall concentrate on the estimation of the environmental adjustments needed for the depletion of a specific non-produced economic exhaustible resource, namely oil.

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[20] Quoted from P. Vaze, 'Environmental Accounts- Valuing the Depletion of Oil and Gas Reserves', *Economic Trends* (1996, April) 510, p.37.
[21] S. El Serafy, 'The Environment as Capital', in Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993), p. 20.
[22] C.W. Sadoff, 'Natural Resource Accounting: A Case Study Of Thailand Forest Management' (DPhil dissertation, University of California, 1993).

2.2 Three Ways of Accounting for Environment

National accounting is by no means an exact science. Therefore, nations should not expect to measure either their income or their wealth precisely; their objective should be to approximate these as closely as possible using clear, widely accepted methods that are applicable in a wide array of circumstances.[23]

National accounts have provided the most widely used indicators for the assessment of economic performance, trends of economic growth, and the economic counterpart of social welfare. These economic indicators, and national accounts generally, have been criticised from three inter-related perspectives: their shortcomings as welfare indicators, their inability to assess the sustainability of the current development path, and their inadequacy as a measure of true economic activity. Having recognised these three problems, scholars have attempted to generate alternative indicators or to adjust the national accounts to measure: welfare, sustainability and true economic activity.[24]

In relation to the environment, national accounts have neglected: (1) scarcities of natural resources that threaten the sustained productivity of the economy; (2) the degradation of environmental quality, mainly from pollution, and its consequences for human welfare. In addition, some expenditures for maintaining environmental quality are counted as increases in national income and product. Such outlays should be considered as a maintenance cost rather than final consumption.[25] The depletion of

[23] E. Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993).

[24] Although the first welfare-adjusted version of the national accounting system (that of W.D. Nordhaus and J. Tobin, *Economic Growth and Declining Social Welfare* (New York, 1972)) did not include environmental aspects, these were progressively added to welfare adjustments to traditional economic indicators. See for example: X. Zolotas, *Economic Growth and Declining Social Welfare* (Athens, 1981), H.E. Daly and J.B. Cobb, *For the Common Good* (London, 1990)and T. Jackson and N. Marks, *Measuring Sustainable Economic Welfare. A pilot index: 1950-1990* (Stockholm, 1994). Sustainable development has been examined, among other economists, by P. Dasgupta and G. Heal, 'The Optimal Depletion of Exhaustible Resources', *Review of Economic Studies. Symposium on the Economics of Exhaustible Resources* (1974), R.M. Solow, 'The Economics of Resources or the Resources of Economics', *The American Economic Review* 64 (1974) 2; R.M. Solow, ' Intergenerational Equity and Exhaustible Resources', *Review of Economic Studies* (1974); J. Stiglitz, 'Growth with exhaustible natural resources: efficient and optimal growth paths', *Review of Economic Studies. Symposium on The Economics of Exhaustible Resources* (1974) 41 and J.M. Hartwick and R. Lindsey, *NNP and Economic Depreciation of Exhaustible Resource Stocks* (Ontario, 1989) .For the shortcomings of the system of national accounts as a measure of true economic activity see for example R. Eisner, 'Extended Accounts for National Income and Product', *Journal of Economic Literature* XXVI (1988) and C.W Cobb. and J.B.J. Cobb, *The Green National Product: a proposed Index of Sustainable Economic Welfare* (New York, 1994).

[25] P. Bartelmus, E. Lutz and J. van Tongeren, 'Environmental Accounting: an operational perspective', in Serageldin and Steer (eds.), *Valuing The Environment: proceedings of the First Annual International Conference On Environmentally Sustainable Development held at the World Bank, September 30-October 1, 1993* (Washington D.C., 1993).

non-renewable resources has been considered both from the sustainability and true economic activity perspectives.[26]

The Environmental Accounting Workshops have struggled with the complex methodological issues of how various heterogeneous environmental data should be selected, organised, aggregated, and incorporated into or linked with the information provided by the System of National Accounts (SNA).[27] There are at least three ways of approaching the integration of natural resources with traditional economic indicators. These are: direct inclusion into the SNA, the development of separate Satellite Environmental Accounts (SEA), and a more sophisticated attempt in terms of the System of Integrated Environmental and Economic Accounting (SEEA). The three attempts respond to different conceptions and to different aims when accounting for natural resources. This section will describe them very briefly. In addition, it will survey what has been empirically done so far within each approach. The main aim is to ponder the tractability, usefulness and coherence of each of the alternatives -National Accounts, Satellite Accounts and Integrated Accounts- with regard to our objective of taking account of resource depletion in measures of economic growth in an historical perspective.

The System of National Accounts

The System of National Accounts (SNA) traces both the activities related to the production and disposition of goods and services and the associated income flows.[28] In other words, it merely assesses the implications of past behaviour for profits or income, thus providing a measurement of performance and therefore indicating net worth. Traditional economic indicators like the Gross Domestic Product (GDP), the National Income and other macroeconomic variables related to the national accounting system were designed as tools for economic analysis and an aid for conducting economic policy. On the basis of the accounts, individuals, entrepreneurs and

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[26] The welfare objection does not generally account for the depletion of natural resources as such although it eventually acknowledges the indirect effects of pollution and externalities caused by the depletion and use of non-renewable resources. The most notable exception is the Index of Sustainable and Economic Welfare (ISEW) proposed in C.W. Cobb and J.B.J. Cobb, *The Green National Product: a proposed Index of Sustainable Economic Welfare* (New York, 1994). Their introduction provides great detail on previous welfare adjustments to GNP.

[27] R.B. Norgaard, 'Linkages between Environmental and National Income Accounts', in Ahmad, Serafy and Lutz. (eds.), *Environmental accounting for sustainable development : a UNEP-World Bank symposium* (Washington, D.C., 1989), p.54.

[28] A. Harrison, 'Natural Assets and National Accounting', in Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C, 1993),p.22.

governments can make decisions about the future, relying also on many other factors, including their expectations.[29] In a broader sense GDP has almost literally been seen as a measure of national success.[30]

In theory, the GDP can be estimated in three different ways:[31]

(1) The income approach, which is total income earned from the production of goods and services.

(2) The output method, which is the sum of value added by activities that produce goods and services.

(3) The expenditure method, which is the sum of the total expenditure on all finished good and services, work in progress, and stocks, less the cost of imports.

Figure 2.2-1 summarises the three approaches. In practice, only two methods are generally by national statistics offices.[32] These can be valued at market prices or at factor cost. The valuation at market prices is the actual price paid for the output of an industry. The valuation at factor cost refers to the three factors of production: labour, capital and land. Hence, in theory, it consists of wages, profits and rents. It will generally result in a smaller GDP than that obtained at market prices, because it is measured after the payment of taxes on expenditure and the receipt of subsidies.

However, as firms buy large amounts of fuel, materials and services from one another, simply adding gross outputs would result in double, or multiple, counting of output. Double counting is avoided by subtracting purchased inputs from gross output to get value added for each enterprise. The national product is total value added.[33] At the firm level value added is the value of the firm's output minus the value of the inputs it purchases from other firms. Essentially it is the sum of the factor incomes: the wages and profits of the firm.[34]

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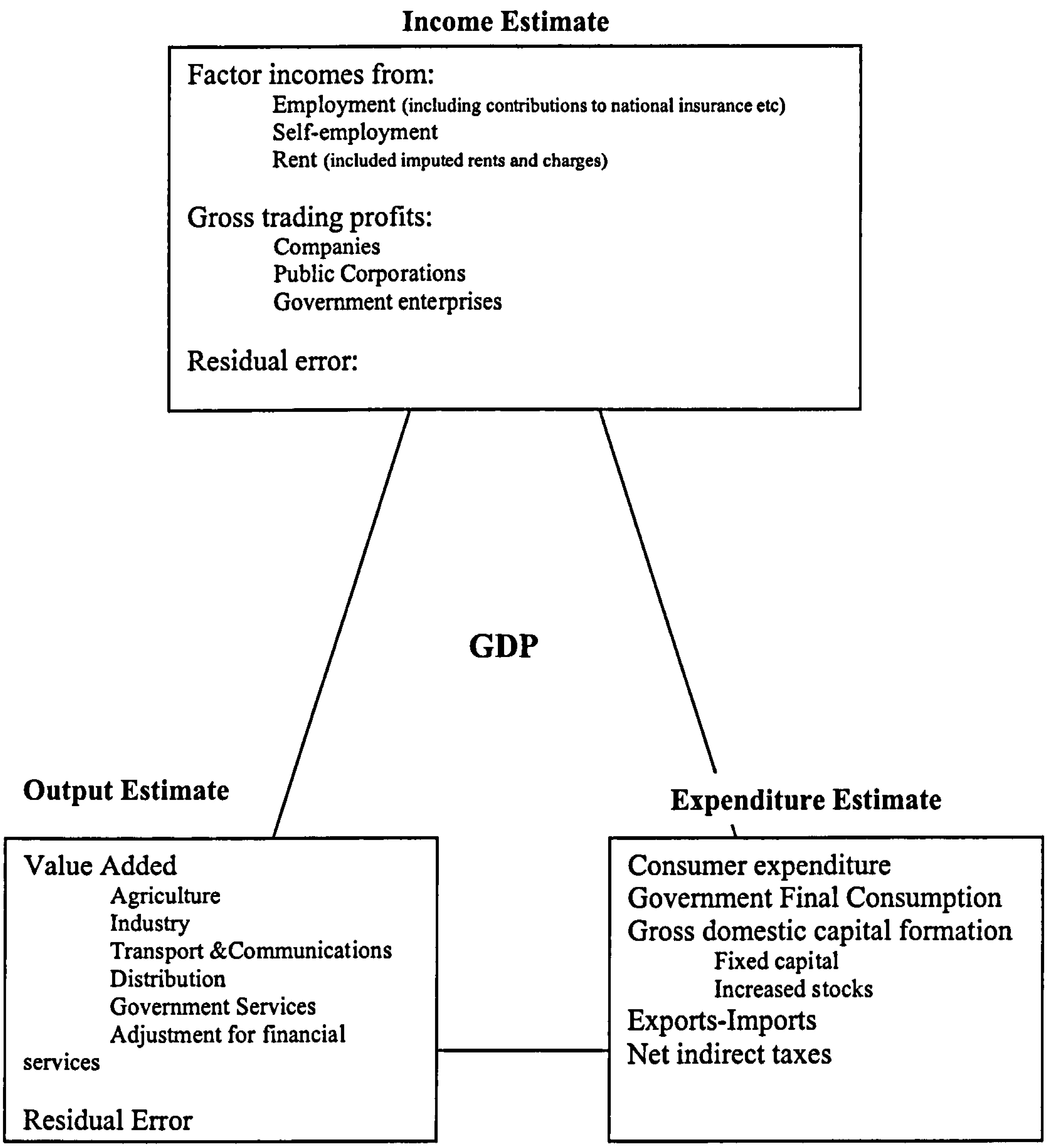
[29] S. El Serafy, 'The Environment as Capital', in Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993), p.19.
[30] M. Lindmark, 'Some principles for Environmental Historical National Accounting. A discussion paper', in *Nordiska Historiska Nationalräkenskaper- Workshop 2 in Jyväskylän Yliopsto Historian Laitos. Suomen Historian Julkaisuja 25* (Järvenpää, 1997), p.58.
[31] P. Vaze and S. Balchin, 'The Pilot United Kingdom Environmental Accounts', in *Economic Trends* (1996), p. 45.
[32] Thanks to M.Weale for pointing to me that only two estimates of GDP are actually calculated.
[33] J. Black, *A dictionary of economics* (Oxford, 1997).
[34] D.W. Pearce (ed.), *The MIT dictionary of modern economics* (Boston, 1992).

Figure 2.2-1: Three estimates of Gross Domestic Product



Source: R.G.D. Allen, *An Introduction to National Account Statistics*, (1980), p. 28.

The gross measures of the national accounting system provide an insight into the performance of the economy but for understanding where the economy is heading to, the use of net measures is needed. The basic reasoning for the use of net measures is that the GDP of the year is not very effective at identifying whether a nation is building up its capital or living off its capital. 'A part of the year's consumption may be supported by drawing on stocks of goods held by business firms at the start of the year, wearing out machines and plant, and using up natural resources. A nation thus living on its capital has a current consumption larger than its national income.' [35] Apart from war, such a situation has been historically perceived as unusual, but only because - environmental accounting argues- the use of natural resources has been ignored in national accounts so far.

The Hicksian definition of income is 'the largest permanently maintainable level of consumption sustained on those receipts that are not derived at the expense of declining capital.'[36] At the national level, this concept is approximated by the net income measures (NDP and NNP). Net income is derived from the GDP by two main adjustments. First, net property income from abroad has to be added as national income, and transfers of income abroad by residents of other countries should be subtracted. This transforms the 'domestic' into 'national' product (GNP). Second, to pass from 'gross' to 'net', consumption of fixed capital has to be subtracted. The consumption of fixed capital accounts for the part of the capital base that is used up in generating the output in the current period and therefore, should be replaced in order to be available to sustain production in the next period. This adjustment is central to the arguments of environmental accounting as shown below in Section 2.3.

Based on the Hicksian definition, the net income has been identified as the best proxy to the level of sustainable income of an economy. Nevertheless, some caveats are needed. At a high level of abstraction and under certain restrictive assumptions, it can be shown that the theoretical concept of NNP is indeed income in the sense that Hicks employed.[37] Nevertheless, the practical application of this criterion at the national level

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[35] C.S. Shoup, *Principles of National Income Analysis* (Cambridge, MA, 1947), p.10

[36] T.M. Crowards, 'Natural Resource Accounting: A Case Study of Zimbabwe', *Environmental and Resource Economics* 7 (1996), p.214. For the original definition of income see Chapter 14 in J.R. Hicks, *Value and Capital: An inquiry into some Fundamental Principles of Economic Theory* (Oxford, UK, 2nd ed., 1946).

[37] See, M.L. Weitzman, 'On the Welfare Significance of National Product in Dynamic Economy', *Quarterly Journal of Economics* 90 (1976) 1.

has been criticised.[38] 'It should be pointed out that there is a fundamental difference between the abstract concept of NNP and the actual practice. The former requires 'shadow' or accounting prices derived from inter- and intratemporal optimisation models that accurately reflect economic scarcity. The later measures market or transaction prices, which is appropriate for economic management. If NNP were calculated on the basis of shadow prices, it would be a better measure of Hicksian income. The two would only converge in a highly idealised economy -perfect competition, no policy-induced distortions (e.g. taxes), perfect knowledge and foresight and so forth'.[39] According to Sefton and Weale, 'the two are only equal if the country actually follows a constant consumption path.'[40] Notwithstanding these caveats, the net income at market prices is, in practice, the best approximation to the level of income that we can consider sustainable. In addition Weitzman demonstrated that the net income at market prices 'is the 'annuity equivalent' or 'stationary equivalent' [of future consumption] or ... a proxy for money-metricised welfare'.[41] In brief, the net income provides information about a country's long-run economic possibilities.

The environmental accounting literature argues that since the traditional system of national accounting (SNA) ignores the use of natural resources, national accounts produce misleading signs about the prospects of the economy. A priory, given the definitions in the SNA, it seems impossible to include environmental assets within this framework. The environment does not have money values ascribed to it. After all, it consists of non-produced assets and hence is outside the production boundary considered by the SNA. Yet this is just a problem of considering 'the environment' as a whole. It would be quite infeasible to account for 'all' the physical surroundings, conditions, circumstances, etc. in which a person lives (the dictionary definition of environment) either within the SNA or within any other system.

The situation changes when, if instead of considering the whole environment, we take

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[38] Hicks himself acknowledged its difficulties: ' by considering the approximations to this criterion, we have come to see how very complex it is, how unattractive it looks when subjected to detailed analysis. We may allow a doubt to escape us whether it does, in the last resort, stand up to analysis at all, whether we have not been chasing a will-o'-the-wisp', Hicks, *Value and Capital: An inquiry into some Fundamental Principles of Economic Theory*, p. 176.

[39] C.S. Pearson, *Measuring Sustainable Development* (Cambridge, UK, 1st. ed., 2000), p.488.

[40] J.A. Sefton, and M.R. Weale, 'The net national product and exhaustible resources: The effects of foreign trade', *Journal of Public Economics* 61 (1996), p.28. They also state that 'if the production frontier is concave, then the actual market value of output will always be higher than sustainable output or consumption' (p.29, fn.5).

[41] M.L. Weitzman, 'The linearised Hamiltonian as comprehensive NDP', *Environment and Development Economics* (2000) 5, p.59

a deeper view of it and classify its different items according to their economic characteristics. Take our definition of exhaustible economic non-produced assets from the previous section. Among the characteristics attributed to exhaustible economic non-produced assets, was that they have an actual profitable use to their owners. Hence, an associated income flow exists. This economic rent contributes to national accounts in the form of wages, return to capital invested, taxes paid to government and other forms of rent appropriation. Though the rent appears in the GDP, no allowance is made for the fact that the assets base is being liquidated in order to generate this income. So at least a part of the environment is already included into the system, albeit probably in an inaccurate way.

There are several works that try to include the depletion of exhaustible resources within the SNA. El Serafy's attempt using Saudi Arabia's oil data is probably the most significant. [42] His methodology, the user cost method, is presented later in the chapter and tested empirically in Chapter 5. For its part, OPEC commissioned a study in 1984 in order to promote further research into the question of measurement of oil or mineral-derived income.[43] Stauffer started from the same conviction that the GDP of oil exporting states is exaggerated, because some of their 'income' is due to the consumption of depletable oil resources and hence is the liquidation of capital, not income. He constructed two adjustments to the GDP, naming them 'non-depletable' GDP and 'oil-independent' GDP. The former is a static measure in which the economic rents from oil have been debited against the total GDP. According to him, this is the value that allows comparison most closely with the GDP reported by states not dependent upon the exploitation of exhaustible resources. The 'oil-independent' GDP is the net result after subtracting the multiplier impacts of those mineral rents. Stauffer's calculations included Kuwait, Nigeria, Norway, Saudi Arabia, the United States and Venezuela for a period ranging from the early 1970s to 1980, constrained by data availability in some countries. For Venezuela, his adjustment is equal to about one-half of the reported GDP, so that the non-depletable GDP lies between 50 percent and 62 percent of the nominal figure. Despite being an extremely interesting work and providing a comprehensive survey of the theoretical framework and methods of evaluation, Stauffer's work is not an historical study. Baptista and Mommer have made

[42] S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy and Lutz (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989).
[43] R. Stauffer, *Accounting for "Wasting Assets". Income Measurement for Oil and Mineral-Exporting Rentier States*, Vol. 25 (Vienna, 1984).

a slightly different attempt for the Venezuelan economy.[44] They focused on the difference between oil as a *productive activity* and oil as a *non-productive activity.* Non-productive stands for the ground rent gained by Venezuela due to the mere ownership of oil. This can be thought of as a rental paid by the importer to the exporter for the use of the resource. They suggest that non-productive oil profits should not be included in GDP, and subsequently calculated a GDP that excluded the rent. They called this measure 'non-rent GDP'. On the view of Baptista and Mommer, only exported oil generates rents, regardless of the level of internal prices for oil. In their reasoning 'oil reservoirs are public property, [Venezuelan consumers] will never pay for the natural resource [...] the income that would be generated by increasing domestic energy prices to international market levels must be considered taxes, not rent'.[45] Other authors have also expressed this idea of 'international ground rent payment' and the need of taking into account the effects of the terms of trade in resource exporting countries.[46] The methodological section of this chapter analyses the theoretical model put forward by Sefton and Weale in this regard.[47]

The crucial difference between these last two studies and the ones carried from the environmental perspective is that for environmentalist the depletion is the important fact regardless of who is producing and who is consuming the resource. The common theme of all of them is the adjustment of the traditional income measures, although they diverged greatly in their approach and the methods for calculating the adjustment. Section 2.3 will investigate further the divergences and similarities of approaches and methodologies just outlined here.

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[44] There are various works in which Baptista and Mommer develop this idea. The best summary and empirical work is B. Mommer and A. Baptista, 'El Petróleo En Las Cuentas Nacionales: Una Proposicón', *Working Paper IESA* 10 (1983). See also A., Baptista, 'Integrar el petróleo: fundamentos para una nueva política petrolera', in *Ideas sobre el porvenir de Venezuela* (Caracas, 1993); A., Baptista, *Teoría Económica del Capitalismo Rentístico. Economia, petróleo y renta* (Caracas, 1997) and B., Mommer, ' Integrating the oil. A structural analysis of petroleum in the Venezuelan economy', *Latin American Perspectives* 23 (1996 summer) 90.

[45] B. Mommer, ' Integrating the oil. A structural analysis of petroleum in the Venezuelan economy', *Latin American Perspectives* 23 (1996 summer) 90, p.147.

[46] See M. R. Weale, 'Environmental Statistics and the National Accounts', in Dasgupta, P. and K.G. Mäler (eds.), *The Environment and Emerging Development Issues*, Studies in Development Economics, edited by UNU/WIDER, Vol. I (Oxford, 1997), p.100.

[47] J.A. Sefton and M.R. Weale, 'The net national product and exhaustible resources: The effects of foreign trade', *Journal of Public Economics* 61 (1996).

Satellite Environmental Accounts

An attempt to solve the apparent incapacity of SNA to include environmental issues was the creation of a system of Satellite Environmental Accounts (SEA). It has become an increasingly popular way of developing new aspects of economic and social accounting, because it is flexible and permits experimental innovations to be introduced while preserving the basic system intact for a more conventional analysis.

Environmental Accounts are central to assessing the relationship between the economy and the environment. The SEA aim to provide information, by industry and for the economy as a whole, on the way in which economic development affects the environment in an objective, comprehensible and systematic form.[48]

Therefore, SEA have a complementary role in relation to the SNA. The SNA will keep us informed about the evolution of our product and income and the SEA will tell us how our 'welfare' evolves (understanding that 'welfare' stands here for a certain level of environmental quality). It is important to note that, in practice, SEA just account for those parts of the environment directly related with economic activity; either as a source of raw materials or as a recipient of wastes (that is, the shadowed area in Figure 2.1-1 above). The SEA mainly account for changes in volume of non-produced economic assets, degradation of non-produced economic assets reflected in market values of assets and it separates environmental protection expenditures from the SNA. Given that is not possible to find widely agreed prices for environmental damage, implementations of SEA often use a mixture of monetary and physical units (for instance metric tons of CO_2).

On the empirical side, this approach seems particularly well suited to the interests of national statistics offices. At least two empirical attempts can be cited here, though neither relates to our case studies. One is the pilot United Kingdom Environmental Accounts (UKENA) by the Office for National Statistics (ONS). They present atmospheric emissions disaggregated by households and industries, data on depletion and stocks of oil and gas reserves and estimates of environmental expenditure by industry. A combined input-output matrix accompanies the accounts.[49] UKENA data

[48] Vaze and Balchin, 'The Pilot United Kingdom Environmental Accounts', p.41.
[49] Ibid. for a complete description of UKENA.

relate to 1993. The other empirical attempt along these lines is by the Institut National de la Statistique et des Etudes Economiques (INSEE).[50]

As for our concern about adjusting the measures of economic performance, the SEA is not intended to help us. It can be said that the aim of SEA is to keep us informed of the situation of the environment, without losing sight of traditional economic measures through concerns over environmental issues. In the view of the ONS, 'values placed upon environmental damage are, to a degree, subjective. The ONS thinks it would be confusing to present such numbers along side data from the core accounts'.[51]

Integrated Environmental Accounts

The SEA describe the first step towards accounting for the environment by generating environmental detail separately, without changing SNA concepts and procedures. For more comprehensive environmental-economic analysis, modifications in the SNA are required. This further step is known as the System of Integrated Environmental and Economic Accounting (SEEA).[52] The two basic modifications to the traditional SNA are: (1) considering volume changes of environmental assets as costs to the production/income accounts, and (2) to cover previously ignored non-produced environmental assets, by replacing SNA's market valuation by a maintenance-cost valuation. As a consequence of these valuations, alternative green indicators of value added, net domestic product (NDP), and capital formation can be calculated.[53] This is an ambitious programme, for its aim is to incorporate the whole 'environment' into the traditional measures of economic performance. Figure 2.2-2 shows the position of the different additions to and modifications of conventional economic accounts in the overall framework of the SEEA.

[50] Institut National de la Statistique et des Etudes Economiques, *Les Comptes Satellites de l'Environment, Méthodes et Résultats* (Paris, 1996).
[51] Vaze and Balchin, 'The Pilot United Kingdom Environmental Accounts', p.47.
[52] United Nations, *Integrated Environmental and Economic Accounting*, Vol. XVII (New York, 1993) United Nations, *Integrated Environmental and Economic Accounting: An operational Manual.* (New York, 2000).
[53] The bulk of this section comes from Bartelmus, Lutz and van Tongeren, 'Environmental Accounting: an operational perspective'.

Figure 2.2-2: Framework for integrated environmental and economic accounting

			Asset balances by type of assets		
			Produced assets (including natural assets)	Non-produced assets	
				'Economic assets'	'Environmental assets'
Supply and use tables			Opening stocks of produced assets	**Opening stocks of non-produced economic assets**	Opening stocks (physical assets only)
Output	Imports				
Output for environmental protection	Imports of environmental protection goods and services				
Intermediate consumption	Exports	Final consumption	Gross capital formation	Gross capital formation (for land only)	
Intermediate consumption for environmental protection	Exports for environmental protection	Final consumption of environmental protection goods and services	Gross capital formation for environmental protection	Gross capital formation for environmental protection (for land only)	
Gross domestic product					
Consumption of fixed capital			Consumption of fixed capital		
Consumption of fixed capital used for environmental protection			Consumption of fixed capital used for environmental protection		
Net Domestic Product					
Compensation to employees					
Operating surplus					
Taxes on production less subsidies					
Environmental charges and subsidies					
Depletion of non-produced assets				**Depletion of non-produced asses (except for land)**	Depletion on non-produced 'environmental' assets
Degradation of non-produced assets		Degradation of non-produced assets		Degradation of non-produced assets (for land)	Degradation of non-produced 'environmental' assets
Environmentally adjusted net domestic product					
Factor incomes and current transfer paid to less received from abroad	Factor incomes and current transfer paid to less received from abroad			**Other accumulation**	Other accumulation
Net Disposable Income	Current external balance		Other volume changes for produced assets	**Other volume changes for non-produced assets**	Other volume changes
External use of natural assets less national use of external natural assets			Revaluation	Revaluation	
Environmentally adjusted net disposable income			Closing stocks for produced assets	**Closing stocks for non-produced assets**	Closing stocks (physical assets only)

Source: A.Alfierei, and P. Bartelmus, 'Implementation of environmental accounting: towards an operational manual', in Uno, K. and P. Bartelmus (eds.), *Environmental Accounting in Theory and Practice*, Economy and Environment, Vol. 11 (London, 1998), p.17.

Along these lines is the pilot project presented by Van Togeren et al.[54] The work of Van Togeren et al. was originally published as Environment Working Paper of the United Nations (N.50) in 1991 and has been cited in several other publications as one of the first attempts to include the environment in traditional measures of economic performance.[55] This final version is included in a volume edited by Lutz, which constituted one of the early efforts to establish a common framework for the integration of the environment in national accounts.

Van Togeren et al. focused on three environmental problems facing Mexico: oil depletion, soil degradation and air and water pollution. They started by classifying 'environmental assets' and split them into 'economic' and 'non-economic', which in the end is no more than a division between those that have a market price and those that do not. Given the topic of this thesis, this brief review focuses on the way that the study treated oil depletion, leaving the other issues aside. Nevertheless, some of the criticisms of the paper apply to the whole of its underlying assumptions and not specifically to the treatment of oil depletion.

Van Togeren et al argue that that oil depletion matters because it implies the quantitative exhaustion of a natural resource that is an important source of revenue for the economy. The traditional economic aggregates do not make any allowance for depletion of natural capital as they do for the depreciation of man-made capital. This practice, they argue, affects the future income-generating capacity of the economy. In other words, traditional economic analysis treats oil resources as free goods. Their classification of 'environmental assets' treats oil as 'capital' by drawing an analogy between natural resources and man-made capital. Hence, in their view new discoveries are regarded as capital accumulation and oil depletion is subtracted from NDP, as it would be done with man-made capital depreciation. On the empirical side, Van Togeren et al. used official data from Pemex for the year 1985. The Environmentally Adjusted Net Domestic Product represents 86% of the traditional GDP. 'Yet more needs to be done both in terms of further applied works as well as in term of conceptual work'.[56]

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[54] J. Van Tongeren, S. Schweinfest, E. Lutz, et al., 'Integrated Environmental and Economic Accounting: A Case Study for Mexico', in Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993).

[55] See for example C. Bryant and P. Cook, 'Environmental issues and the national accounts', *Economic trends* (1992 Nov) 469 and Bartelmus, Lutz and van Tongeren, 'Environmental Accounting: an operational perspective'.

[56] Ismail Seragelding, Vice-president, Environmentally Sustainable Development, in the foreword to E. Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993).

The main purpose of Van Togeren's study was to apply SEEA methods in a country at a relatively early stage of industrial development, where actual environmental problems were still limited. At the same time, limited statistical and accounting capacities in the country provided a test of the feasibility of attempting to estimate SEEA with constrained resources. Van Togeren et al. also attempted the accounting of subsoil assets such as copper, gold, and silver for the years 1986-90. These studies demonstrated the feasibility as well as the difficulties and limitations of such accounting. Among the latter, the most important are the many significant data gaps that had to be bridged by numerous assumptions and rough estimates.

Further Observations

We have seen so far three ways of accounting for natural resources. Their different aims can be identified within the framework provided by Figure 2.1-1. The SNA only accounts for the *input* flow. The SEA accounts for the *input* to the economic process and the *outflow* of pollution and waste going back *into* the environment. Finally, the SEEA tries to account for all the flows represented in the diagram. With regard to including historical resource depletion in measures of economic performance, it seems that only direct inclusion in the SNA or a restricted use of the SEEA can be of help. Restricted because in the SEEA framework presented in Figure 2.2-1 this research can only contribute to the few boxes highlighted in the figure (depletion of non-produced assets, opening and closing stocks of non-produced economic assets) and therefore can produce only a partially environmentally adjusted NDP. For its part, the SEA does not have any aim of 'inclusion', for it only sets the environmental accounting aside.

However, a second problem appears when moving a step closer towards empirical application. It is whether depletion should be subtracted from GDP or NDP. Let us remember that the direct inclusion into the SNA opts for the adjustment of GDP, whereas the SEEA prefers to correct NDP. Very briefly, the reasoning behind each choice is as follows. In the view of the United Nations and the World Bank (parents of the SEEA), all natural resources are assimilated to man-made capital. The NDP is GDP minus an allowance made for the deterioration of man-made capital. Viewed this way, a depreciation allowance for the loss of natural capital ought to be subtracted only from NDP. Nevertheless, in traditional national income accounting, the reduction in the inventory in the current period of, say, autos produced but not sold in the previous accounting period shows up as a reduction in gross and net investment and hence is subtracted from GDP. Therefore, if one characterises exhaustible resources as 'stock' (inventory) rather than 'capital' (fixed assets), it would lead us the adjustment of GDP.[57] These distinctions are crucial for the calculations in Chapter 6.

The main aim of this section was to consider the usefulness and tractability of each of the alternatives -National Accounts (SNA), Satellite Accounts (SEA) and Integrated Accounts (SEEA)- with respect to our objective of including resource depletion in measures of economic performance in an historical perspective. Given the descriptions above, it is clear that, the SEA is not useful. It creates a parallel account system for the environment, but does not aim to include the environment as part of the economic indicators. For its part, the SEEA tractability is problematic in an historical perspective. Full implementation of the SEEA requires an enormous amount of data (e.g. air and water quality, lost of ecosystems, resource depletion, defensive expenditures). Most of these data would be difficult to obtain in historical series and it is even difficult to gather at present. Nevertheless, as El Serafy argued, 'let us adjust income gradually for degradation of petroleum, forestry and fisheries, water quality, soil erosion one at a time, until our methodologies firm up and the physical basis of our calculation improves'.[58] Therefore, the only approaches that seem to be simultaneously useful and tractable are direct adjustment of the traditional SNA and the partial completion of the entries corresponding to oil in the SEEA.

In any case, the discussion and testing of the different valuation methods is one of the contributions of the present research. The thesis contributes towards the improvement of both the SEA and the SEEA approaches that use the same evaluation methods. Some of the numbers generated in the process will, however, be useful in the future for those aiming to generate a complete set of satellite or integrated accounts. The theoretical discussion of the actual valuation methods used by the literature is in the final section of this chapter and its empirical evaluation takes place in Chapter 5.

[57] For a brief discussion on the debate over whether natural capital should be considered inventory or fixed asset see C.S., Pearson, *Measuring Sustainable Development* (Cambridge, UK, 1st ed., 2000), p.495-496.
[58] El Serafy, 'The Environment as Capital', p.19.

2.3 Approaches and Methods of Evaluation

Two distinct approaches concerning environmental degradation in relation to national income accounts derive from the previous section. While the sustainability approach emphasises the intergenerational justice and long term sustained economic growth, the true economic activity approach stresses the generation of better measures of the current economic performance for mineral producers. Adjustments obtained from the first approach will result in a divergence from traditional NNP, whereas the second case will end up with a different from traditional GDP.[59] This section surveys the seemingly competing methods available for computing the values associated to resource depletion that will subsequently be used to adjust national income accounts. Since most environmental accounting exercises derive from the sustainability approach it constitutes the bulk of the section, although estimation methods from the competing approach are also reviewed in passing. For exposition purposes the section first defines the premises of the sustainability approach, then reviews the methods of estimation of natural capital depreciation and finally presents an indicator of sustainability that requires the use of such estimations.

Sustainability Approach

The premise of the sustainability approach is that since the extraction of any natural resource enriches the generation using it while reducing the quantity available to future generations, these could be compensated for this loss if investments were made to ensure the maintenance of the flow of goods and services. Such compensation (re-investment) is intended to guarantee sustainable development that in this context can be defined as no declining per-capita well being over time.[60] The literature has established that in order to achieve constant real consumption through time (the lower bound of sustainability) it is necessary to keep the underlying capital stock constant.[61]

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[59] The question of whether these two objections are complementary or substitutes is as yet unclear. In theory, the two adjustments advocate two different measures. The sustainability approach advocates for a 'reproducible' income measure and the true economic activity objection seeks for a 'non-depletable' income measure. Where 'reproducible' stands for the amount that is left for consumption after a reinvestment is done each year to maintain a given level of consumption and 'non-depletable' means the income that is derived from other sources than the ruin down of the resource. The nomenclature has been borrowed from R. Stauffer, *Accounting for "Wasting Assets". Income Measurement for Oil and Mineral-Exporting Rentier States*, Vol. 25 (Vienna, 1984), p.13.

[60] C.S. Pearson, *Measuring Sustainable Development* (Cambridge, UK, 1st ed., 2000), p.474. Alternative approaches to sustainable income can be found in W.D. Nordhaus, 'How Should We Measure Sustainable Income?', *Cowles Foundation Discussion Papers* 1101 (1995).

[61] This is the line of analysis set by J.R. Hicks, *Value and Capital: An inquiry into some Fundamental Principles of Economic Theory* (Oxford, UK, 2nd ed., 1946); J. Hartwick, 'Intergenerational Equity and

The implication in relation to national income accounts is that the cost associated with depleting the natural resource is conceptually equivalent to the consumption of fixed capital that is discounted for transforming gross into net measures.[62] The traditionally computed NDP does not account for the depreciation of natural capital, and therefore, it can no longer be considered a good approximation to income in the Hicksian sense. The question being debated among those practising natural resource accounting is how to measure that cost of depleting natural resource capital.[63] The starting point is the concept of depreciation.

Methods of evaluation

The selling price of an asset, where competition exists, should be equal to the value of the asset, V. The market rate of interest is i. So if the asset is sold and the proceeds are 'banked', the 'profit' or return after a period elapsed is $iV_t/(1+i)$.[64]

The alternative to selling the asset is to keep the asset for a period. The benefits of owning a capital asset for a period is composed of two items; first, N_t, the per period rent earned by using that asset, and second, the capital gain or loss incurred when the asset is sold at the end of the period, $V_{t+1}- V_t$. In equilibrium, the benefits of selling the

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the Investing of Rents from Exhaustible Resources', *American Economic Review* 67 (1977) 5 and R. Solow, 'On the intergenerational allocation of natural resources', *Scandinavian Journal of Economics* (1986) 88 and it is the line followed by the U.N. System of National accounts.
According to the weak sustainability criterion, the particular mix of resources in the stock does not need to be maintained and sustainability could be accomplished through investment in new capital. Under strong sustainability, the maintenance of individual stocks is required. For support of the weak sustainability see R. Solow, 'On the intergenerational allocation of natural resources'. Strong sustainability criterion had been preferred by D. Pearce and others, *Blue Print For A Green Economy* (London, 1989). In relation to non-renewable resources, weak sustainability became more widely accepted since the only infinitely sustainable consumption level of non-renewable resources under the strong criterion is not to use the resource at all since it cannot be replaced.

[62] The United Nations manual of National Accounting describes no less than four methods for calculating the consumption of fixed capital, which represents the bulk of the discount from gross to net measures. United Nations, *System of National Accounts 1993* (New York, 1993), paragraph 6.188 and following. Strictly speaking depreciation and consumption of fixed capital do not refer to the same thing (the depreciation reported each year is set equal to a proportion --usually one tenth-- of the original costs of the capital goods while capital consumption in the present year is usually calculated as a proportion of the prevailing replacement cost), both terms plus 'depletion cost' are interchangeably used in the text For exact definitions of the terms see D. King, *An Introduction to National Income Accounting* (London, 1984), p. 12 and 31-32.

[63] G.D. Santoprieto, 'Alternative Methods for estimating resource rent and depletion costs: the case of Argentina's YPF', *Resources Policy* 24 (1998) 1 p.39. This work provides an excellent review of alternative methods proposed from the sustainability perspective. So does P. Vaze, 'Environmental Accounts- Valuing the Depletion of Oil and Gas Reserves', *Economic Trends* (1996, April) 510.

[64] This section derives from J. Hartwick and A. Hageman, 'Economic depreciation of mineral stocks and the contribution of El Serafy', in Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993), pp. 215-216. Herein we shall use the formulae in discrete time rather than continuous time. The practical difference is to use $iV/(1+i)$ rather than iV. Though it may be thought that in the real world extraction occurs in continuous time, accountants work with discrete periods, commonly years. Hartwick suggests that discrete time is a more accurate estimate of depreciation for the first period.

asset should equal the benefits of 'holding' the asset. Thus the fundamental assets equilibrium equation states:

$$iV_t/(1+i)=N_t+(V_{t+1}-V_t) \qquad [2.3\text{-}1]$$

Rearranging, the change in value of the asset during the period is

[2.3-2]

$$V_{t+1}-V_t=\left(\frac{i}{(1+i)}\right)V_t-N_t$$

The change in value of the asset should be equal to the difference between the receipts, N_t, and the true income. The general assumptions regarding mineral assets have a limited time horizon, and that the natural asset continues to be extracted at constant pace until exhausted generating a stream of rents. Under those assumptions the change in value can be identified with the natural asset depreciation, i.e. the decline in the value of the asset due to its depletion over time. This equation serves to frame several conceptually equivalent methods of computing depreciation. Here we show this is the case of the present value method, the net price method, the user cost method and the imputed income method.

The left-hand side of equation 2.3-2 suggests that depreciation could be calculated based on changes in observed market values for mines. In some cases, the reserves of natural assets and exploitation rights are marketed. However, in fact there have been very few publicly recorded sales of natural resources. [65] So the first problem is that V_t is not readily available. Nevertheless, even if market transactions of mineral reserves are rare to observe, we can estimate what would be the expected market price of such transaction. The market prices are supposed to reflect to a high degree the expected net returns from the exploitation of the resource since investors would base their decision of buying an asset on relative present values of future net income streams.[66] Therefore, the value, V_t, of a natural resource can be defined as the sum of the expected net revenue flows discounted at nominal or real interest rates i for the life n of the asset, that is its present value:[67]

[65] Santoprieto, 'Alternative Methods for estimating resource rent and depletion costs: the case of Argentina's YPF', p.40.

[66] A. Born, 'Development of Natural Resources Accounts: Physical and Monetary Accounts for Crude Oil And Natural Gas Reserves In Alberta, Canada', *Statistics Canada* (1992) 34.

[67] The appropriateness of using present valuation for valuing non-renewable resources has been contested by A.K. Dixit and R.S. Pindyck, *Investment under Uncertainty* (Princeton, 1992) and in J.L. Paddock, D.R. Siegel, et al., 'Option Valuation of Claims on Real Assets: the Case of Offshore Petroleum Leases', *The Quarterly Journal of Economics* 103 (1988) 3. The argument states that since oil

$$V_t = N_t + \frac{N_{t+1}}{(1+i)} + \frac{N_{t+2}}{(1+i)^2} + ... + \frac{N_{t+n}}{(1+i)^n} \qquad [2.3\text{-}3]$$

where N_t is defined as the gross revenue from the resource minus the costs of extraction, development and exploration, over the period n that represents the expected lifetime of the resource, R_t/q_t, that is the reserves to production ratio. The calculation of the change in the value of the asset becomes theoretically possible, but in order to become operational the present value needs assumptions regarding the behaviour of N_t in the future, which involves assumptions regarding extraction rates, prices, costs, etc.

At least one proposal has been made regarding the optimal behaviour of the rents generated by non-renewable resources. It is known as the Hotelling rent theory. [68] According to this theory, the price of a depletable resource includes two components: the production cost and the resource rent or depletion cost.[69] As a consequence the Hotelling rent is defined as the difference between the price of the resource and the marginal cost of extraction, that is $u=(p-mc)$.[70] The Hotelling rent reflects the unit value of the natural stock. Thus to optimise rents derived from the resource, increases in rent per unit due to increasing scarcity will be set equal to the rate of discount, or in other words the rate of change in rental will exactly match the rate of interest. This can be illustrated as follows:[71]

[2.3-4]

$$\frac{(u_{t+1} - u_t)}{u_t} = i$$

Since the rent per unit is assumed to rise annually by the rate of interest, expected future rents can be expressed as a function of present rental:

$$u_{t+1}=u_t(1+i); \quad u_{t+2}=u_t(1+i)^2; \ (.....); \quad u_{t+n}=u_t(1+i)^n \qquad [2.3\text{-}5]$$

price uncertainty is not completely diversifiable, the greater is the perceived volatility of oil prices, the larger would be the discount rate, and the smaller (greater) the estimated value of the undeveloped (depleted) reserve. However, this would underestimate the value of the reserve. The reason is that it ignores the flexibility that the owner has over when to actually develop the reserve, that is the reserve's option value. Also note that, because of this option value, the greater the volatility of oil prices is, the larger the value of the reserve is -just the opposite of what a standard present value calculation would tell us.

[68] H. Hotelling, 'The Economics of Exhaustible Resources', *Journal of Political Economy* 39 (1931) 2.

[69] Ibid, and also P. Dasgupta and G. Heal, *Economic Theory and Exhaustible Resources* (Cambridge, 1979).

[70] P. Bartelmus, E. Lutz, et al., 'Environmental Accounting: an operational perspective', in Serageldin and Steer (eds.), *Valuing The Environment: proceedings of the First Annual International Conference on Environmentally Sustainable Development held at the World Bank, September 30-October 1, 1993* (Washington D.C., 1993) Appendix 1, p.170.

[71] The algebraic manipulation that follows belongs to T.M. Crowards, 'Natural Resource Accounting: A Case Study of Zimbabwe', *Environmental and Resource Economics* 7 (1996), p.216-217.

Total annual rent in year *t* (N_t) is the product of the quantity extracted (q_t) and unit rent u_t in that year:

$$N_t = q_t u_t \qquad [2.3\text{-}6]$$

Substituting into equation 2.3-3 the value of the mine in year t can be expressed as:

$$V_t = q_t u_t + \frac{q_{t+1}u_t(1+i)}{(1+i)} + \frac{q_{t+2}u_t(1+i)^2}{(1+i)^2} + \ldots\ldots + \frac{q_{t+n}u_t(1+i)^n}{(1+i)^n} \qquad [2.3\text{-}7]$$

which simplifies to

$$V_t = (q_t + q_{t+1} + q_{t+2} + \ldots.. + q_{t+n})u_t \qquad [2.3\text{-}8]$$

Let us define Q as the total stock of resource in year t, i.e. the sum of all possible future quantities extracted. Then the value of the resource in a given year is Qu_t, which is known as the Hotelling Valuation Principle (HVP). The present value of the resource in the following year is then:

$$V_{t+1} = \frac{1}{(1+i)}(Q - q_t)u_{t+1} = (Q - q_t)u_t \qquad [2.3\text{-}9]$$

The depreciation is the loss in value due to the use of the asset during a given period, derived from V_t minus V_{t+1}, so that equation 2.3-2 simplifies to

$$V_t - V_{t+1} = Qu_t - (Q - q_t)u_t = q_t u_t = N_t \qquad [2.3\text{-}10]$$

Thus according to this simplification the depreciation of an asset can be calculated by estimating the total rent for the year, *Nt*, where $N_t=(p - mc)q_t$. Thus, thanks to the Hotelling rent theory, we can estimate the depreciation of the mineral assets without having to calculate the total value of the resource, just by using the rents generated in the current year. This method is known as the net price method.

The net price method was first used by Reppetto to estimate the depletion of Indonesian oil reserves, and has become one of the standard methods in environmental accounting.[72]The net price method is based upon the premise that total profit from resource extraction represents Hotelling rents (with normal profit regarded as necessary cost of extraction). A first problem is that this surplus may be composed of

[72] R. Repetto, *Wasting Assets: Natural Resources in the National Income Accounts* (Washington, D.C., 1989). Repetto advocated adding the discovery of new resources to the income in the year of discovery. This proposition is discussed in later chapters. Most users of this method, calculate the net price adjustment without treating new discoveries as income see for example, J. Van Tongeren, S. Schweinfest, et al., 'Integrated Environmental and Economic Accounting: A Case Study for Mexico', in Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993); US Department of Commerce, 'Accounting for mineral resources: issues and BEA's initial estimates', *Survey of current business* (1994, April).

several distinct types of rents in addition to the resource rent. These could include rents due to the differences in the costs of production, monopoly rents due to the exercise of market power in setting price, or ownership rents claimed by the owners of the resource in the form of royalties, surface taxes, etc. The assumption in the net price method that total profits reflect only Hotelling or scarcity rents implicitly assumes that marginal costs of extraction remain constant. Hartwick and Hageman show that when marginal costs are rising, total profits can be expected to overestimate Hotelling rents by including a proportion of rents derived from holding the assets (Ricardian rent).[73]

Given the difficulty of measuring marginal costs, empirical studies have used average cost of extraction as an approximation.[74] In fact, the most common way to calculate N_t has been to obtain the surplus revenue accruing to the owners of the resource after accounting for the contribution of labour and capital inputs.[75] This implies constant marginal costs. Given that marginal costs are expected to increase as the resource is depleted, the total rents calculated using average costs might overestimate the true value of Hotelling rent and therefore exaggerate asset depreciation.

There are some other possible distortions on the cost side of the formula that are mostly ignored by the literature. For instance, state-owned enterprises are likely to have higher production costs than firms operating in competitive markets.[76] This is relevant and recognised for Venezuelan PDVSA, Mexican PEMEX, recently privatised Argentinean YPF, etc. Higher costs mean lower value of the rent, and the subsequent underestimation of the resource rent for those countries. The consequence is that part of the resource rents that ought to have been re-invested for sustainable development has already been spent on inefficient production in the current period.[77] In the extreme case an oil sector that is being subsidised may result in negative rents if the gross

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[73] Hartwick and Hageman, 'Economic depreciation of mineral stocks and the contribution of El Serafy'.

[74] The most notable exceptions to the widespread use of average costs are: J.M. Hartwick, 'Natural resources, national accounting and economic depreciation', *Journal of Public Economics* (1990) 43. He obtains marginal extraction costs from a series by Adelman. For their part, J.R. Vincent, 'Resource depletion and economic sustainability in Malaysia', *Environment and Development Economics* (1997) 2 and J.R. Vincent, T. Panayotou, et al., 'Resource depletion and sustainability in small open economies', *Journal of Environmental Economics and Management* (1997) 33, convert observed average costs to the marginal extraction cost after forecasting mineral prices and applying a discount rate. M.L. Weitzman, 'Pricing the limits to growth from minerals depletion', *Quarterly Journal of Economics* 114 (1999) 2, p.704 estimates marginal costs to be about 40 percent higher than unit (average) costs for crude oil and natural gas.

[75] Santoprieto, 'Alternative Methods for estimating resource rent and depletion costs: the case of Argentina's YPF', p.39.

[76] The view of J. Amuzegar, *Managing the Oil Wealth: OPEC's Windfalls and Pitfalls* (London, 1999), p.10 that 'state ownership of oil ...made misallocation, inefficient use, waste and misappropriating much easier than if the reserves had been in private hands' seems to be widely accepted.

[77] Santoprieto, 'Alternative Methods for estimating resource rent and depletion costs: the case of Argentina's YPF', p. 43

revenue cannot afford the production costs. This can be easily the case in a country in which oil prices are set artificially low in order to lubricate the rest of the economy, such as in Mexico. Some evidence supporting this point will be presented in Chapter 4.

All in all, it would be hard to imagine a set of assumptions more at odds with the actual characteristics of resource use in most countries (and in particular our two case studies) than the assumptions underlying the Hotelling rent, and thus the net price method:[78]

- optimal management (in presence of state enterprise and/or monopoly/oligopoly)
- endogenous prices (most countries are price takers on international prices)
- endogenous costs (technological advance has driven extraction costs steadily downward)
- absence of production constraints (in general producers do face production constraints)

In situations where these assumptions are violated, which is to say most empirical situations, the simplification of the net price method becomes misleading. This theoretical analysis will be endorsed in Chapter 5, when the method will be implemented.

Finally, the net price method may also overstate the true depletion cost since it does not consider that the surplus for a depletable resource also includes a part that can be consumed. In principle, the net price method allocates the full rent for reinvestment in order to guarantee the consumption level of future generations. It has been argued that, in presence of technological change, re-investment of the entire surplus value would mean that future generations would inherit a capital sum far greater than necessary for them to receive an after depletion revenue equal to that received by the present generation.[79]

Along these lines, El Serafy has argued that only a part of the rents generated by the resource are to be reinvested for guaranteeing future consumption.[80] El Serafy argued that the surplus for a depletable resource represents two values: (1) a true income component which can be consumed; and (2) a separate depletion costs. The depletion

[78] J.R. Vincent, 'Green accounting: from theory to practice', *Environment and Development Economics* 5 (2000), p.21. The last assumption added from W.D. Nordhaus and E.C. Kokkenlenber (eds.), *Nature's Numbers: Expanding the U.S. National Economic Accounts to Include Environment* (Washington D.C., 1999), chapter 3. The comment that follows belongs to the former source.
[79] Mikesell, 1994, *Resources Policy*, n.20 as quoted by Santoprieto, 'Alternative Methods for estimating resource rent and depletion costs: the case of Argentina's YPF'.
[80] S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy, et al. (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989).

costs or 'user cost', should be set aside year after year and invested to create a perpetual stream of income that would provide the same level of true income, both during the life of the resource and after the resource has been exhausted.[81] The user cost method has been widely used as alternative to the net price and the present value methods.[82]

As the previous two methods (present value and net price), the user cost method can also be thought in terms of the fundamental equation of assets equilibrium [2.3-1].[83] Here the scenario is one in which the mine could theoretically either be sold and the revenue invested in financial assets, thereby earning interest X each year to infinity, or alternatively rentals, N could be earned yearly from exploitation of the asset for a finite period of n years until reserves are fully depleted, which is given by the reserves to production ratio R_t/q_t. The present value of the finite series, N_t, should equal the present value of the perpetual income, X. The present value of the finite series is:[84]

$$\sum_{n=0}^{R_t/q_t} \frac{N}{(1+i)^n} = \frac{N\left[1-\frac{1}{(1+i)^{n+1}}\right]}{1-\frac{1}{1+i}} \qquad [2.3\text{-}11]$$

The present value of the infinite series X is:

$$\sum_{n=0}^{\infty} \frac{X}{(1+i)^n} = \frac{X}{1-\frac{1}{1+i}} \qquad [2.3\text{-}12]$$

Setting equations 2.3-11 and 2.3-12 equal and multiplying by the denominator gives:

$$X = N\left[1-\frac{1}{(1+i)^{n+1}}\right] \qquad [2.3\text{-}13]$$

Rearranging the equation, the amount representing the 'user cost' is:

$$N - X = N/(1+i)^{n+1} \qquad [2.3\text{-}14]$$

[81] Ibid, p.13.

[82] See for instance the pilot environmental accounts of Papua New Guinea in Bartelmus, Lutz, et al., 'Environmental Accounting: an operational perspective'.

[83] User cost in the Keynensian sense can be regarded as capital depreciation: the decline in the value of an asset through its use in producing an economic rent. J.M. Keynes, *The General Theory of Employment, Interest and Money* (London, 1973), p. 69-70. However, El Serafy argued that depletion of natural resources couldn't be conceptually regarded as depreciation and he suggested that his user cost calculation has to be discounted from the traditional GDP measure. See El Serafy, S., 'The Environment as Capital', in Lutz (ed.) *Toward Improved Accounting for the Environment,* an UNSTAT-World Bank Symposium, Washington, 1993, p. 20-21.

[84] From the Annex 2 of C. Bryant and P. Cook, 'Environmental issues and the national accounts', *Economic trends* (1992 Nov) 469.

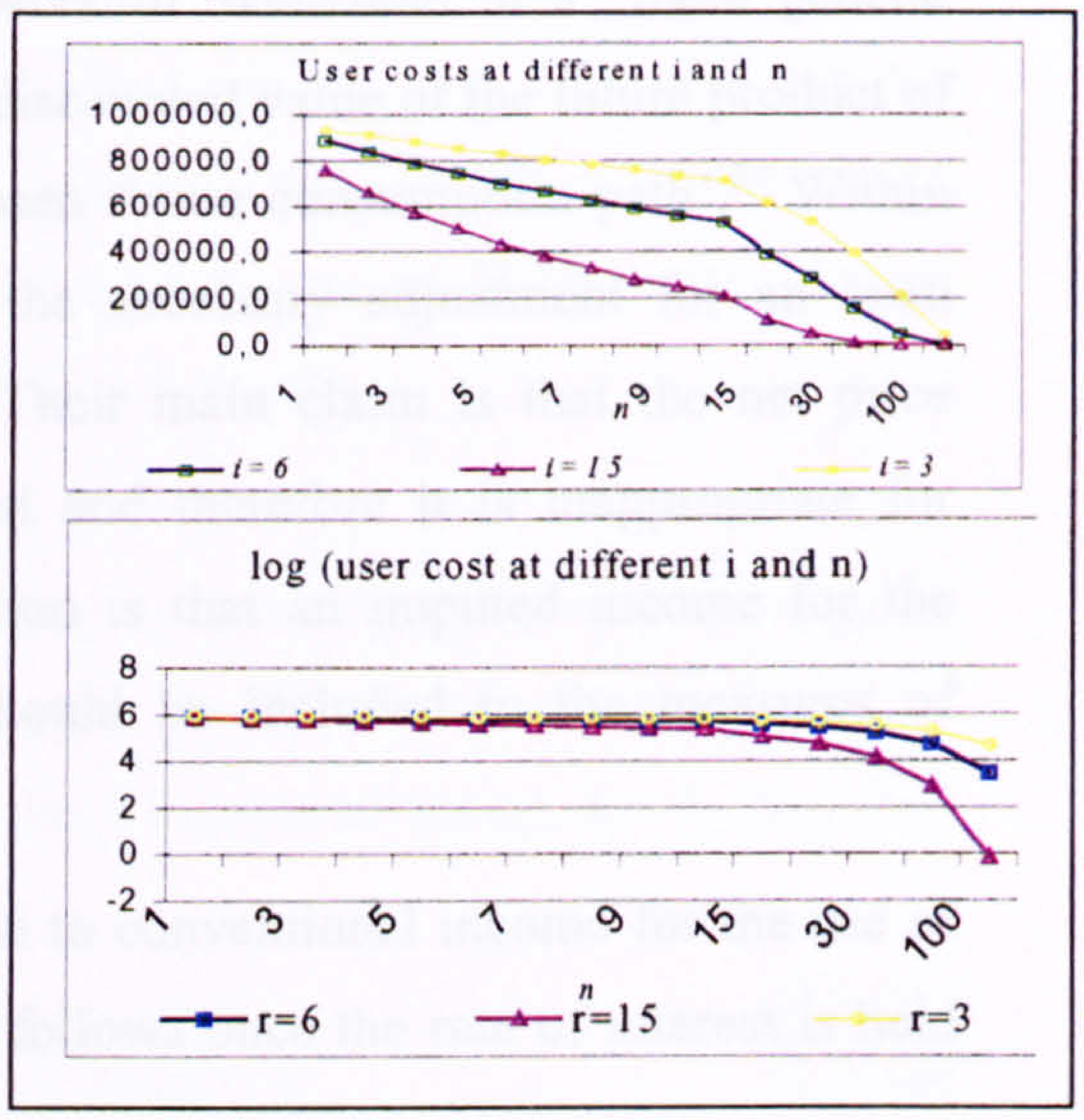
where X is the true income that can be consumed, N is the total annual receipts (net of extraction cost), i the rate of discount and n the further number of years for which current extraction rates could be sustained.

The user costs (or depletion costs) measured by this method is just a mere percentage of the receipts. This percentage depends upon two values, the discount rate i, and the expected life of the resource, n. The following table and graph show the effects of different discount rates and life expectancies for an identical net receipts value.

Figure 2.3-1: User cost sensitivity to life expectancy and discount rate

User cost results for different *n* and *i*				
n	*N*	*i=3*	*i =6*	*i =15*
1	1000000	942595,9	889996,4	756143,7
5	1000000	837484,3	704960,5	432327,6
10	1000000	722421,3	526787,5	214943,2
15	1000000	623166,9	393646,3	106864,8
20	1000000	537549,3	294155,4	53130,7
30	1000000	399987,1	164254,8	13133,1
50	1000000	221463,2	51215,4	802,4
100	1000000	50517,3	2780,4	0,7

Source: own elaboration



In general the greater the life expectancy of the reserve and the higher the rate of discount used, the lower the proportion that the user cost suggests should be reinvested. If the reserves were to be exhausted in one-year time almost the whole of the receipts obtained should not be consumed but reinvested for guaranteeing a sustainable income. If the resource was to last for a long enough period the cash obtained could be almost entirely consumed, reinvesting a minimum amount that goes to zero when the life expectancy surpasses the century. The logarithm graph also demonstrates that the effect of an extra year of life of the reserve reduces the user cost at a faster pace the higher the rate of return considered.

Observe that in order to calculate the user costs, 'El Serafy needed several assumptions that are likely to bias the estimates.'[85] Regarding N_t, the current level of receipts is held constant during the lifetime of the resource. The rate of extraction is also held constant until the final exhaustion of the resource, thus the life expectancy of the reserve in the

[85] Hartwick and Hageman, 'Economic depreciation of mineral stocks and the contribution of El Serafy'.

present year, n, is not allowed to change over time. It also assumes a constant discount rate. Finally, El Serafy is implicitly assuming an open economy, since it needs someone to sell the resource to. Hartwick does by implication say the user cost method does not apply to a closed economy case.[86] The effects of these assumptions will be further explored in Chapter 5.

Sefton and Weale elaborated what we are going to call the imputed income method. As opposed to the methods discussed above, their departing point is not the Hicksian concept of income. Instead, they place the work of Weitzman in a more general framework and define welfare income as 'the discounted value of the future product of the interest rate and consumption along a chosen future consumption path'.[87] Within this general framework their paper derives the necessary adjustment for an open economy which exported natural resources. Their main claim is that the net price method is based on a closed-economy model and therefore it is inappropriate for resource exporting countries.[88] Their suggestion is that an imputed income for the stock of the resource targeted for export should be included in the measures of income.[89]

The adjustment proposed by Sefton and Weale to conventional income for the use of non-renewable resources can be expressed as follows once the rate of interest is held constant over time:[90]

$$NNP_w = NNP_c - s(0)\big(R_1(0) + R_2(0)\big) + \int_0^{\infty} srR_2 \exp\left(-\int_0^t r\,d\tau\right)dt \qquad [2.3\text{-}15]$$

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[86] J.M.Hartwick, , 'Natural resources, national accounting and economic depreciation', *Journal of Public Economics* (1990) 43.

[87] J.A. Sefton and M.R. Weale, 'The net national product and exhaustible resources: The effects of foreign trade', *Journal of Public Economics* 61 (1996) p.45. They generalised the model presented in Weitzman, 'On the Welfare Significance of National Product in Dynamic Economy'.

[88] The models explicitly mentioned by Sefton and Weale are Dasgupta and Heal, *Economic Theory and Exhaustible Resources* and Hartwick, 'Natural resources, national accounting and economic depreciation'.

[89] In fact their model suggest two adjustments: an imputed income for the stock of resource targeted for export and a rate of interest effect. Yet, the second adjustment is considered 'harder to estimate and it seems reasonable to assume is negligible as real interest rates can be expected to remain almost constant in the long run', Sefton and Weale, 'The net national product and exhaustible resources: The effects of foreign trade', p.46.

[90] This equation is a simplification of equation (46) in Ibid, p.40, which originally reads:

$$\int_0^{\infty} rC_1 \exp\left(-\int_0^t r\,d\tau\right)dt = C_1(0) + q_1(0)I_1(0) + (s(0)R_2(0) - T(0)) + r(0)H_1(0) - s(0)(R_1(0) + R_2(0)) + \int_0^{\infty} srR_2 \exp\left(-\int_0^t r\,d\tau\right)dt + \int_0^{\infty} \dot{r} H_1 \exp\left(-\int_0^{\infty} r\,d\tau\right)dt$$

The left-hand side is welfare income. The four first terms in the right-hand side are the principal elements of the standard NNP: consumption, investment, the balance of trade and net property income. The last term corresponds to the imputed income due to future interest rate changes and it is equal to zero if the interest rate is not expected to change over time.

NNP_w and NNP_c denote the welfare income and the conventional expenditure estimate of national income respectively. The rest of their nomenclature is as follows: s represents the per unit price of the resource net of costs; R_1 the amount of the resource used domestically, R_2 the amount of the resource exported and r is the rate of interest. As derived from Weitzman's work, in the absence of natural resource, the conventional income equals the welfare income.

According to Sefton and Weale 'the term $-s(0)(R_1(0)+R_2(0))$ is Hartwick's adjustment for the extraction of exhaustible resources in a closed economy'.[91] Indeed, translating into our own notation we can write this term as $u(q_1+q_2)= N_t$, that is the per unit rent times the amount produced in the year. The remainder of the expression adds up to an imputed income on the stock of the resource targeted for export. Both terms together constitute the adjustment term proposed by Sefton and Weale.

They argue that a resource exporter 'can enjoy a level of positive consumption, because even though the country deplete its resource stock, the value of the remaining stock increases in value'.[92] This, they say, can be illustrated clearly from the expression above. If the resource producing country exports all its oil, $R_1=0$, then they claim the adjustment term becomes

$$-sR_2 + \int_0^{\infty} rsR_2 \exp(-\int_0^{t} rd\tau)dt = 0 \qquad [2.3\text{-}16]$$

So they conclude that 'in this case welfare income equals the conventional measure of NNP so there is effectively no adjustment required'.[93] But how can the adjustment term be equal to zero? Take the alternative form of expressing the adjustment term also provided by Sefton and Weale. Define $S_E(t)$ as the amount of the present stock of the resource earmarked for export, so that

$$S_E(t) = \int_t^{\infty} R_2(\tau)d\tau \qquad [2.3\text{-}17]$$

Making use of Hotelling's rule, which implies that the price of the resource net of extraction costs increases over time at the rate of interest (this is the continuous version of the discrete equation 2.3-4 above), thus

$$s = s(0)\exp\left(\int_0^t rd\tau\right) \qquad [2.3\text{-}18]$$

[91] Ibid, p.40.
[92] Ibid, p.41-42.
[93] Ibid, p.42.

then the adjustment term can be expressed as:[94]

$$-sR_2 + r(0)s(0)S_E \qquad [2.3\text{-}19]$$

Since $R_1=0$, all of the resource is exported and S_E equals the whole stock of the resource available $S(0)$. Observe that for adjustment term to become zero (so that no adjustment is required), the only possibility is that the ratio of production to reserves must equal the exogenous rate of interest ($R_2/S(0)=r$), otherwise 'the adjustment could be positive or negative at any point along the optimal path'.[95]

A closer look at the adjustment proposed by Sefton and Weale reveals that, if the whole of the resource is exported, their adjustment is conceptually equivalent to the adjustment framed by the FEAE equation. Translated into the notation used earlier in the chapter, s is the per unit price of the resource u_t; R_2 is the quantity extracted for exports q_2 (understanding that total production equals production for domestic use plus production for exports, $q_t=q_1+q_2$); Q was the notation used for the reserves or total stock $S(0)$; using discrete instead of continuous time formulation, so that the interest rate is i. If all the production is exported the adjustment proposed by Sefton and Weale becomes:

$$-u_t q_t + \frac{i}{(1+i)} u_t Q_t \qquad [2.3\text{-}20]$$

the first term is simply N_t, and by equation 2.3-8 we know that $u_t Q$ is the value of the resource V_t according to the Hotelling Valuation Principle (HVP), substituting

$$-N_t + \frac{i}{(1+i)} V_t \qquad [2.3\text{-}21]$$

The adjustment proposed by Sefton and Weale is precisely the change in value of the asset as defined in equation 2.3-2, if the country exports all of its production, the per unit rents increase following Hotelling's rule and the interest rate does not change over time. In a closed economy model, where the country exports none of its resources and the rate of interest is constant, the adjustment is identical to the net price, $-N_t$, because there will be no gains from trade, thus V_t is nil.

From this exposition it is clear how all four methods (change in value, net price, user cost and imputed value) are conceptually equivalent within the frame of the

[94] This is simply the result of taking the solution of the integral side of the adjustment term from equation (48) in Sefton and Weale (assuming real interest remains constant) as in Ibid, p.48.
[95] Ibid, p.42.

fundamental equation of asset equilibrium (FEAE).[96] All four result in adjustments to the traditional estimate of net national income in the form:

$$NNP_{adjusted} = NNP_c - (V_t - V_{t+1}) = NNP_c - N_t + \frac{i}{1+i}Vt \qquad [2.3\text{-}22]$$

Of course, the four methods considered differ in their expectations about the future rents earned by the resource, u_t and N_t. The net price and the imputed income approaches assume an optimal extraction path with the unit rents following Hotelling's rule. The user cost method assumes that future unit rents will be equal to current values. The change in value method (the change in present value) can be calculated under either assumption, but it can also be calculated using the historical evolution of the rents. Thus the values of V_t and of the total adjustment will differ across methods, unless very restrictive assumptions apply.[97] All in all, an estimation of the value of the rent per unit, u_t, and the aggregate rent, N_t, at time t is needed.

Stauffer calculates a current-year 'mineral rent' that is equal to the gross value of total production, minus operating costs and an imputed rate of return to all capital investment or exploration outlays attributable to current-year production, essentially N_t as defined above. Nevertheless, according to this author 'the rent can be approximated without serious error using the government revenues from oil only in those cases in which the government fully participated in the production operations and captures most of the

[96] A noticeable exception to the main line of argument followed here for the estimation of resource value and its depreciation is M.H. Adelman, 'Mineral Depletion with Special Reference to Petroleum', *Review of Economics and Statistics* (1990) 72. Adelman argues that the resource rent should be seen as discovery value. In his view, mineral stocks are not non-renewable assets but rather, as any other capital assets, mineral stocks can be created and consumed. Reserves constitute an inventory that can be replenished by investing in the discovery and development of additional stocks. Resource rent from this perspective is the cost of replacing the inventory used up in production. Exploration costs become the tacit value of the resource. This approach implicitly uses the strong sustainability criterion since it measures depletion costs according to the costs of maintaining the stock of each particular resource. The question is whether this is the best way of valuing the compensation for future generations. The Stone Age did not ended because of a lack of stone and the oil age may well end leaving behind plenty of oil in the world's fields. It is not difficult to think of a future scenario in which despite having the same stock of natural resources, future generations choose not to use it. They will own a stock of oil of the same size as we do, but how would that provide them with the same flow of goods and services we enjoyed if that stock is worthless?

[97] The net price approach can be considered as a special case of both the user cost and the imputed income approaches. If either the depletion period or the discount rate are zero or if the extraction is costless the user cost becomes just N_t, the net price adjustment. See Hartwick and Hageman, 'Economic depreciation of mineral stocks and the contribution of El Serafy', p.117. Sefton and Weale demonstrate that if all of the resource is used for domestic production, rather than for financing imports or investment abroad with the export revenue (that is $R_2=0$), their adjustment is identical to the net price. See Sefton and Weale, 'The net national product and exhaustible resources: The effects of foreign trade', p.43. In addition, according to Vaze, if new discoveries are not treated as income the net price gives the same adjustment to income as the present value. Vaze, 'Environmental Accounts- Valuing the Depletion of Oil and Gas Reserves', p.40.

rents.'[98] Stauffer is not the only proponent of approximating the value of N_t by oil taxes. Mommer whose starting point differs from both Stauffer and the sustainability approach, also used oil taxes as a proxy for N_t.[99] Chapter 4 is devoted to the estimation of, u_t and N_t and will check the appropriateness of using oil taxes as proxy measure for rents.

To say that the methods are conceptually equivalent and anticipate they may get different answer due to their different underlying assumptions also implies that they attempt to resolve different questions. Sefton and Weale's adjustment seeks a better indicator of where the economy is heading, since their welfare income embodies information about the expected path of future consumption. The Sefton and Weale model does not respond to the question of how much of the resource should be consumed internally or exported, or the proportions of the export revenue that should be dedicated to import goods and investment. This is quite different from the net price and user costs method that apart of adjusting the conventional estimates of net income, try to establish how to distribute N_t between consumption and investment in order to guarantee the consumption of future generations. While the net price allows no consumption from the rent in the current period, by allocating all the rent for reinvestment, the user costs allows a proportion of the rent to be consumed in the present period and the remaining fraction should be reinvested. The two questions: What is the 'true' net income of the economy? And what should be done to achieve sustainability? are interrelated since the future of the economy is conditioned by the current consumption and investment choices.

A Sustainability Indicator

A further question that the environmental literature attempts to answer is to what extent the specific strategy of a resource producer is sustainable. The definition of non-renewable capital consumption is critical in the efforts to analyse economic sustainability in resource-extracting economies not only because that is the value that is supposed to adjust the traditional NDP but also in the generation of sustainability indicators. It was mentioned above, that in order to achieve constant real consumption through time it is necessary to keep the underlying capital stock constant. It becomes a requirement that the value of the net change in the total capital stock (K) must be equal or greater than zero:

[98] R. Stauffer, *Accounting for "Wasting Assets". Income Measurement for Oil and Mineral-Exporting Rentier States*, Vol. 25 (Vienna, 1984) p.19 and p.24

[99] B. Mommer, ' Integrating the oil. A structural analysis of petroleum in the Venezuelan economy', *Latin American Perspectives* 23 (1996 summer) 90, p.141.

$$\frac{dK}{dt} = \dot{K} = \frac{d(K_M + K_N + K_H)}{dt} \geq 0 \qquad [2.3\text{-}23]$$

Note that the total capital stock is defined as $K = K_M + K_N + K_H$, where K_M is man-made capital (or 'reproducible physical capital'), in the conventional sense of machines and infrastructure; K_N is natural capital, and K_H denotes human capital. The net capital accumulation can be expressed as:

$$\dot{K} = S(t) - \delta K(t) \qquad [2.3\text{-}24]$$

where S(t) is gross savings and δ is depreciation on overall capital stock. From equations 2.3-15 and 2.3-16, Pearce and Atkinson established an intuitive rule for sustainability:[100]

$$S(t) - \delta K(t) \geq 0 \qquad [2.3\text{-}25]$$

Decomposing K into its three main components, this becomes:

$$S(t) - \delta_M K_M - \delta_H K_H - \delta_N K_N \geq 0 \qquad [2.3\text{-}26]$$

For current purposes we assume $\delta_H = 0$, that is, knowledge and skills do not 'depreciate'. If we assume knowledge and skills are specific to an individual (acknowledging the non-rival public good aspects of knowledge), depreciation occurs through either death or obsolescence.[101]

Dropping time and dividing by GDP (Y) gives:

$$\frac{S}{Y} - \frac{\delta_M K_M}{Y} - \frac{\delta_N K_N}{Y} \geq 0 \qquad [2.3\text{-}27]$$

Inequality 2.3-19 provide us with a sustainability indicator in the form[102]

$$Z = \frac{S}{Y} - \frac{\delta_M K_M}{Y} - \frac{\delta_N K_N}{Y} \qquad [2.3\text{-}28]$$

where Z is a sustainability index also denominated 'genuine savings'. It is an intuitive zero-order rule for determining whether a country is on or off a sustainable development path at any one point in time. The value of Z must be either zero or

[100] This was pioneered in D.W. Pearce and G. Atkinson, 'Capital Theory and the Measurement of Sustainable Development: An Indicator of Weak Sustainability', *Ecological Economics* 8 (1993) and more recently used by D.W. Pearce and G. Atkinson, 'Measuring Sustainable Development', in Bromley (ed.), *Handbook of environmental economics* (Cambridge, MA, 1995). The latter is the source of the discussion presented here.

[101] This is also the assumption adopted by Pearce and Atkinson, although they recognise that: 'obviously if human capital depreciation is different from zero the sustainability criterion presented here will alter [...] depreciation may occur through obsolescence [or] the loss of indigenous skills and knowledge. Such considerations are important but actual measurements present immense difficulties'. Pearce and G. Atkinson, 'Measuring Sustainable Development', p.168. See World Bank, *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development*, Vol. 17 (Washington, D.C., 1997) for the results of making human capital depreciation different from zero.

positive to ensure sustainability. According to the World Bank, 'the policy implications of measuring genuine savings are quite direct: persistently negative rates of genuine savings must lead, eventually, to declining well being'.[103]

A number of different theoretical objections to the validity of the rule of 'keeping genuine savings above zero' have been put forward. Several authors have noted the role of the terms of trade and capital gains in modifying the $Z>0$ rule for an open economy.[104] The reasoning had been based on Hotelling's principle by which resource rents rise over time at the rate of interest as the resource grows scarcer. With marginal costs not declining faster than the interest rate, future resource prices will be higher than current ones, thus providing the resource exporter with improving terms of trade. Therefore, the exporter of natural non-renewable resources can have negative genuine savings and still ensure sustainability.[105] For his part, Weale argues that given these gains in the terms of trade, the exporter of natural resources 'does not have to do any investing in order to maintain its level of income constant, so the whole of the revenue is available for consumption'.[106] Therefore, the sustainability rule would differ for open and closed economies.

Also, both technological change and population growth are left out of the sustainability index presented. On the one hand, in the event of technological change, a constant capital stock would leave future generations with higher well being than the present generations, as the capital stock grows more productive. Then technological change would be consistent with a declining capital stock and negative net savings.[107] On the other hand, a growing population creates an investment need to increase the overall capital stock in order to maintain capital per head and thus sustainability of

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[102] It is worth emphasising that Z is an indicator of 'weak' sustainability. It assumes substitution possibilities between the component parts of capital. It is therefore possible to run down the stock of natural capital provided that the proceeds are reinvested.

[103] World Bank, *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development*, p.8. This report used the net price method for evaluating natural capital depreciation.

[104] See G.B. Asheim, 'Hartwick's rule in open economics', *Canadian Journal of Economics* 86 (1986); G.B. Asheim, 'Capital gains and net national product in open economies', *Journal of Public Economics* 59 (1996) 3 and J.M. Hartwick, 'Sustainability and constant consumption paths in open economies with exhaustible resources', *Review of International Economics* 3 (1996) 3.

[105] E. Newmayer, 'Measuring Genuine Savings: Are Most Resource-extracting Countries Really Unsustainable?', in Munasinghe, M., O. Sunkel and C.de Miguel (eds.), *The Sustainability of Long-term Growth. Socioeconomic and Ecological Perspectives* (Cheltenham, UK, 2001), p.424;

[106] M. Weale, 'Environmental Statistics and the National Accounts', in Dasgupta, P. and K.G. Mäler (eds.), *The Environment and Emerging Development Issues*, Studies in Development Economics, edited by UNU/WIDER, Vol. I (Oxford, 1997), pp.99-100.

[107] R.M. Solow, 'Intergenerational Equity and Exhaustible Resources', *Review of Economic Studies* (1974), pp. 29-46.

consumption per head. In sum, technological change permits a declining capital stock only to the extent that this change exceeds population growth.[108]

Chapter 6 will return to the sustainability index and to these issues in order to determine whether Venezuela and Mexico have been living beyond their means at any point during the 20th century.

2.4 Conclusions

This chapter is to applied green accounting as say, microeconomic theory is to market analysis: it furnishes the economic rationale for the exercise and serves as broad guideline for conducting it and interpreting the results.

The Fundamental Equation of Asset Equilibrium served as general framework for presenting an array of seemingly competing methods of environmental accounting, two of which (net price and user cost) have now found its way into the proposed systems of environmental accounting. The other two, present value and imputed income, have never been used in applied studies. An important conclusion derives from the analysis of the different methods: they seem to apply to different scenarios. Hartwick does by implication say the user cost method does not apply to a closed economy case.[109] Sefton and Weale argue that the net price method does not apply to open economies, and from their theoretical propositions it can be inferred that, at least in part, the user cost method applies to the open economy case.[110] In open economies the possibility of capital gains on the depleting asset stock becomes relevant but not otherwise. These theoretical implications are the fruit of the comparative analysis of the methodologies provided in this chapter.

The arduous task of fitting the real world into these theoretical models is Chapters 4 and 5 endeavour. The theretical models implicitly assume that depletion takes place under very strict assumptions (optimal depletion, constant prices, and constant marginal extraction costs, homogeneous reserves and perfect information to mention some). Chapter 4 analyses how far from reality these assumptions are in the case of oil when calculating the resource rent (u_t and N_t). The effects of removing these assumptions will be explored in Chapter 5 when the methods are applied to the historical data set. Chapter 6 will come back to the issues presented in Section 2.2

[108] D.W.Pearce, and G. Atkinson, 'Measuring Sustainable Development', in Bromley, D.W. (ed.), *Handbook of environmental economics* (Cambridge, MA, 1995), p.176.
[109] J.M.Hartwick, , 'Natural resources, national accounting and economic depreciation'.
[110] J.A.Sefton, and M.R. Weale, 'The net national product and exhaustible resources'.

regarding the inclusion of environmental depletion in national income accounts and to the sustainability indicator just presented. Before entering the numerical analysis, Chapter 3 describes the different resource depletion strategies of Mexico and Venezuela. It also demonstrates that the worries presented in this chapter regarding the particular nature of income in economies based on non-renewable resources have long been present in the debates regarding the exploitation of oil in these two countries.

'It is illusory, and would be harmful,
to pretend that petroleum produced and exported in large quantities
could become the factotum of Mexico's economy
or the panacea for Mexico's economic ills.
Mexico does not wish ever to be forced to export
such an indispensable energy and chemical resource'[1]

'Oil is fantastic and induces fantasies.
It created the illusion of a miracle;
it created, in practice, a culture of miracles...
Oil wealth had the power of a myth'.[2]

Chapter 3

Oil illusion and delusion: Mexico and Venezuela 1900s-1980s

'In the current system of national accounts, revenue derived from the sale of natural resources is treated as current income, or rent, that is available for consumption. If the revenue accrues to the public sector, it can be used just like revenue from any other source, such as the proceeds from income taxes. Given their short perspective, the politicians in charge of such economies often do not want to be reminded that the revenue derived from liquidating their country's natural assets is neither recurrent nor sustainable. A developing country rejoices in having its leadership praised for illusory rapid economic growth, apparently high rates of saving and investment, and deceptively stable or near stable price levels brought about by import surpluses. Such apparent prosperity is bought at the cost of assets erosion – a sure recipe for future economic decline'.[3]

[1] Antonio Bermúdez, Director General de Petróleos Mexicanos for the period 1947-1958, in 1963 as quoted in R.Duncan, *Mexico's Petroleum Exports: safe collateral for a $50 Billion Loan?* Available from: www.halcoyn.com/duncanrc/. (cited Dec 2000).

[2] Jose Ignacio Carbujas, a Venezuelan political commentator. This sentence was pronounced in a conference given for the Presidential Commission for State Reform (COPRE); no date provided. As quoted in F. Coronil, *The magical state: Nature, money, and modernity in Venezuela* (Chicago and London, 1997), p.1.

[3] S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy, et al. (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989), p.10.

These words of Salah El Serafy were written in 1989, when he was Economic Adviser to the World Bank. However new they sounded at the time of the 'environmental revolution', this chapter shows that Mexicans and Venezuelans of different epochs have not ignored the false prosperity of resource driven economies. Yet their arguments were not strictly related to the national accounts framework, and they hardly ever quantified their claims. For the purposes of this chapter, one needs to analyse the wide literature on oil and economy, looking for references regarding the issue of the use of natural resources and the generation of wealth for the country. This chapter returns to the history and historiography presented in Chapter 1 but seeking references to the issues referred in Chapter 2, namely, the concerns about the effects of oil exploitation on the income and wealth of the country. The chapter demonstrates that Mexican and Venezuelan scholars have contemplated the matter of the actual wealth of the country, the ephemeral prosperity delivered by oil depletion and the biases that oil cash introduced in the economic perception of the country.

The chapter also sets out the different approaches to oil exploitation in both countries in greater depth. While the Mexican government opted very early on for using oil to supply the domestic market with cheap energy, Venezuelan governments adopted the 'sowing oil' slogan almost simultaneously. As will become clear in the ensuing chapters, the implications of each strategy affected every aspect of oil exploitation: management, pace of exploration and exploitation, prices, costs of operation, etc.

3.1 Mexico: The Perception of the Oil Question during the Century

The following sections follow the benchmarks of the Mexican industry described in Chapter 1 in order to analyse different contemporary views. Therefore, the first section covers the years from the start of commercial production of crude oil in 1901 to 1938. The second section scrutinises the period between the expropriation-nationalisation of oil production in 1938 and the mid-1970s. For this period, Mexico was mainly producing for its own internal consumption with a small amount of exports, becoming a net importer of petroleum by the late 1970s. The last section analyses the new era of Mexican energy development that was launched by major oil discoveries in the south of the country in 1974, then the country's production and exports experienced an important thrust.

The First Oil Boom: Naive Optimism

As mentioned above, during the early days of the twentieth century Mexico was following the pattern of a typical export economy, which depended upon increasing exploitation of natural resources with cheap labour and foreign capital and technology to expand production for overseas markets. Due to the small amount of oil produced at this time (a maximum of 10 thousand barrels), the government did not bother to give it any special tax treatment until 1912.[4] Oil was not yet a major item of international trade and investment, neither a crucial source of power nor an object of bitter economic and political competition. For most people, chapopote was not more than a local curiosity or a local resource for fishermen and furniture-makers. Chapopote was the indigenous word for asphalt. It was used as a form of varnish or to waterproof boat bottoms.

Indeed, oil became only known by the catastrophes it caused.[5] In 1908, the British company of W. Pearson, hit a gusher. The well caught fire and burned uncontrollably for 58 days, with an estimated loss of a million tons of oil. When the raging fire was finally bought under control, the well produced only salt water. One year later, a second gusher, Portero del Llano No.4, burst from the soil at a tremendous pressure. Engineers improvised the technology required to tame the well: three million barrels of oil spewed into the surrounding countryside, devastating the fields during the 60 days before it was capped. From the perspective of the early literature, the accidents were justifiable; thanks to them, Mexican oil potential became known to the world. However, one can assume they were the cost incurred for the early development of the industry. Considering that the oil wasted in both accidents almost equalled the actual amount exported in those years, the cost acquires its full dimension. They represented lost oil stocks for the nation, although no one considered them so or valued their dimension in monetary terms. Waste was not yet a worry.

This attitude slowly changed, partly due to the nationalism arising from the Revolution, and also to the increasing economic importance of oil for Mexico. Oil companies managed to isolate production from the effects of the Revolution, so that

[4] D.G. López Rosado, *Curso de Historia Económica de México* (México D.F., 1963).
[5] Summaries of the main accidents of this epoch originally extracted from journals and pamphlets of the time are available from the following sources: PEMEX, (Petróleos Mexicanos), *El Petróleo* (México D.F., 1970), pp. 130-135; 'Introduction' to J.C. Brown and A. Knight (eds.), *The Mexican Petroleum Industry in the Twentieth Century* (Austin, 1992); R.B. Mancke, *Mexican Oil and Natural Gas. Political, Strategic and Economic Implications* (New York, 1979).

output in 1921 was fifty-three times greater than in 1910.[6] At the beginning of the first oil boom, in 1917, the geologist Miguel Bustamante wrote a long report that can possibly be considered the first Mexican oil monograph.[7] The report provides some very useful information on prices, taxes, production, etc., and surveys and summarises foreign and national articles. In addition, the whole of its second chapter is dedicated to 'the future of the Mexican oil industry and its influence on the industrial development of the Republic'. What comes out of those pages can be called naive optimism. Naive because it implied hoping and dreaming about the limitless possibilities of oil as an engine of economic growth and political independence for Mexico. But overall, naive when considering Mexico as an unlimited producer of raw materials and hydrocarbon fuel. Apparently, Mexican gushers showed signs of lasting longer than in any other place in the world.[8] This was not only a Mexican view; a couple of years earlier, an article published in San Francisco stated that Mexican oil fields would last much longer than American ones.[9]

Despite considering the oil fields to be everlasting, Bustamante repeats once and again the importance of preventing the waste of Mexican natural resources for the future of the Republic. Here we find what is probably the most recurrent topic of Mexican oil history, namely, Mexican oil should be for today's and tomorrow's Mexicans:

> ' It is not enough that the land of our birth contains inexhaustible treasures and that our soil is fertile; it is also necessary to know how to take advantage of those resources and not to dissipate them on behalf of foreign nations...'.[10]

> '[...]it will be possible to develop the exploitation of the natural resources that these territories contain in immense quantities and variety [...] in some other more prosperous time'.[11]

The first statement already shows the incipient nationalism regarding resource exploitation. Even if the resources were inexhaustible, the key was how to take advantage nationally. The second one points at a possible conservation strategy, waiting for better times for using the resources, which implicitly indicates a concern for future generations.

[6] A. Maddison and associates, *The Political Economy of Poverty, Equity and Growth. Brazil and Mexico* (Washington, D.C., 1992) p.145.
[7] México. Secretaría de Industria y Comercio, *El petróleo en la República Mexicana* (México D.F., 1917).
[8] Ibid., p. 83.
[9] Huntley, L.G, San Francisco, 1915. Quoted in Ibid., p 32.
[10] Ibid., p. 91.
[11] Ibid., p.103.

As would occur again in the 1970s, the forecasts in 1917 were over-optimistic. The potential estimated production was 200 million barrels per annum.[12] Such production would imply massive investment in infrastructure, but would allow the establishment of oil related industries and other industries supported by national demand in the Republic. Furthermore, industries established abroad would come to Mexico due to the unlimited quantities of hydrocarbons available and the advantage of low wages.[13] Oil could make it all possible. After all, oil was seen as the ultimate transforming force able to take the Mexican economy to a higher level:

> 'Fortunately, the economic conditions of the Nation can be rapidly transformed by oil exploitation when we achieve a wide internal consumption [...] we shall be able to avoid the present lack of affordable fuel by having unlimited quantities, which has been so far the main obstacle to all our growth attempts.
>
> In summary: to be profitable for the country our oil industry should endeavour, by all possible means, to use all of its production within the country in order to increase our means of transport and to develop national industry and agriculture'.[14]

The path towards economic success was through affordable energy for the country. Contrary to what happen in other Latin American countries (i.e. Venezuela), Mexico wanted to take advantage of oil as a source of energy within the country from the very beginning.

These ideals received their most famous –though not necessarily their most efficacious- assertion in the 1917 Constitution in which Article. 27 stated that:

> 'The Nation shall at all times have the right to impose on private property such limitations as the public interest may demand, as well as the right to regulate the utilisation of natural resources which are susceptible of appropriation, in order to conserve them and to ensure a more equitable distribution of public wealth'[15]

Conservation and distribution issues were at the core of the article that would provide the constitutional basis for the oil expropriation.[16] However, the immediate post-revolutionary governments maintained a hands-off policy with regard to American

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[12] In order to understand the magnitude of that estimation one must consider that Mexico produced only 30 million barrels in 1916. The forecast multiplied the actual production times six.
[13] México. Secretaría de Industria y Comercio, *El petróleo en la República Mexicana* p. 104.
[14] Ibid., p.100.
[15] Organisation of American States. General Secretariat, *Constitution of Mexico 1917* (Washington D.C., 1977), p.8.
[16] The same article also provided the constitutional basis for the land reform, since it referred to 'natural resources' as a whole. For an early analysis of the implications of the article see México, Cámara de

property, and the potential threat posed by the 1917 Constitution was not taken very seriously in the 1920s.[17]

Notwithstanding the differences in language and concerns, it is possible to identify some aspects of the later environmental literature in early Mexican writings on oil. Both Bustamante and the clauses dedicated to oil in the 1917 Constitution try to take into account the interest of future generations. However, the fact that these early judgements considered oil exploitation as the economic panacea for Mexico's ills, distinguishes them from the environmental approach.

The Nationalisation: Facing Reality (1938-1970)

In 1917, everything seemed possible in Mexico thanks to oil. Looking at contemporary sources, no one would be able to foresee the long decline of the industry for the half-century ahead. The predicted production of 200 million barrels per annum would not be achieved until some sixty years later. What took place in the years immediately after Bustamante's article was the rise and fall of Mexican oil production, as shown in Table 3.1-1. Production increased almost three fold in four years (1917-1921), taking Mexico to a prominent position among oil producers and exporters.[18] Yet, this was not maintained for long. By 1928 production was below what it had been ten years before and it did not recover the levels of the early 1920s until the 1970s.

Table 3.1-1: Oil production. Mexico 1917-1928 (thousand barrels)

Year	Production
1917	55,293
1918	63,828
1919	87,063
1920	157,069
1921	193,398
1922	182,278
1923	149,584
1924	139,678
1925	115,515
1926	90,421
1927	64,121
1928	50,151

Source: Appendix A

The increasing disagreement between companies and government was both cause and consequence of the reduction in production. From the Mexican point of view, the companies exhausted oil fields in order to cope with demand. The so-called limitless capacity of Mexican oil fields turned into fears of exhaustion in the 1920s and 1930s.[19] From the companies' side, the government's increasing nationalist tendencies paralysed exploration and reduced production. The creation of national reserves –i.e., the retention of land for further exploration and potential exploitation by the state-

Diputados (by M. de la Peña), *Estudio jurídico, político y económico sobre el Art 27 constitucional* (México D.F., 1921).

[17] R. Thorp, 'Economy, 1914-1929', in Bethell (ed.), *Latin America Economy and Society 1870-1930* (Cambridge, 1989), p. 63.

[18] Mexico was the world's greatest exporter and second larger oil producer in 1921.

exemplified the point made by the companies.[20] As a consequence, capital started to flow away from Mexico, particularly to Venezuela. For the companies, Venezuela was a better recipient of capital since they found legislative facilities similar to those of Mexico before 1910.[21]

Mexicans justified the decline of the oil industry in a different manner. The recent discoveries of oil in Venezuela attracted capital which otherwise would have been invested in further development of the Mexican industry, if Mexican oil fields had not been over-exploited beforehand.[22] The general agreement among Mexican scholars was that oil exploitation could not be done in a sensible manner when there were several companies involved.[23] According to this view, fields would be totally exhausted under private exploitation. Oil was such an important element that its exploitation should be beyond individual interest. Oil should not be extracted for profit but for the salvation of a society. In addition, the companies were accused of hiding profits.[24] The companies were said to be distorting information about their profit margins in order to evade taxes. They were not only exhausting Mexican oil, but also going away without paying any compensation.

According to one observer of the time, liberal countries were just generating a 'misleading and ephemeral prosperity' by allowing rapid exploitation of their oil resources.[25]. In her own words:

> 'A misleading and ephemeral prosperity would have taken place in Mexico if the legislation of the beginning of the century had continued to apply. Rich oil fields would have probably been discovered. If they were not exhausted by now, they would be exploited to the top of their capacity. We would remain as the world's second oil producer while wanting for the day of the complete exhaustion to arrive. That day we would find that no wealth had been retained'.[26]

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[19] M. Manterola, 'La Situación de la Industria del Petróleo en México y su Reciente Nacionalización', *Revista de Economía* I (1937) 1-6, p. 364.

[20] For a discussion of National Reserves see J. López Portillo, 'Las Reservas Petroleras Mexicanas', *Revista de Economía* II (1938) 7-12.

[21] On this matter see J.C. Brown, 'Why Foreign Oil Companies Shifted Production from Mexico to Venezuela during the 1920s', *American Historical Review* (1985) 90.

[22] At least that is the Mexican view expressed by several authors in the monthly journal of the National Union of Mexican Economists – *Revista de Economía*- quoted below. It is also the view of E. Sangines Villavalva, 'La industria petrolera en México', *Revista de Hacienda* II (1938 Marzo).

[23] The following sentences mostly come from: López Portillo, 'Las Reservas Petroleras Mexicanas'. Identical views are expressed by Sangines Villavalva, 'La industria petrolera en México'.

[24] J. Silva Herzog, 'La expropiación de las compañías petroleras en México', *Revista de Economía* II (1938) 7-12.

[25] Sangines Villavalva, 'La industria petrolera en México'. (Although published in 1938 the article was written in June 1937).

[26] Ibid., p. 10. Note the reference to the change of legislation already mentioned in Chapter 1. From 1884 to 1910, Mexico adopted the unity of so il and subsoil prevalent in North American legislation –the

To some extent, these words are very similar to the more recent environmental claims stating that 'the expansion of economic activity as a consequence of accelerating the liquidation of subsoil assets is applauded as good economic performance and it is confused with the growth that comes from labour, capital formation, technological progress, and efficient organisation'.[27] Mexicans were identifying some of the premises of the environmental accounting. This is not to say that the agenda of the Mexican government and scholars matched environmentalists' concerns, but it is certainly true that the idea of the ephemeral prosperity brought about by resource exploitation was present as early as the 1930s.

What was on the agenda of the Mexican government was the nationalisation of the oil industry. In fact, it had long been contemplated. As mentioned above the first hints can be identified in the 1917 Constitution. During the 1930s, President Cárdenas made known on repeated occasions his earnest desire to 'to put the machinery in to the hands and ownership of the workmen' since that was the faithful interpretation of the Revolution. According to him, 'the economic independence of Mexico should be based accordingly on the liberation of the subsoil from the usurious exploitation to which it is now subjected'.[28] On 18 March 1938, the Mexican government expropriated by executive decree the property of seventeen foreign-owned oil companies without compensation. As mentioned in Chapter 1, thousand of pages were written for and against this action.

On the other side of the conflict were the American and British companies whose property was confiscated. They supported their position against the expropriation not only in defence of their own interests and on a legal basis, but also on grounds of efficiency, macro-economic performance and even in social terms. On the American side, Rockefeller's Standard Oil Company published two extensive pamphlets on the

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owner of the surface so is of the subsoil. The Revolution brought back the old Spanish split between both –subsoil substances belong to the State independently of surface's owner.

[27] El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', p.12.

[28] Speech of March 28, 1934, at Villa Hermosa, Tabasco, p.81 as quoted in Standard Oil Company, *The Reply to Mexico* (New York, 1940), p. 31. The role of the workers in the nationalisation process was mentioned in passing in Chapter 1. For a deeper analysis of this issue, see among others S.L. Adleson, 'The Cultural Roots of the Oil Workers' Unions in Tampico1910-1925', in Brown and Knight (eds.), *The Mexican Petroleum Industry in theTwentieth Century* (Austin, 1992); V. Novelo, *La difícil democracia de los petroleros* (México, D.F., 1991); and R. Ramirez Heredia, *La otra cara del petróleo* (México, D.F., 1979).

matter by 1940.[29] Apart from discussing the genuine legal issues of the 'confiscation', it also judges the record of the Mexican government in the oil business: [30]

> 'The practices of this Mexican oil company [Pemex] are instructive. To date it has developed no new oil fields. For the most part it has contented itself with tapping oil fields discovered and developed through private initiative...The prospect that a substantial volume of oil will continue to be produced by the Mexican government is not great'.[31]

The companies judged the government incapable of running the industry in their absence. In truth it took Pemex almost a decade to organise itself.[32] Emphasising Pemex's incapacity by the lack of discoveries and the poor prospects of producing substantial volume by the national company brings an interesting point to our attention. For the companies the key variable was how much oil they could extract. Below we will see that the real issue for the Mexican government was not how much oil was available, but for how long would it last.[33]

The foreigners continued their arguments against the expropriation by questioning the achievements of the government:

> 'Nothing has been accomplished by the oil expropriation, which could not have been better accomplished by wise governmental regulation of the industry. The only real justification for the step, even from the Mexican point of view, was the prospect of improving the standard of living within the country. To date this has not been accomplished, while the oil expropriated has been sold so hurriedly and at such cheap prices as to constitute a sad commentary on the announced ideal of conserving the oil in the interest of the nation'.[34]

From the foreigners' perspective the nationalisation was a failure in all respects. According to the companies, the mismanagement of the industry by the government made it inefficient and economically unsustainable, and failed to fulfil its aim of conserving the oil and improving living conditions in the country. The nationalisation process, or rather the whole debate over subsoil rights, seriously slowed the pace of

[29] Standard Oil Company, *Present Status of the Mexican Oil "Expropriations"* (New York, 1940) and Standard Oil Company, *The Reply to Mexico.*

[30] For two different views on legal issues concerning the nationalisation see A. García Robles, *La Question du Petrole au Mexique et le Droit International* (Paris, 1939) for the Mexican side, and R.B. Gaither, *Expropriation in Mexico. The Facts and the Law* (New York, 1940) for the American side.

[31] Standard Oil Company, *Present Status...*(1940), pp.45-46. Square brackets added.

[32] On 31 July 1946 the company was still trying to produce a report on the company's activities for 1938-1939. PEMEX, (Petróleos Mexicanos), 'Estado al 31 de julio de 1946 del trabajo de la memoria 1938-1939'. (Unpublished internal document, 1946).

[33] See also Appendix E for the exploration policies of Pemex and a brief analysis of the causes behind the lack of discoveries in the early days of the national company.

[34] W.C. Gordon, *The Expropriation of Foreign-Owned Property in Mexico* (Washington D.C, 1941).

economic growth.[35] The inefficiency of the national company has been established by the literature and even been recognised by Pemex officials.[36]

The government's understanding of sustainability and economic development diverged substantially from the companies' view. Overall, the government pursued public benefits over private profits:

> 'Pemex contributes to the support of national industry and to Mexico's national railways by selling them fuels at the world's lowest prices. Such a thing would not be possible if Pemex was a private company whose aims should logically be lucrative'.[37]

Therefore, the Mexican government justified the low prices argued by the companies in terms of the benefits for society and the country's economy of enjoying inexpensive energy. The reproach of the companies also referred to failure to sell abroad. Even though the rhetoric of Pemex stabilised the fulfilment of domestic requirements before oil could be exported, the truth was that the nationalisation had provoked an American blockade for Mexican oil.[38] Pemex could do very little to obtain higher prices when no market was available.

On the macro-economic side of the argument, neither the effects of the Great Depression on the Mexican economy nor the latter's general performance during the 1930s have been clearly established in the literature.[39] However, economically, and to a lesser extent fiscally, oil was much less important than it had been back in the early 1920s.[40] Consequently, it is difficult to establish the effect of the nationalisation on the Mexican economic growth in those years. Nevertheless, if the premises of environmental accounting hold, even if Mexico had continued to exploit the oil fields at a rapid pace, it would not have contributed to higher income levels. This also seems to have been the belief of the Mexican government.

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[35] S.H. Haber, *Industry and Underdevelopment. The Industrialisation of Mexico, 1890-1940* (Stanford, 1989).

[36] G. Philip, *Oil And Politics In Latin America. Nationalist Movements And State Companies* (Cambridge, 1982), pp.338-339; L. Randall, *The Political Economy of Mexican Oil* (New York, 1989), p.1-2; PEMEX, (Petróleos Mexicanos), *Venta de Pemex 1950-1962* (México D.F., undated), pp.10ff

[37] PEMEX, (Petróleos Mexicanos), *Informes del Director General Senador Antonio J.Bermúdez 1947-1952* (México D.F., 1952), 1948 report, p.52.

[38] J.D. Báez, 'Influencia de la guerra en el petróleo mexicano', *Revista de industria* 5 (1939 November) 35.

[39] E. Cárdenas, 'The Great Depression and Industrialisation. The case of Mexico', in Thorp (ed.), *Latin America in The 1930s, The Role of Periphery in the World Crisis* (Oxford, 1984).

[40] L. Meyer, *Mexico and the United States in the Oil Controversy. 1917-1942* (Mexico, 1972), as quoted by A. Knight, 'The Political Economy of Revolutionary Mexico, 1900-1940', in Abel and Lewis (eds.), *Latin America, Economic Imperialism and the State: The Political Economy of The External Connection form Independence to the Present* (London, 1992), p.303. Knight continues, 'the expropriation was more significant as an act of nationalist defiance, carrying important political consequences both at home and abroad, than as element within some broad, integrated blueprint for national development'.

What is clear is that by the late 1930s the Mexican government insisted on the path, initially suggested by Bustamante in 1917, of making productive use of their oil endowment within the country's boundaries:

> 'Our effort should lead towards consuming in the country all the oil we produce; wasting not a single drop; we can be certain that when we have achieved this ideal, Mexico will be prosperous, important and respected'.[41]

For the Mexican authorities, it was obvious that the only way the country's economic conditions could benefit from the national endowment of oil resources was by providing affordable energy for the country. This doctrine shaped the principles ruling Pemex's policy for the subsequent decades. These were:

1. The conservation of Mexico's petroleum resources and their use for the good of the nation.
2. The abundant and efficient supply of fuels to all consumers of the Republic.
3. Sale for export only when domestic needs had been fulfilled.
4. The contribution to public expenditures of the highest possible amounts through the punctual payment of taxes and duties that the Exchequer determines.
5. The promotion of the social and cultural improvement of oil workers and their families by raising their living standards.
6. The guarantee that the exploitation of petroleum resources would leave collective benefits to the regions whose natural wealth has been exploited.[42]

These principles stated unequivocally that the Mexican government considered oil as a resource for national development in a very specific way: as a source of affordable energy for the country and of income for the oil workers. The fact that those principles imposed a heavy burden on Pemex, particularly on its finances, was considered just as a subsidy to the national economy.[43]

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[41] Báez, 'Influencia de la guerra en el petróleo mexicano', .The Engineer José D. Báez was chairman of the oil department of the Mexican Exchequer (Jefe del Departamento del Petróleo de la Secretaría de la Economía Nacional).

[42] PEMEX, *Informes del Director General Senador Antonio J.Bermúdez 1947-1952* , report of 1949, p.104.

[43] Pemex estimated that the indirect subsidy to the national economy between 1950 and 1962 was 7693.8 millions of pesos and a direct subsidy for the same period 3559.1 millions of pesos. In fact, Pemex was obliged to sell its products at production cost and even below cost for many years. The yearly report of the General Director of Pemex in 1957 indicated that the diesel cost them 46.2 cents per litre but they only sold it at 17.9 cents so the lost 28.3 cents. The 'tractomex' cost them 44.4 cents per litre but they sold it at 13.1 so on, and so forth. This policy affected the costs structure of the company which worsened during the 1950s. By 1950 for every peso of product sold the company had to spent 17.3 cents. However, in 1962 for every peso sold, the company spent 22.3 cents. Data from PEMEX, *Venta de Pemex 1950-1962* , pp.17ff, 10 and 29.

Partly as a consequence of conservation and self-sufficiency policies, and the weak financial situation of Pemex, only ten percent of the potentially productive geological areas were explored between 1938 and 1970.[44] The outcome was that Mexico started importing oil products by 1956. By the 1960s Pemex recognised that Mexico was on the edge of facing a real energy supply problem. As Table 3.1-2 shows, Mexico's reserves to production ratio (R/P), in other words the life expectancy of Mexican oil fields, had been declining since 1960. The mandate of supplying abundant and affordable fuels to the Republic was at risk. Exploration needed to be urgently supported. The creation of the Instituto Mexicano del Petróleo in 1965 helped substantially to improve the gathering and systematic interpretation of the geophysical information available. The rebirth of the Mexican oil industry was on the way.

Table 3.1-2: Mexico's R/P selected years

Year	Reserves Mill barrels	R/P Years
1960	4,787	29.3
1965	5,078	24.1
1970	5,568	19.7
1975	6,338	15.5
1976	11,160	25.4
1977	16,002	22.9
1978	40,194	64.9
1979	45,126	61.1

Sources: Appendix E

The Second Oil Boom: Bounded Optimism and Crisis (1970s-1980s)

The first results of the increasing exploration activity were visible by 1972.[45] In 1974, Mexico produced enough oil to be able to export. Two years later huge discoveries were made public, together with the decision to export oil in meaningful amounts again. Oil continued being a core development resource for the Mexican government, but now not only as a supply of economical abundant energy but also, for the first time since the nationalisation, as an earner of export revenues. Several explanations are given for the change in policy of the 1970s. 'A change in administration in 1976 combined with serious economic problems. Other variations derive from unexpected frustration and unanticipated opportunities that emerged as the nation's export potential increased. Still another explanation is the novelty of the situation that saw the decision-makers confronted with new conditions that had not been carefully thought out'.[46]

The change in oil policy was a process in two phases. During the presidency of Echevarría (1970-1976), nationalistic sensitivities and domestic political discretion weighed heavily in favour of conservationist rhetoric, but evolving practice hinted at a

[44] A.M. Sordo and C.R. López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985* (México D.F., 1st. ed., 1988). See Appendix E for Pemex's exploration policies.
[45] Between ten and fifteen years elapse from the beginning of exploration work until economically profitable production is obtained.

less restrictive policy.[47] After 1976, with the rise of López Portillo to the presidency, the official stance changed to emphasise increasing exports. Oil was expected to relieve the economy from both foreign and fiscal constraints. The public and private sectors went on an investment spree beginning in 1978, which was accelerated by an oil price rise and new oil discoveries in 1979.[48]

By the early 1980s, Pemex played a strategic role in the country's situation and prospects. Oil exports accounted for 75 percent of Mexico's total merchandise exports, making them the main source of foreign exchange. The oil industry contributed 26 percent of fiscal revenues (see Table 3.1-3). In addition, almost a third of total public investment was directly carried out by the oil industry.[49] In words of Ramón Beteta, in theory, 'oil wealth should bring Mexico beyond the reach of the ambitions of the powerful'.[50] High expectations of future public revenues encouraged a rising fiscal deficit. For some time, this public-expenditure-led-growth made possible for the economy to grow at 8 and 9 percent per annum. In 1981, with lower oil prices and higher interest rates, the deficit reached unprecedented levels. It was largely financed with more indebtedness in the erroneous belief that the decline in oil prices was temporary. This was the most serious mistake of the Mexican government according to Lustig.[51] The limit of external borrowing capacity was finally

Table 3.1-3: Fiscal and export dependency on oil. Mexico 1972-1982

Year	Fiscal revenue			Export revenue		
	Total mill pesos	Oil mill pesos	Oil/Total	Total mill pesos	Oil mill pesos	Oil/Total
1972	148,445	1,921	1.3%	20,830.0	324	1.6%
1973	205,661	2,283	1.1%	25,896.3	449	1.7%
1974	281,626	3,800	1.3%	35,665.0	1,668	4.7%
1975	403,615	7,674	1.9%	38,280.0	5,288	13.8%
1976	528,451	9,682	1,8%	57,354.8	7,003	12.2%
1977	734,180	19,764	2,7%	105,504.0	23,431	22.2%
1978	950,647	30,283	3,2%	137,996.2	41,796	30.3%
1979	1,293,073	62,390	4,8%	201,219.9	91,691	45.6%
1980	683,781	168,107	24,6%	347,325.3	239,503	69.0%
1981	931,777	242,706	26,0%	475,974.4	357,538	75.1%
1982	1,515,403	317,040	20,9%	1,275,914.5	953,188	74.7%

Sources: Appendixes B for export data and C for fiscal data.

[46] E. Williams, *The Rebirth of the Mexican Petroleum Industry* (Massachusetts, 1979), p.42.
[47] Ibid.
[48] N. Lustig, *Mexico, the remaking of an economy* (Washington, DC, 1992), p. 20
[49] M.R. Beteta, 'The Role of The Oil Industry in Mexico', in Falk (ed.), *Petroleum and Mexico's Future* (London, 1987).
[50] 'Introduction' to P.S. Falk (ed.), *Petroleum and Mexico's Future* (London, 1987). Mr. Beteta was head of Pemex from 1982 to 1987.
[51] Lustig, *Mexico, the remaking of an economy*, p.26.

reached in 1982, following large devaluations of the peso, chaos in the financial markets and the beginning of the international debt crisis.[52]

The oil boom did not produce the desired dramatic transformation of the economy and permanent improvement in living standards. On the contrary, crisis and increased poverty followed it. This forced a reconsideration of the role oil played in the Mexican economy:

> 'Mexico should reduce its dependence on oil.... [Petroleum] neither signifies any special excellence on our part nor makes us worthy of any special privilege. Rather, it placed on our shoulders many grave responsibilities and problems'.[53]

In a very brief period of time, oil passed from being once again the cure to all Mexican economic ills to being at the root of most problems. Yet we also know that, in comparative perspective, Mexico's history is not one of 'petrodependency'. This was only a relatively recent concern for Mexico. Not even in the 1920s did the Mexican government contemplate 'petrodependency' as an issue. Nevertheless, it did not take too long for the old rhetoric of the 1930s, which had been abandoned in the late 1970s, to come back but with slight modifications:

> 'Hydrocarbons are non-renewable resources and therefore finite. For this reason, and given that the period of cheap and abundant energy is coming to an end, we must be increasingly conscious of how important it is for the country to save hydrocarbons and to use them economically and rationally. As we make progress in using and conserving our energy resources, we shall be able to prolong our export capacity and, with it, our foreign exchange earnings. Above all, we shall be able to maintain our current level of self-sufficiency'.[54]

The finiteness of the oil endowment, the conservationist approach to its use, and maintaining the level of auto-sufficiency had formed part of Pemex's policy from the beginning of its existence. The main difference is that, from the 1970s, export and fiscal revenues from the oil sector re-emerged as contributions to the economic progress of Mexico. The ephemeral prosperity that this may entail was forgotten.

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[52] For the chain of events leading to the 1982 crisis see J. Ros, 'Mexico from the Oil Boom to the Debt Crisis: and analysis of policy responses to external shocks, 1978-1985', in Thorp and Whitehead (eds.), *Latin American Debt and Ajustment Crisis* (Oxford, 1987) and/or the numerous references provided by Chapter 1 in Lustig, *Mexico, the remaking of an economy*.
[53] Beteta, 'The Role of The Oil Industry in Mexico', p. 64.
[54] Ibid., p. 71.

After this brief survey of Mexican policies towards oil exploitation it is worth asking how 'conservationist' Mexican governments were from the 1930s to the 1970s when applying today's 'green' criteria to their decisions. If one were to analyse Mexican strategy for that period from the eyes of today's green economist, the result would not be totally satisfactory. For the 'green' economist, the basic idea is that 'true' or 'sustainable' income is that flow of income that leaves the capital stock of the economy intact.[55] In other words, no development path can be sustained beyond the short-run if it involves running down national assets.[56] That is separate from the issue of who is exploiting the resources. Bustamante's proposition differs from the latter as long as Mexicans were entitled to use their oil resources on their behalf.

It is also possible to ask whether the 'conservationism' exhibited by Mexican authorities with respect to oil exploitation was just a result of the situation created by their own nationalistic aspirations. After the expropriation, exploration activities stopped and export markets were closed to Mexican oil. Had they aimed at exporting oil, they would have found it very difficult. Even during the mid-1980s, when the export policy began to inch back to a rather moderate stance, the main concern was economic destabilisation brought about by oil revenues, not the conservation of the resource for future generations.

The Mexican strategy resulted in a slower pace of exploitation overall, which would be approved by 'green' standards. However, the reasoning leading to such a result was not inspired by environmental but nationalistic principles. Notwithstanding this, it is also true that Mexican scholars and government officials acknowledged very early on in the century some of the crucial concerns of the environmental literature of the last quarter of the century.

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[55] D.W. Pearce, 'Valuing The Environment : Past Practice, Future Prospect', in Serageldin and Steer (eds.), *Valuing The Environment: proceedings of the First Annual International Conference On Environmentally Sustainable Development held at the World Bank, September 30-October 1, 1993* (Washington D.C., 1993).
[56] Ibid., p.53.

3.2 Venezuela: The Illusion of Oil Wealth through History

Chapter 1 made clear the importance of oil for Venezuela. The historiography of Venezuelan oil covers not only exploitation itself but also many repercussions and influences on the economy, society, politics and culture of Venezuela.[57] However, it is not the purpose of this section to analyse the literature on oil and development in Venezuela, nor to distinguish between authors who bless oil for all the progress it brought to Venezuela and those who blame oil for all the problems of the country. The aim of the present paragraphs is briefly to review the historiography, looking for testimonies throughout the century that corroborate the claim that the leitmotif of this research has not been ignored by Venezuelans of different epochs.

In the historical statements of politicians, experts and journalists, it is easy to identify concerns about the 'real gains' from oil, which emerged almost as soon as Venezuelans realised their dependence on oil. Nevertheless, since national accounting in Venezuela was not developed until the 1950s, there is no direct suggestion that the economic performance portrayed by national statistics may be misleading for Venezuela until the second half of the century.[58]

The benchmarks chosen for the analysis of Venezuela are based on the discussion in Chapter 1. The first one is the ultraliberal period of the early years of the oil industry. Those come to an end with the change in the balance of power between the companies and the government brought about by the Hydrocarbon Law of 1943. During the subsequent decades, the State progressively gained more control over the industry, which ultimately culminated in nationalisation in 1976. Finally, the oil boom and bust of the late 1970s and early 1980s is analysed.

The Early Years

As early as 1839 the Ministry of Finance sought advice from a scholar of the time, José Vargas, about the possible ways in which the State could benefit from 'certain mineral substances found scattered in the country'.[59] In his reply to the Ministry, Vargas stated that:

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[57] I. Rodriguez Gallard, *El petróleo en la historiografía venezolana* (Caracas, 1974). This work provides an excellent review of the Venezuelan literature on oil up to the 1970s, as does J.V. Lombardi, G. Carrera Damas, et al., *Venezuelan History : A comprehensive working bibliography* (Boston, 1977).

[58] See Appendix D for a brief description of the evolution of national accounting in Venezuela.

[59] When Spanish colonists arrived in Maracaibo in 1499, they found Indians using oil and asphalt that emerged naturally on the lake shores. Nevertheless, these substances were rarely used during the colonial period.

> 'It would be more convenient to rent the mine [of asphalt/oil] than its direct exploitation by the State. I would suggest to the Government that it continues its inquiries to discover the extent to which the mineral exists...it is my only belief that this finding has more value for Venezuelan people and its liberal government than the finding of silver and gold.' [60]

Vargas acknowledged that the best way to take advantage of the 'mineral substance' was by leasing the rights to exploit the mines to the private sector. He not only proposed the main outline of Venezuelan oil policy almost a century in advance, but also correctly predicted the crucial importance that oil would acquire for Venezuela.

At the turn of the century, Venezuela was largely an agricultural and underdeveloped country. Yet there were signs that oil could be found in large quantities in the country.[61] The government strictly followed the advice given by Vargas: from 1878 to 1920, the government awarded 1312 contracts for oil exploitation.[62] Juan Vicente Gómez's dictatorial regime (1908-1935) relied on the new fiscal revenues generated by the oil concessions to confront the stagnant economy and the large foreign debt. The government preached about the brilliant future oil secured for Venezuela:

> 'The economic and industrial activity is vast in the country. Mining in particular has enormous progress assured mainly because of oil, but also due to the existence of extensive deposits of gold, copper, coal, etc. Venezuela holds the first position among South American oil producers, and her natural endowment guarantees her a brilliant future'.[63]

As in the early days in Mexico, oil was perceived as the key for the economic success of the country. In fact, the aim of one of the earliest ministers of industrial planning (Gumersindo Torres) was to obtain as much revenue from oil as Mexico did at the

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[60] Extracts from the letter of José Vargas to the Ministry of Finance. The full text of the letter can be found in P.E. Mejía Alarcón, *La industria del petróleo en Venezuela* (Caracas, 1972) pp.81-83. The letter is also quoted in A.R. Martínez, 'El papel de la explotación petrolera en el proceso de modernización de la sociedad venezolana y la perspectiva inmediata', in Mieres (ed.), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989), p.12.

[61] The existence of widely scattered oil seeps had been known for centuries. The first reported application for an oil lease was in 1863 and the first two oil concessions were issued in 1866 (though asphalt concessions were granted as early as 1854). *The Petroleum Times*, 23 July 1927.

[62] Most of the contracts belonged to foreign companies, though in 1913 Royal-Dutch Shell bought nearly all the concessions granted between 1907 and 1912. W.M. Sullivan, 'Situación económica y política durante el período de Juan Vicente Gómez, 1908-1935', in John Boulton Foundation (ed.), *Política y economía en Venezuela,1810-1976* (Caracas, 1976), p.258.

[63] Minister Dr. Planas-Suárez in an interview to the newspaper 'Dimineata ' of Bucharest (9 Oct 1924) during the First Diplomatic Mission of Venezuela to Romania, as quoted in Venezuela. Ministerio de Relaciones Exteriores, 'La Primera Misión Diplomática de Venezuela en Rumania', *Boletín del Ministerio de Relaciones Exteriores* 1 (1924) 1.

time.[64] Yet, while the Mexican government was hinting at increasing the use of the resource domestically, the Venezuelan government dictated laws that facilitated the expansion of the oil industry. The law passed on 13 June 1922 gave the oil companies the incentives to redouble their exploration efforts.[65] Major discoveries followed in the subsequent years, which led Venezuela's oil production to overtake that of Mexico by 1928.[66]

Nevertheless, there were criticisms of government policy on oil exploitation. For some, the concessions were nothing but the 'surrender of national sovereignty to the imperialist capital'. The overall perception was that 'only the favourites of the dictator prospered. The petroleum enclave benefited foreigners and the dictator'.[67] After Gómez's death in 1935, opponents of the petroleum industry were permitted to speak openly. The attacks were three-pronged: against Gómez's policy, against company behaviour, and against the industry's dominant position in the national economy.[68] They marked the onset of the shadows of nationalism that were to impregnate the late 1930s and were the prelude of the changes of the early 1940s.

In 1936, Arturo Uslar Pietri urged the Venezuelan government to 'sow oil'.[69] Uslar Pietri referred to 'sowing oil' as the use that the State made of oil tax revenues. According to him, the cash received by the State from selling oil was not the result of any productive effort but a kind of 'divine loan' with either terms or interest.[70] Therefore, it should be employed precisely as a loan: prudently and sensibly, taking into account the returns and the possibilities of recovering the amount received. His concern was how to transform the transitory income from oil into permanent wealth

[64] J. Salazar-Carrillo, *Oil and Development in Venezuela During the Twentieth Century* (London, 1994), p.37.
[65] Ibid., pp.37-38.
[66] As mentioned in Chapter 1, no major discoveries occurred in Venezuela until the blow out of well Los Barrosos No2 in December 1922.
[67] L. Allen, *Venezuelan Economic Development. A Politico-Economic Analysis*. Contemporary Studies in Economic and Financial Analysis, edited by Altman, E.I. and I. Walter, Vol. 7 (Connecticut, 1977), p.3.
[68] E. Lieuwen, *Petroleum In Venezuela : A History*, University of California Publications in History, Vol. 47 (Berkeley, 1954). It is worth recalling here that the commented bibliography of this work provides an excellent overview of the historiography of oil before the 1950s.
[69] A. Uslar Pietri, 'Siembra del petróleo', *Ahora*, (14 June 1936).
[70] A. Uslar Pietri, '¿En qué medida se ha cumplido el vaticinio de Uslar Pietri (*Ahora*, 1936) sobre el parasitismo rentista en la Venezuela petrolera?', in Mieres (ed.), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989), p.114. The rest of the argument also relies in this source.

for the nation, not whether Venezuela was obtaining a 'fair share' (*participación justa*) of the petroleum profits.[71]

Uslar Pietri's proposition set the basis of the national policy regarding the use of monetary resources obtained from oil in the promotion of development in its human, scientific and economic dimensions.[72] Already in 1937, one finds echoes of 'sowing oil' in speeches in Congress and in government publications.[73] Transforming the transitory income from oil into permanent wealth for the nation required treating oil income as 'extraordinary resources' that should not form part of the ordinary national income flow but be set aside and reinvested.[74] In this regard, Ulsar Pietri's concerns were identical to the environmental accounting literature of the 1990s presented in Chapter 2.

Comprehending the Reality of Oil (1940s)

The nationalist voices that rose in Venezuela spurred on by the nationalisation of oil in Mexico were the prelude to the reforms that took place in Venezuela in the early 1940s. The balance of power shifted slowly from the companies towards the government side. The Hydrocarbon Law of 1943, which broadened the government's technical and administrative powers, made this obvious.[75] The enforcement of the 1943 law had a special importance in the historic evolution of the petroleum industry, since it governed the industry with small modifications until nationalisation in 1976. It introduced the concept of income tax and raised royalties to $16^{2/3}$ percent. This figure was calculated in order to assure the government of one-half of the net profits of the

[71] I. Rodriguez Gallard, *El petróleo en la historiografía venezolana* (Caracas, 1974), p.86. For a good insight into the 'fair share' question see J.P. Pérez Alfonzo, *La Dinámica del Petróleo en el Progreso de Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]* (Caracas, 1965). Some more radical propositions from the left can be found in the works of Hector Malave Mata and Pedro Mejía Alarcón.

[72] E. Arcilla Farias, '¿En qué medida se ha cumplido el vaticinio de Uslar Pietri (*Ahora*, 1936) sobre el parasitismo rentista en la Venezuela petrolera?, ¿en qué medida se ha sembrado el petróleo?, ¿cuál es el significado del momento actual en esta evolución?', in Mieres (ed.), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989), p.124.

[73] See Venezuela. Cámara de Diputados, 'Intervención del Senador Rojas Contreras', in *Diario de Debates:* (Caracas, 1937, July 3) and Venezuela. Ministerio de Hacienda, *Memoria* (Caracas, 1937).

[74] See Arcilla Farias, '¿En qué medida se ha cumplido el vaticinio de Uslar Pietri...', p.124. See also the doctrine of Pérez Alfonso as government minister during the late 1950s, and his intervention in the seminar by T.E. Carrillo Batalla, 'El ingreso fiscal petrolero', in *La evaluación de la inversión del ingreso fiscal petrolero en Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]* (Caracas, 1968), p.51.

[75] Lieuwen, *Petroleum In Venezuela : A History*, p.97.

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[75] Lieuwen, *Petroleum In Venezuela : A History*, p.97.

industry.[76] The 1943 law also introduced the principle of reversion. The concessions would last forty years, and at that time the concession and all property associated with it would revert free of encumbrances to the State. Gumersindo Torres had already introduced the idea of reversion in his law of 1920, but the companies rewrote it the following year. The 1943 law was clear and unequivocal: the companies could extract oil owned by the nation from the nation's property for a specified period after which everything, including all improvements and company property, belonged to the State.[77] Most of the reforms introduced in 1943 set the pattern for other oil countries' legislation in subsequent decades.

According to the Venezuelan government, 'the system of taxing the oil industry did not come into existence spontaneously. It grew with the realisation that oil is a non-replaceable natural resource that belongs to the nation'.[78] This recognition led the oil minister during the three years of the first Acción Democrática government (1945-48) to attempt to reduce the amount of oil extracted in order to preserve future generations' income. It was all in vain, since his efforts did not offset the expanding market for Venezuelan oil in the post-war reconstruction of Western Europe. In addition, the government had an increasing need for funds to finance ambitious programs of social reform and economic development.[79] Accordingly, Venezuelan production almost doubled between 1945 and 1950 (see Table 3.2-1).

Table 3.2-1: Oil Production. Venezuela 1940-1950 (thousand barrels)

1940	183,800
1941	226,800
1942	152,000
1943	179,400
1944	257,000
1945	323,400
1946	388,500
1947	434,900
1948	490,000
1949	482,000
1950	546,000

Source: Appendix A.

The increasing production also increased the dependence of Venezuela's economy upon oil. The Ministry of Development, in its analysis of diverse aspects of the Venezuelan economy towards the end of the decade recognised that:

> 'About 2 million bolivars of imports for a population not exceeding four million people, in a country with a very small internal economic activity, provides a clear idea of the condition of the Venezuelan economy. To this

[76] Yet, on 1948, arguing that 1943 was a year of unusually low market price, thus royalties were insufficient to guarantee the government one-half of the profits, the congress moved the 50-50 concept to the income tax.

[77] Allen, *Venezuelan Economic Development. A Politico-Economic Analysis* , p.65.

[78] From the introduction to Venezuela. Ministry of Mines and Hydrocarbons, 'The petroleum industry and its fiscal obligations in Venezuela by A. Parra', in *1st Venezuelan Petroleum Congress organised by the Venezuelan Society of Petroleum Engineers* (Caracas, 1962).

[79] E. Lieuwen, 'The politics of energy in Venezuela', in Wirth (ed.), *Latin American Oil Companies and the Politics of Energy* (London, 1985).

> grave situation we shall add the fact that 95 percent of all we import is paid for by exports of a single product: oil. [...] this denotes a dangerous circumstance which need to be reversed [...] we know we cannot produce oil forever. We have to make the effort to produce different products in order to be less dependent on foreign commodities and to be able to pay with things other than oil'.[80]

None of the issues raised in the analysis were new. The dependence on oil revenues had been recognised since Juan Vicente Gómez's times. The transitory nature of oil proceeds had been acknowledged by the adoption of the 'sowing oil' slogan. The only difference was that the magnitudes involved at the end of the 1940s were greater than ever before. The share of oil exports in total exports rose from 90 percent in 1935 to 97 percent in 1948. The percentage of government income dependent on oil revenues had been about 30 percent in 1935 but was double that amount in 1948.[81]

Venezuelan governments progressively started to impose their authority over the oil industry during the 1940s. However, the strategy regarding oil exploitation still followed the advice provided a century earlier: leasing the oil fields to the private sector in order to produce revenues for the State.

Measuring the Gains (1950s-1960s)

From the point of view of this research, the 1950s and 1960s provide some more useful testimonies regarding the misleading nature of economic statistics for oil producing countries, the difficulties of measuring the value of natural resources and the evaluation of the oil depletion strategy followed by Venezuela.

The concerns about the 'special' economic circumstances of the country and the possibly misleading indicators displayed by the incipient national statistics become apparent by the early 1950s. Within the country itself, the government admitted that 'the circulation of such an extraordinary volume of wealth (that obtained from oil) injects a *special* bonanza to the country's economy'.[82] The perception that Venezuela's economic indicators were peculiar also started to be contemplated by international organisations in their reports. A 1955 survey on the post-war industrialisation of Latin

[80] Venezuela. Ministerio de Fomento, *Diversos Aspectos de la Economía Venezolana* (Caracas, 1948), pp.5-6.
[81] See Appendixes B for export data and C for fiscal data.
[82] Venezuela. Ministerio de Trabajo, *Realidades de la Seguridad Social* (Caracas, 1955), p.141. Parenthesis and emphasis added. The translation may lose some of the connotation of the sentence in

2. In a speech to the newly instated National Congress in 1959, the Ministry of Mines and Hydrocarbons declared that:

> 'To determine the intrinsic value of a non-renewable natural product would be very difficult if not impossible. That value was never considered before in cost studies, because economists generally based their theories in man-made products and not natural resources. The great abundance of the latter allows their exploitation for some time without assigning them any intrinsic value'.[86]

The Minister identified a key area of environmental accounting of crucial relevance to this research: the monetary valuation of non-produced economic exhaustible assets. He also acknowledged that part of the problem lay in the fact that natural resources generally lie outside the interest of economic boundaries –generally constrained to produced assets. We know from Chapter 2 that the solution has been to assimilate the properties of natural resources to those of man-made assets. Finally, he concluded that there was no urgent need to assign any value to the resources given their abundance. The environmental literature aims to demonstrate that even when most natural resources have not grown scarcer historically, it is still important to account for the cost of exploiting them.

Nonetheless, even if assigning an intrinsic value to the resource was considered an impossible task, the cost associated with the depletion of the natural resources was not a totally neglected issue. In the words of Pérez Alfonso, former oil minister, in 1965:

> 'We are liquidating national assets [when extracting oil]; therefore, the national commitment should be to substitute those liquidated assets in order to avoid collective ruin. [To that end] we should set aside the oil fiscal receipts *(ingreso petrolero)* and reinvest it'.[87]

The first sentence of this remark is identical to the arguments of the sustainability school presented in Chapter 2. The difference, however, is that Venezuelans assigned the value of the fiscal intake by the State to the oil depleted.[88] The reasoning was as

[86] Venezuela, Government of, *Exposition of the Minister of Mines and Hydrocarbons to the National Congress* (Caracas, 1959), p.6.

[87] See the words of Pérez Alfonso in Carrillo Batalla, 'El ingreso fiscal petrolero', p.51.

[88] Carrillo Batalla, 'El ingreso fiscal petrolero', p.42. It is fair to notice at this point that fiscal oil receipts are referred to as 'oil income' *(ingreso petrolero)* in the original documents. 'Oil income' should generally refer to all the cash flows directly thrown into the economy by the oil industry. However, these cash flows have two distinctive components, each of which tends to be referred as 'oil income'. On the one hand, what is normally identified as the oil sector contribution to the national income that basically aggregates wages and salaries plus the remuneration to capital. On the other hand, the fiscal intake by the State from the oil industry. 'Sowing oil' analysts referred to 'oil income' only as the oil fiscal intake by the State. Nevertheless, from their discussion it is possible to say that they were identifying the oil fiscal revenue with the oil depletion value.

follows.[89] The State owned the mineral resources by law.[90] Therefore, when mineral products are sold, a national good is being traded and liquidated. Hereupon, the State should be compensated for the liquidation of the mines. In this view, taxes upon oil extraction are not a fiscal obligation on nature, but the price received from the sale of a good that belongs to the national endowment. Taxes are the liquidation value of a pre-existing asset. Therefore, oil fiscal revenues should not form part of the national flow of resources available in any given year and should be reinvested in the promotion of economic development.[91] Otherwise, Venezuelans would fail 'to transform the *transitory wealth* from oil into permanent wealth for the nation'.[92] These statements constitute the essence of the 'sowing oil' rhetoric.

Scholars and policy makers have attempted to evaluate the success of 'sowing oil' policies ever since its adoption as a generic slogan in the late 1930s. The general conclusion was much the same whenever the evaluation took place either in 1950s, 1960s or the late 1980s: sowing oil had been a flawed project.[93] It could be said that rather than 'sow' it had been an oil spill.[94] In general terms, the economic resources of the nation had only been marginally used.[95]

In order to evaluate 'sowing oil' policies, comparisons were drawn between the oil tax revenues collected by the government and public capital expenditure. The approach adopted was to consider that all of the fiscal receipts should have been invested in capital goods. That is, the equivalent to the net price approach that suggests that all the

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[89] The nature of the oil taxes has been taken from Carrillo Batalla, 'El ingreso fiscal petrolero', p.16-17 and several of the remarks of the participants of in the seminar. See, in particular, Pérez Alfonso's commentaries there and in T.E. Carrillo Batalla, 'Evaluación de la inversión del ingreso fiscal petrolero en Venezuela: resumen y conclusiones', in *La evaluación de la inversión del ingreso fiscal petrolero en Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]* (Caracas, 1968), p. 114.

[90] We saw in Chapter 1 that contrary to the unity of soil and subsoil prevalent in the North American legislation, where the owner of the surface also owns the subsoil, the old Spanish law split between both, giving the ownership of the subsoil to the State regardless of the surface's owner.

[91] Arcilla Farias, '¿En qué medida se ha cumplido el vaticinio de Uslar Pietri...', p.124.

[92] A. Uslar Pietri, *De una a otra Venezuela* (Caracas, 1966). Emphasis added.

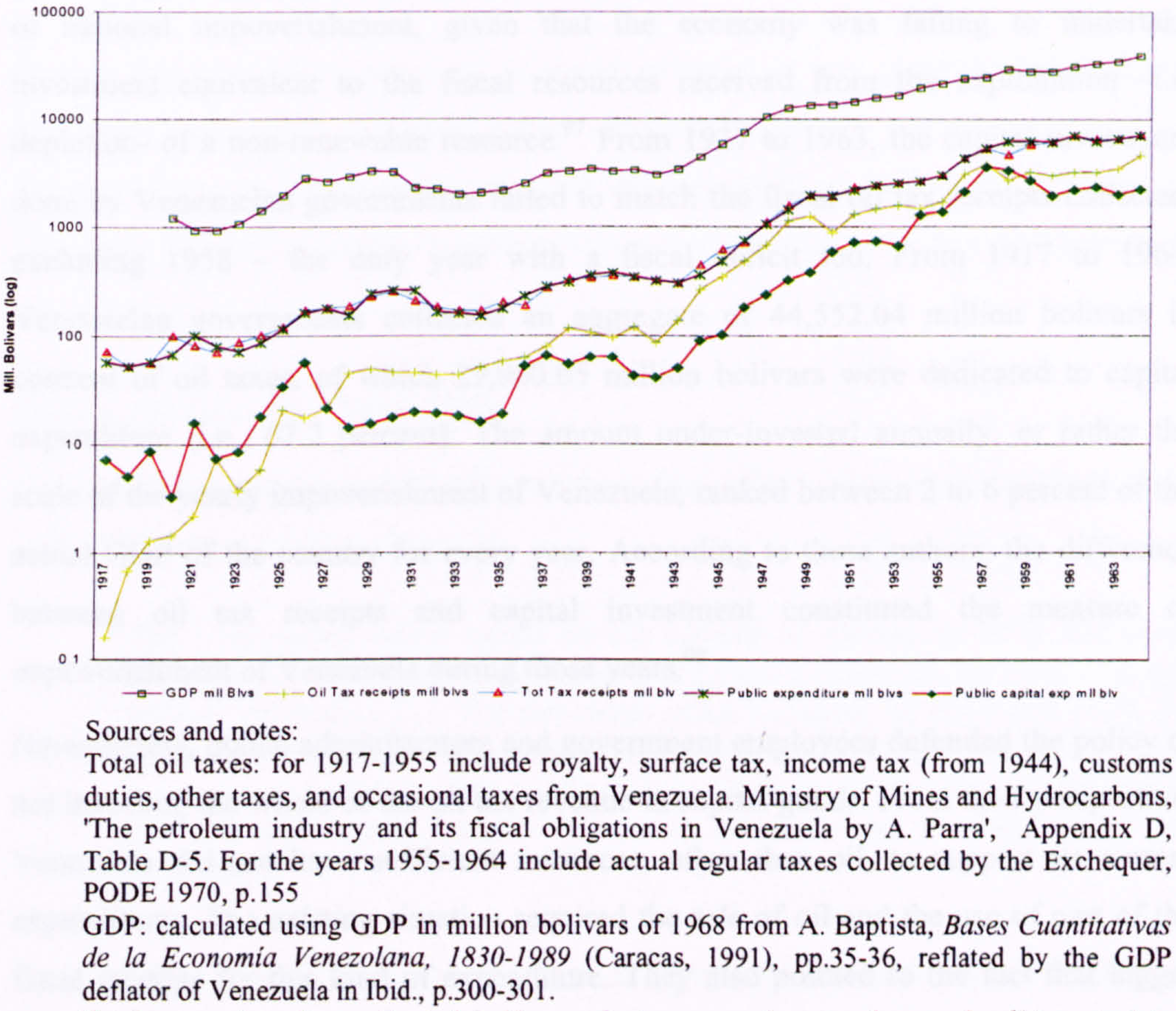
[93] Among others, see, Lieuwen, *Petroleum In Venezuela : A History* , p.119; T.E. Carrillo Batalla, *La evaluación de la inversión del ingreso fiscal petrolero en Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]* (Caracas, 1968); C. Balestrini, '¿Cuál ha sido el papel cumplido por la explotación petrolera en el proceso de modernización de la sociedad venezolana?', in Mieres (ed.), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989).

[94] Hector Malave Mata in his intervention in the seminar by T.E. Carrillo Batalla, 'La distribución del ingreso fiscal petrolero entre gastos corrientes y gastos de inversión', in *La evaluación de la inversión del ingreso fiscal petrolero en Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]* (Caracas, 1968), p. 91.

[95] 'Sowing oil', *The Economist*, 7 Jan 1950.

resource rent is to be reinvested for guaranteeing future consumption.[96] Figure 3.2-1 shows the evolution of total tax receipts, oil tax receipts, total public expenditure, public capital expenditure and the traditional GDP of Venezuela for the period 1917-1964.

Figure 3.2- 1: Evaluating 'sowing oil policies'. Tax receipts, public expenditure and GDP in Venezuela 1917-1964



Sources and notes:
Total oil taxes: for 1917-1955 include royalty, surface tax, income tax (from 1944), customs duties, other taxes, and occasional taxes from Venezuela. Ministry of Mines and Hydrocarbons, 'The petroleum industry and its fiscal obligations in Venezuela by A. Parra', Appendix D, Table D-5. For the years 1955-1964 include actual regular taxes collected by the Exchequer, PODE 1970, p.155
GDP: calculated using GDP in million bolivars of 1968 from A. Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991), pp.35-36, reflated by the GDP deflator of Venezuela in Ibid., p.300-301.
Total tax receipts: Banco Central de Venezuela, *La economía venezolana en los últimos treinta cinco años* (Caracas, 1978), p. 273.
Public expenditure: 1917-1964, Carrillo Batalla, *La evaluación de la inversión del ingreso fiscal petrolero en Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]*, cuadro no.1, p.225.
Public capital expenditure: 1917-1964, Ibid. , cuadro no 1, p.225. The figures of capital investment from Carrillo Batalla exclude the amortisation of public debt (p.81).

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[96] R. Repetto, *Wasting Assets: Natural Resources In the National Income Accounts* (Washington, D.C., 1989).

Several conclusions were drawn from these series in 1965. The first related to the narrowing gap between total GDP and total public expenditure. The public sector had become increasingly important in Venezuela, and public expenditure was progressively funded more by oil fiscal income. Yet the issue on which analysts focused was the evolution of oil tax receipts and public capital investment. As long as oil tax revenues exceeded public capital investment, they said, it was possible to talk of national impoverishment, given that the economy was failing to undertake investment equivalent to the fiscal resources received from the exploitation –i.e. depletion- of a non-renewable resource.[97] From 1927 to 1963, the capital investment done by Venezuelan governments failed to match the fiscal oil tax receipts collected, excluding 1958 – the only year with a fiscal deficit too. From 1917 to 1964, Venezuelan governments collected an aggregate of 44,552.04 million bolivars in concept of oil taxes, of which 29,960.05 million bolivars were dedicated to capital expenditure (i.e., 67.2 percent). The amount under-invested annually, or rather the scale of the yearly impoverishment of Venezuela, ranked between 2 to 6 percent of the actual GDP of the country for every year. According to these authors, the difference between oil tax receipts and capital investment constituted the measure of impoverishment of Venezuela during those years.[98]

Nevertheless, public administrators and government employees defended the policy of not investing the whole of the oil tax revenue in capital goods. From their perspective, Venezuela did not have sufficient resources, other than oil, to support its current expenditures. The existing situation required the sale of oil and the use of part of the fiscal receipts for this kind of expenditure. They also pointed to the fact that bigger capital investment implied increasing current expenditures. 'If we build more hospitals, we need to increase the number of doctors, nurses and resources needed for the maintenance of the service; if we build universities and schools, we need to pay the teachers…'.[99] This position was closer to the one proposed by the user costs method,

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[97] Hector Malave Mata in his remarks during the second session of the conference, in Carrillo Batalla, 'La distribución del ingreso fiscal petrolero entre gastos corrientes y gastos de inversión', p.9.

[98] Ibid., p.79.

[99] Hector Hurtado, Director of Cordiplan –Oficina de Coordinación y Planificación-, on his remarks during the seminar in Carrillo Batalla, 'Evaluación de la inversión del ingreso fiscal petrolero en Venezuela: resumen y conclusiones', p.148. Some other authors pointed out later that the main problem of Venezuelan investment was indeed the fact that such investment was only profitable because part of the oil receipts was devoted to the consumption of goods produced by those investments. See A. Baptista, '¿En qué medida se ha cumplido el vaticinio de Uslar Pietri (*Ahora*, 1936) sobre el parasitistmo rentista en la Venezuela petrolera?,¿ en qué medida se ha "sembrado el petróleo"?', in

which asserts that investing all of the receipts from the natural resource may not be the best solution and therefore allows for part of the rent to be consumed in the current period. All in all, the suggested evaluations of the success of 'sowing oil' shared important features with some of the methods later developed by the environmental accounting literature already introduced in Chapter 2. The crucial difference is that the value of oil depletion was approximated by oil taxes. It will be shown in Chapter 4 that taxes were inadequate as a proxy for oil depletion.

Despite limited achievements and persistent setbacks, it was generally believed that Venezuela had steadily progressed towards modernity since the end of the 1950s.[100] At the same time, the evidence suggests that the first doubts regarding the adequacy of Venezuela's economic statistics and oil exploitation strategy surfaced in this period.

Illusion and Delusion (1970s-1980s)

As a major oil producer and founder member of the OPEC, Venezuela's position in the mid-1970s seemed outstanding:

> 'The Venezuelan nation stands on the summit of success in 1975. On every side evidence of maturity, prosperity and promise brightens the economic and political landscape. [...] The petroleum price increases of 1973 and 1974, for which Venezuela may claim some credit, have provided the financial resources for economic growth and diversification [...] It have yielded the highest growth rate and per capita income in Latin America and a sound basis for expansion'.[101]

Venezuelans apparently had every reason to feel they were exceptional. Politically, Venezuela was treated as an exception in Latin America, cited as a model of a successful transition to democracy or as having 'consolidated' democracy.[102] Economically, the oil boom provided extraordinary resources. To give some idea of the dimensions of the increase of oil prices in the national economy, let us say that the value of oil exports almost tripled between 1973 and 1974 (see Table 3.2-2). Between 1973 and 1976, the fiscal income rose form 11,221 million bolivars to 28,991 million

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Mieres (ed.), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989), p.135.

[100] F. Coronil, *The magical state: Nature, money, and modernity in Venezuela* (Chicago and London, 1997), p.367.

[101] Allen, *Venezuelan Economic Development. A Politico-Economic Analysis*, p.3.

[102] Coronil, *The magical state: Nature, money, and modernity in Venezuela*, p. 367. Venezuela enjoyed a democratic regime since 1958, while autocratic and/or military regimes were the norm in Latin America.

bolivars. Monetary liquidity increased from 21,300 million to 51,200 millions bolivars. International reserves grew from $2,400 millions to $9,300 millions.[103] In addition, the Venezuelan data showed increasing income equality from the late 1950s until 1983 and a more equal income distribution than that found in the other large Latin American countries.[104]

Table 3.2-2: Fiscal and export dependency on oil. Venezuela 1972-1982

Year	Fiscal revenue			Export revenue		
	Total mill bolivar	Oil mill bolivar	oil/total	Total mill bolivar	Oil mill bolivar	oil/total
1972	12,309.12	7,964	64.7%	16,273	15,090	92.7%
1973	16,099.00	11,221	69.7%	23,642	22,306	94.3%
1974	42,649.53	36,508	85.6%	64,062	61,827	96.5%
1975	38,130.49	29,513	77.4%	46,704	44,666	95.6%
1976	39,443.54	28,991	73.5%	39,244	37,089	94.5%
1977	36,572.21	26,588	72.7%	41,640	39,481	94.8%
1978	38,566.10	24,798	64.3%	39,548	37,528	94.9%
1979	55,791.00	38,440	68.9%	61,908	58,519	94.5%
1980	76,022.13	54,964	72.3%	83,072	78,328	94.3%
1981	77,918.95	59,608	76.5%	84,647	81,723	96.5%
1982	73,376.79	46,154	62.9%	71,191	67,068	94.2%

Sources: Appendixes B for export data and C for fiscal data.

Nonetheless, there were simultaneously some critical voices already pointing to the illusory nature of the situation in titles such as *An Illusion of Harmony: Venezuela's case.*[105] According to these authors, the rush of petroleum income temporarily postponed a critical assessment of Venezuelan development.[106] It took almost a decade for these arguments to become mainstream opinions. The reason for such a delay was precisely the healthy appearance of most economic indicators and the confidence in continuing high oil prices.

At this time of bonanza, the government planned to set aside half of the current oil revenues for long-term and foreign investment through the Venezuelan Investment

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[103] Banco Central de Venezuela, *La economía venezolana en los últimos treinta cinco años*.

[104] M. Urrutia, 'Twenty-Five Years of Economic Growth, 1960-1985', in Urrutia (ed.), *Long-Term Trends in Latin American Economic Development* (Inter-American Development Bank, Washington D.C., 1991), p.57, cf. United Nations, Economic Commission for Latin America, *La distribución del ingreso en América Latina* (New York, 1970) p.6; P.P. Kuczynski, 'The Economic Development of Venezuela: a Summary view as of 1975-1976', in Bond (ed.), *Contemporary Venezuela and its role in international affairs* (New York, 1977), p.49 and C.R. Silva, 'Bosquejo histórico del desenvolvimiento de la economía venezolana en el siglo XX', in Mendoza (ed.), *Venezuela Moderna: Medio siglo de historia 1926-1976* (Caracas, 2nd ed., 1979).

[105] M. Naim and A. Pinango (eds.), *El caso Venezuela: una ilusión de armonía* (Caracas, 1974).

Fund in 1974.[107] Shortly after, the government of Carlos Andrés Pérez nationalised the oil industry in 1976. It was seen as the culmination of a slow process through which Venezuela progressively gained more control over the resource and the revenues it generated. The nationalisation was to guarantee for Venezuela not a percentage of the gains but one hundred percent of the benefits from the exploitation of petroleum.[108] As occurred in Mexico, ambitious projects, waste and increased volume of luxury and capital imports gradually consumed a higher proportion of current revenues. Less was channelled into the Venezuelan Investment Fund, and more foreign loans were sought. High interest rates and inflation in the US and Europe contributed to inflation and a rising debt service in Venezuela. In 1977, the current account balance showed the first deficit since 1972.[109]

Nevertheless, it was not until well into the 1980s, when oil prices stabilised, that a serious analysis of the effects of the roller coaster of the 1970s took place.[110] Moses Naim, Minister of Industry in the government of Carlos Andrés Pérez in the late 1980s, wrote:

> 'Venezuela's oil wealth no doubt encouraged the plunder by contributing to the widespread perception held by Venezuelans and foreign creditors alike that the country remained rich... A similar delusion about oil wealth had diverted attention from Mexico's grave institutional weakness in the late 1970s (...)
>
> In sum, after decades of consuming more than they produced, to restore balance, Venezuelans' real incomes and consumption would have to decline'[111]

Although not explicitly exposed along the lines of the sustainability school, this quote alluded to the discrepancy between expenditure and production in natural resource producer countries. As Naim here, other authors had also recognised that due to the nature of oil revenues an increasing gap opened between the real production capacity

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[106] J. Ewell, *Venezuela.A Century of Change* (London, 1984), p. 180 reports a survey of Venezuelan society and economy in 1973, which revealed a number of bottlenecks that limited progress in some areas.

[107] Ibid., p.198.

[108] As in the case of Mexico, there is a prolific literature analysing the process leading to the nationalisation of the oil industry in Venezuela, its origins, development and effects. Just to mention some: see L. Vallenilla, *Oil: the Making of a New Economic Order. Venezuelan Oil and the OPEC* (New York, 1975) for the origin of the nationalisation process. For a good insight into the technicalities of the nationalisation and its origins see J.F. Petras, M. Morley, et al., *The Nationalisation of Venezuelan Oil* (New York, 1977). A review of the effects of nationalisation after some years can be found in G. Coronel, *The Nationalisation of the Venezuelan Oil Industry. From Technocratic Success to Political Failure* (Lexington,Massachusetts, 1983).

[109] Ewell, *Venezuela* p.198.

[110] A summary of the literature of the 1980s and 1990s concerning the myth of oil wealth can be found in Coronil, *The magical state: Nature, money, and modernity in Venezuela* , p. 367-380.

[111] M. Naim, *Paper, Tigers and Minotaurs. The politics of Venezuela's Economic Reforms* (Washington, D.C., 1993), p.3 and p.28.

of that society and its earning and expenditure possibilities.[112] Venezuela's exceptional financial wealth made it possible for the State to implement dazzling development plans that obscured structures typical of other Latin American nations.[113] Authors like Karl recognised this when portraying the paradox of the plenty: oil producers were supposed to be rich but confronting very difficult realities.[114] It was only after the 1980s' crisis that the effects of resource availability on the behaviour of economic agents began to be recognised and analysed. It has been argued that the availability of oil resources entails a confidence effect -on perceived future incomes- that influenced the behaviour of economic agents;[115] This partly explained why producer countries increased their debts and creditors facilitated credit.

Despite problems that had become evident by the early 1980s, the myth of Venezuela as a wealthy democratic nation steadily advancing toward modernity continued to hold into the 1990s. The myth endured currency devaluations, a prolonged decline in the standard of living, massive popular riots, and two abortive military coups in 1992. Nevertheless, the final recognition that Venezuela 'suffered from the political, economic and social problems common to most Latin American countries' led to the 'collapse of Venezuelan exceptionalism' in the mid-1990s.[116]

From an environmental perspective, the 1980s crisis can be interpreted as the effects of having ignored the loss of natural resources in calculations of national income, which masked the true state of the economy.

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[112] A. Uslar Pietri, 'Los males del petróleo', *El Nacional* (1985) 28th April. The increasing disparity between consumption and production in a country such as Venezuela is also referred by B. Mommer and A. Baptista, 'El Petróleo En Las Cuentas Nacionales: Una Proposicón', *Working Paper IESA* 10 (1983), p.3. Furthermore, it has also been argued that resource-abundant economies grow more slowly precisely because they are likely to be living beyond their means since the natural resource allows the economy to afford extraordinary (unsustainable) consumption possibilities. F. Rodriguez and J.D. Sachs, 'Why do resource-abundant economies grow more slowly?', *Journal of Economic Growth* 4 (1999), p. 278.

[113] Coronil, *The magical state: Nature, money, and modernity in Venezuela* , p.369.

[114] T.L. Karl, *The Paradox of Plenty: Oil Booms and Petro-States*, Vol. 26 (Berkeley, 1997).

[115] R. Vaez-Zadeh, 'Oil Wealth and Economic Behavior: the case of Venezuela, 1965-81', *IMF Working Paper*, WP/88/56 (1988, June 30).

[116] Coronil, *The magical state: Nature, money, and modernity in Venezuela* , p.368 and L.W. Goodman, J. Mendelson Forman, et al. (eds.), *The lessons of the Venezuelan experience* (Washington D.C., 1995).

3.3 Conclusions

Through the diverse testimonies displayed in this chapter, it has been shown how the Mexican and Venezuelan governments took different positions regarding the use of their natural resources for most of the twentieth century. While Mexico's administration believed that the best way of making use of the national oil endowment was to provide affordable energy for the country's industrialisation, Venezuelan governments maintained that the role of oil resources was to provide the monetary means for developing the nation. The different views resulted in divergent strategies, which affected every aspect of oil exploitation: legislation, management (public vs. private), pace of exploration and exploitation (slow vs. fast). More important to the methodologies of environmental accounting, each country approximates very closely the theoretical cases of a closed economy and an open economy willing to sell most of the resource to the rest of the world.

The qualitative evidence provided in this chapter also shows that Mexican and Venezuelan scholars identified the ephemeral healthy appearance of resource driven economies very early on in the century. However, it is worth recognising that most of the arguments provided were related not to the national accounting framework but to nationalistic rhetoric. Nevertheless, the intuitions were present. The quantification of the arguments was nonetheless missing, except for the attempts to evaluate 'sowing oil' policies in Venezuela and the standard non-oil GDP measures. If environmental accounting premises are correct, some of the issues raised in the historiography regarding the ephemeral prosperity of Mexico and Venezuela will finally find a quantitative endorsement.

Chapter 4
The calculation of the resource rent

This chapter seeks to calculate the resource rent accruing from oil in Mexico and Venezuela for most of the twentieth century. It has already been mentioned in Chapter 2 that all the methods considered are subject to the calculation of a resource rent, whether they are seeking to adjust for the consumption/depreciation of (natural) capital or for the amount that should not be considered production/added value. According to the theory underlying the Hotelling rent, the price of a depletable resource has two components: production costs and resource rent or depletion cost.[1] The most common way to estimate the latter is to calculate the surplus revenue accruing to the owners of the resource after accounting for the contribution of labour and capital inputs.[2] Data on prices, quantities of oil extracted, labour and capital costs are required. Precisely because the details of the data underlying the calculation make a difference, the chapter first presents and contrasts the series of data used, together with offering reflections on labour and capital costs, before presenting the actual values obtained for the resource rent. Given the complications associated with the data, several permutations are considered as possible approximations to the resource rent.

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[1] H. Hotelling, 'The Economics of Exhaustible Resources', *Journal of Political Economy* 39 (1931) 2; P. Dasgupta and G. Heal, *Economic Theory and Exhaustible Resources* (Cambridge, 1979).
[2] G.D. Santoprieto, 'Alternative Methods for estimating resource rent and depletion costs: the case of Argentina's YPF', *Resources Policy* 24 (1998) 1, p.39.

The chapter starts with an account of the physical resource stock. Prices and the cost side of the equation are considered afterwards. The resource rent is then presented under several permutations of the costs for each country. Since part of the literature argues that oil taxes might be a good approximation to the rent under certain specific circumstances, the chapter concludes with a comparison of the rents estimated here with the actual taxes obtained by the Mexican and Venezuelan governments.[3] The conclusion is that both governments managed to capture a bigger share of the rent as the century went by, but neither was able to capture the whole of the rent at any point in time. Hence, taxes do not make a good proxy for the resource rent. They only measure how good governments are at seizing rents, but do not show the part of the rent that labour (via extra wages or extra workers) and/or capital (via extra profits) managed to acquire.

4.1 Stock of Petroleum

How much we have, how much we have used and how long will it last are key questions at the time of valuing any asset. Reserves, depletion, variations in the stock, and the production-to-reserves ratio are particularly relevant to the valuation of natural resources. Though only the quantity produced is needed for the calculation of the rent, the total amount held at a specific point in time and its change over time is required for the calculation of the resource depreciation that will be elaborated in Chapter 5. In addition, opening and closing stocks of non-produced assets are a required piece of information in the SEEA system (see Figure 2.3-1 above). Therefore, an account of the physical resource is an important piece of information for this research. This section presents comparative historical data on the amount of oil used and available for Mexico and Venezuela.

Figure 4.1-1 shows production and proven reserves of hydrocarbons in Mexico and Venezuela for the period 1901-1989. Proven reserves are mineral deposits located on or below the earth's surface which are economically exploitable, given the current technology and relative prices.[4] As a matter of convenience, the term 'reserves' is commonly used for 'proven reserves'. All in all, the reserves available in both countries increased throughout the century -most dramatically in Mexico, whose

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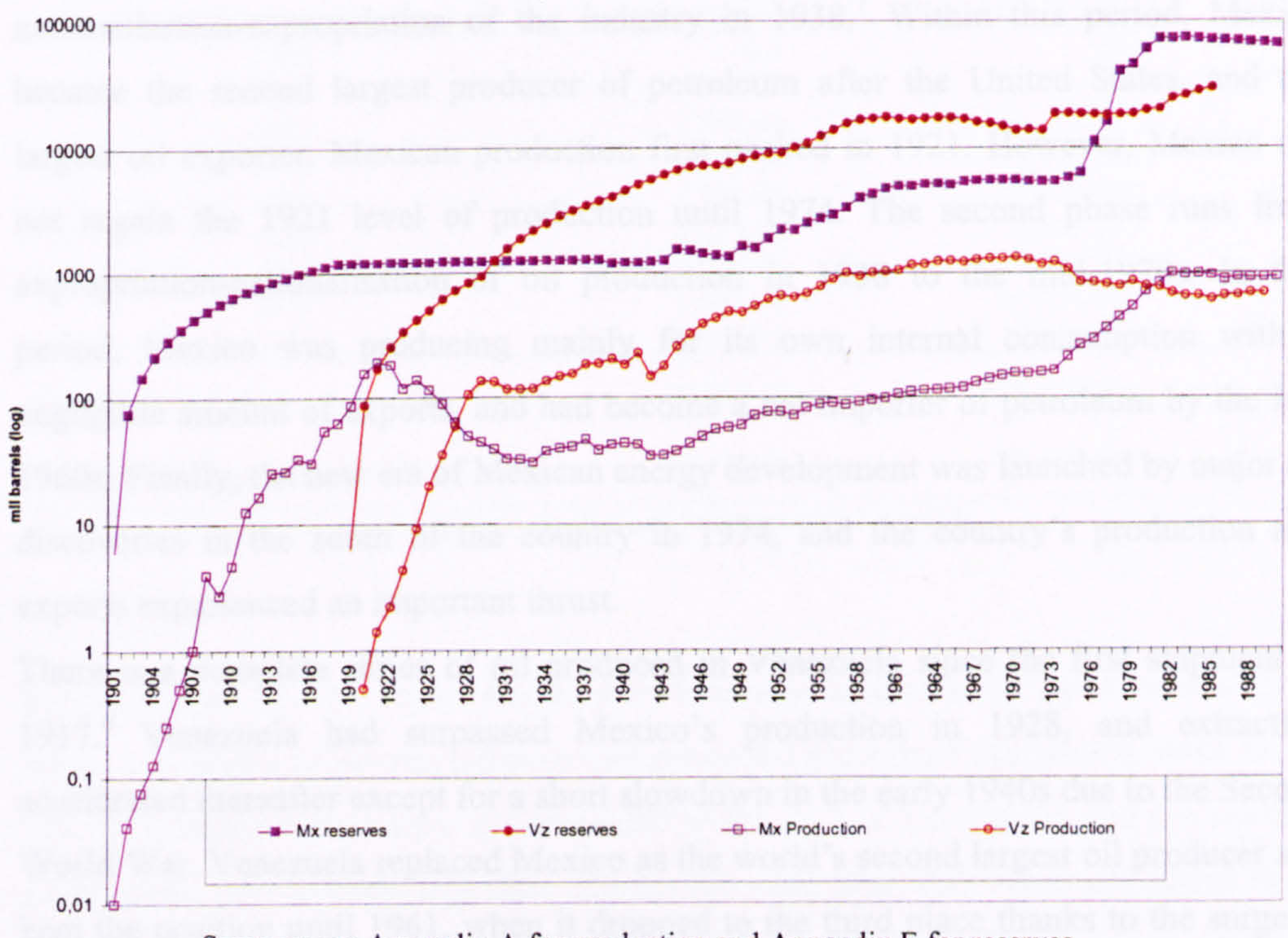
[3] Among those advocating the use of oil taxes as proxy for the rent are R. Stauffer, *Accounting for 'Wasting Assets'. Income Measurement for Oil and Mineral-Exporting Rentier States*, Vol. 25 (Vienna, 1984), p.19 and also B. Mommer, 'Integrating the oil. A structural analysis of petroleum in the Venezuelan economy', *Latin American Perspectives* 23 (1996 summer) 90, p.141.

[4] United Nations, *System of National Accounts 1993* (New York, 1993), paragph.13.59.

reserves sharply rose during the early 1970s. Mexico only experienced a significant period of declining reserves from the 1980s onwards. However, this was mostly due to technical adjustments of the extremely optimistic figures produced during the 1970s rather than the result of rapid depletion.[5] In contrast, Venezuela went through a period of declining reserves between the second half of the 1960s and the early 1970s, which coincided with the years of maximum oil output. A plausible explanation is that companies reacted to the impending nationalisation process by reducing their productive and exploration activities. 'This determined that the oil industry in Venezuela was in a stagnant situation at the time of the nationalisation. The indices of reserves, production, level of employment and reduction of investment in all activities confirm this situation'.[6] Technological change and the increase of the relative price of petroleum made previously un-exploitable resources increasingly available.

Figure 4.1-1: Hydrocarbon Reserves and Depletion. Mexico and Venezuela 1901-1989 (Million barrels)



Sources: see Appendix A for production and Appendix E for reserves.

[5] 'Seismic shifts? (Survey 4 of 8)'. *The Economist*, 6 December 1997. In fact, according to A.M. Sordo and C.R. López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985* (México D.F., 1st. ed., 1988), p.102-103, prior to 1976, proven reserves were estimated by a 'conservative' method based on wells under development. The change to a method that widened the range of 'proven reserves' to the reserves that were economically and technically feasible of development almost doubled the reserves available for that year. This fact only introduces a warning about the conservatism of the figures before 1976 and the exaggerated optimism of those after 1976.

[6] PDVSA, (Petróleos de Venezuela S.A.), *Los primeros diez años de la industria petrolera nacional 1976-1985* (Caracas, 1986), p.9.

The fact that reserves available to each generation increased over time sharply contrasts with the implicit assumption behind most writings in green accounting, which assume the increasing scarcity of resources. This may constitute a problem for the current research, if this underlying assumption underpins the models and methods so strongly that they cannot deal with scenarios such as the historical one depicted here with increasing resources over time. This question is explored in Chapter 5.

The different path of production followed by both countries has already been mentioned in previous chapters, yet let us recall it here once more. Even during the years of the Revolution, the number of barrels of oil produced was carefully annotated in Mexico. There is not much discrepancy between the different figures published. In brief, one can identify three periods in the history of Mexican oil production. The first extends from the first commercial production of crude oil in 1901 to the nationalisation-expropriation of the industry in 1938.[7] Within this period, Mexico became the second largest producer of petroleum after the United States, and the largest oil exporter. Mexican production first peaked in 1921. However, Mexico did not regain the 1921 level of production until 1974. The second phase runs from expropriation-nationalisation of oil production in 1938 to the mid-1970s. In this period, Mexico was producing mainly for its own internal consumption with a negligible amount of exports, and had become a net importer of petroleum by the late 1960s. Finally, the new era of Mexican energy development was launched by major oil discoveries in the south of the country in 1974, and the country's production and exports experienced an important thrust.

There is a complete series of oil produced in Venezuela since the first shipment in 1917.[8] Venezuela had surpassed Mexico's production in 1928, and extraction accelerated thereafter except for a short slowdown in the early 1940s due to the Second World War. Venezuela replaced Mexico as the world's second largest oil producer and kept the position until 1961, when it dropped to the third place thanks to the surge in

[7] A.J. Bermudez, *The Mexican National Petroleum Industry: A case study in Nationalisation* (Stanford, 1963) p.1.

[8] One should be aware of possible problems with the reliability of the data presented here. Although they come from official publications of the Republic of Venezuela, there are reasons to think production might be underestimated. Since exploitation taxes, commonly known as royalties, represented a fixed amount of the production value declared by the company, this likely to have resulted in an under-declaration of production by the companies. Underestimation of the value of oil exports in the official accounts seems unavoidable. Indeed, the efforts to improve the inspection system always found strong opposition from the companies. On this matter, see Chapter 6 in E. Lieuwen, *Petroleum In Venezuela: A History*, Vol. 47 (Berkeley, 1954).

the Middle East.[9] Venezuela accounted for a maximum of 15 percent of world oil production over the whole period.[10] The late 1960s represented the zenith of Venezuela's production. By then, Venezuela produced ten times the amount of oil Mexico was producing. As consequence of the foreseeable nationalisation, Venezuela's production started to decline from 1970. For its part, Mexico oil production revived in the mid 1970s and achieved its maximum output level in 1982, shortly after surpassing Venezuela's production for the first time in over fifty years.

It is worth mentioning that the difference is more one of pace of extraction rather than one of radically different endowments, since the total endowment is relatively similar as Table 4.1-1 shows. The contrast between in the rate of extraction is expected to leave its mark in the value of the resources.

Table 4.1-1 Accumulated oil production 1901-1985. Mexico and Venezuela

Accumulated oil production until	**Mexico** Mill. Barrels	**Venezuela** Mill. Barrels
1905	0.5	0
1915	127.24	0
1925	1,301.46	38.14
1935	1,765.63	1,148.14
1945	2,173.63	3,199.64
1955	2,871.08	8,945.04
1965	3,906.01	19,786.04
1975	5,562.74	31,934.04
1985	12,661.31	39,421.04
Oil reserves in 1985	70,900.00	29,236.00
Aggregated oil endowment 1905-1985	83,561.00	68,747.00

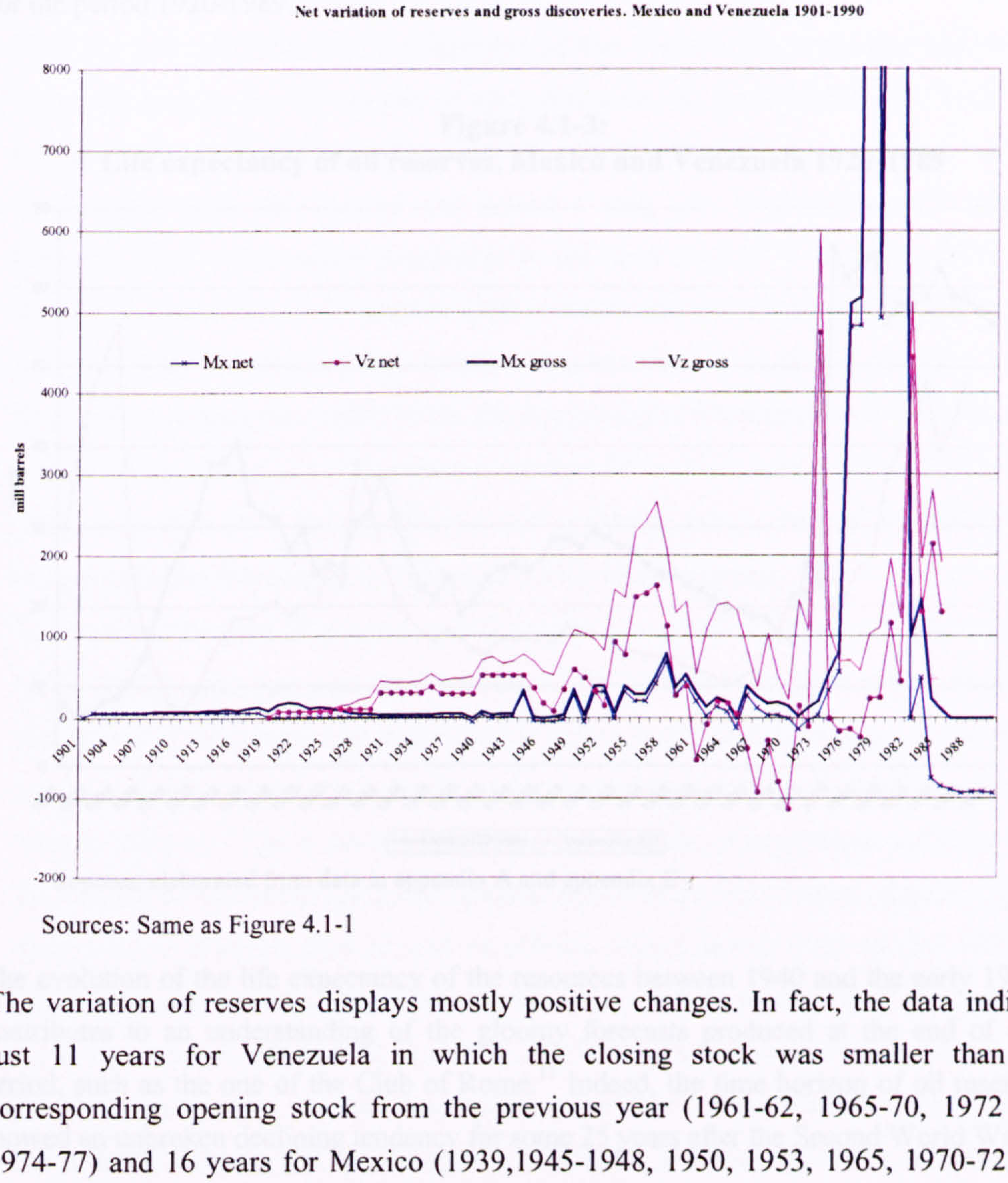
Sources: Own elaboration from the data in Appendixes A and E

Some methods do not require the stock of resources available but the variation of the stock. The series of proven reserves just presented represents the closing stock of the year in question (since they are measured at the 31st of December) and the opening stock of the year immediately after. During the year, new discoveries are added to the reserves and also extraction takes place. Figure 4.1-2 presents the variation of stocks both by plotting the new discoveries (gross additions) and the net changes (differences between opening and closing stocks).

The massive discoveries in Mexico of the first half of the 1970s dwarf the importance of the discoveries made throughout the century despite the re-scaling of the graph.

[9] United Nations. Department of Economic and Social Affairs, *Petroleum Exploration: Capital Requirements and Methods of Financing* (New York, 1962), p.3.

Figure 4.1-2 -Yearly variation of hydrocarbon reserves: Mexico and Venezuela 1901-1989



Sources: Same as Figure 4.1-1

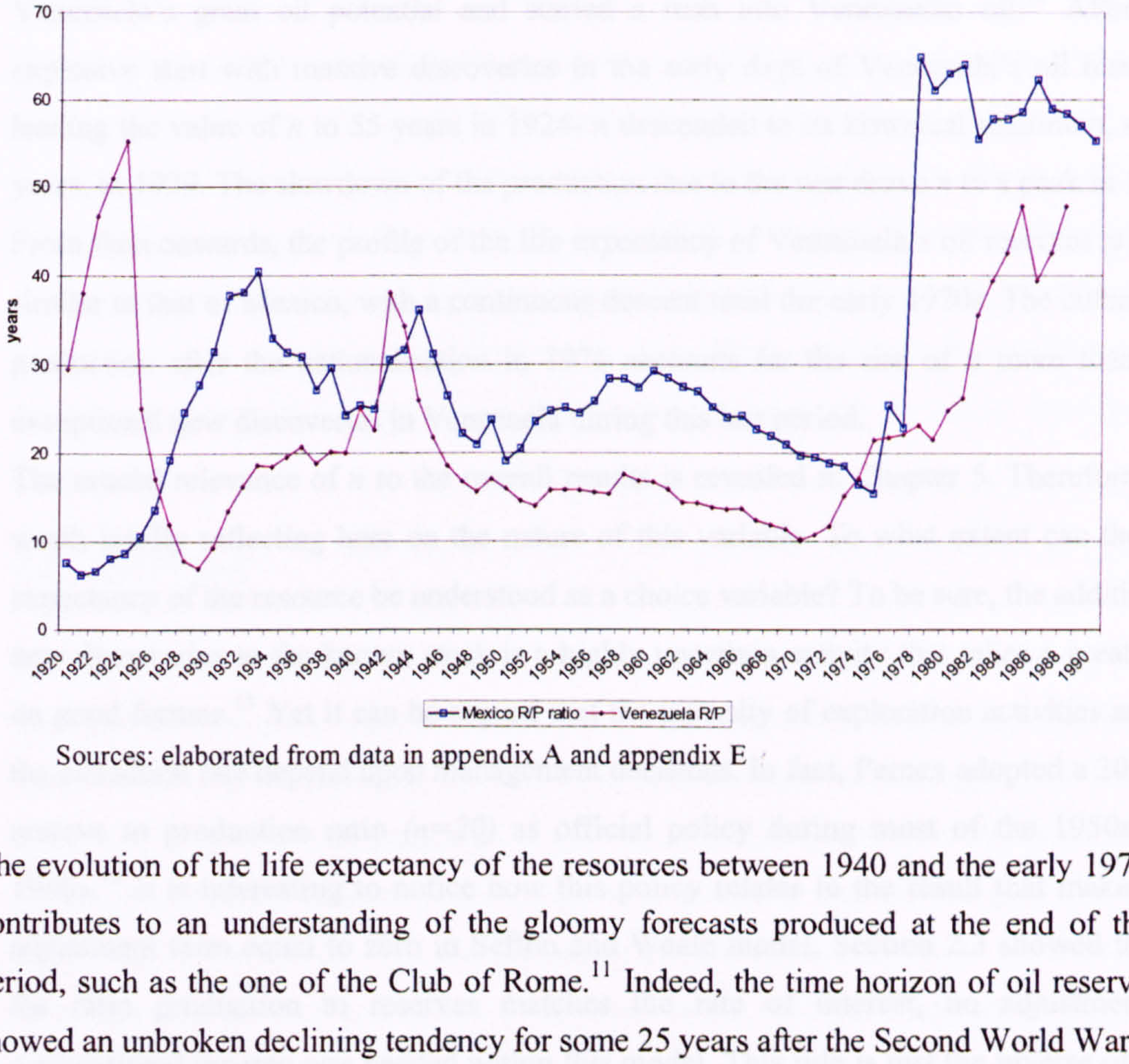
The variation of reserves displays mostly positive changes. In fact, the data indicate just 11 years for Venezuela in which the closing stock was smaller than the corresponding opening stock from the previous year (1961-62, 1965-70, 1972 and 1974-77) and 16 years for Mexico (1939,1945-1948, 1950, 1953, 1965, 1970-72 and 1984-88). For the rest of the series, reserves increased. These figures will be relevant for the calculation of the net price in its most extreme variation, given that the change in the volume of reserves (and not current production) is the figure used for the calculation of the resource depletion. As has already been mentioned, an increasing volume of reserves is the exception rather than the rule among the theoretical models in vogue.

Finally, another set of methods is not concerned with how much we have, use or how the stock varies, but with how much longer the resource is expected to last. The

[10] Oil and Gas Journal, 'World overview', *Oil and Gas Journal,* (monthly) December.

reserves-to-production ratio, namely the life expectancy of the resource, named *n* herein, is calculated by dividing the proven reserves by the amount produced in a given year. Figure 4.1-3 contrasts the life expectancy of oil reserves in Mexico and Venezuela for the period 1920-1989.

Figure 4.1-3:
Life expectancy of oil reserves. Mexico and Venezuela 1920-1989



Sources: elaborated from data in appendix A and appendix E

The evolution of the life expectancy of the resources between 1940 and the early 1970s contributes to an understanding of the gloomy forecasts produced at the end of that period, such as the one of the Club of Rome.[11] Indeed, the time horizon of oil reserves showed an unbroken declining tendency for some 25 years after the Second World War. Despite having held smaller reserves for most of the period, the slower pace of exploitation allowed Mexican reserves a longer life expectancy than those of Venezuela for most of the period. Nevertheless, the short life expectancy of Mexican reserves over the 1920s is notorious. It is worth remembering that the peak of production of the first Mexican oil era was in 1921. These figures justified the fear of exhaustion revealed by contemporary commentators and the subsequent deceleration of the oil production that caused life expectancy to grow until the late 1930s.[12] From then onwards, the lack of

[11] Meadows et al., *The limits of growth* (New York, 1972).

[12] The fear of exhaustion in the 1920s and 1930s was already referred in Chapter 3. See also J. Silva Herzog, 'La expropiación de las compañías petroleras en México', *Revista de Economía* II (1938) 7-12;

discoveries drove *n* downwards in a path hardly broken until the huge discoveries of 1974.[13] These discoveries pushed the life expectancy of Mexican reserves to a level never achieved before: 60 years.

Until the end of 1922, the development of the Venezuelan petroleum industry was restricted. Despite the big number of oil concessions, no great deposits had been found. On December 14th 1922, the blowout of well Los Barrosos No2 showed the world Venezuela's great oil potential and started a rush into Venezuelan oil.[14] After this explosive start with massive discoveries in the early days of Venezuela's oil history - leading the value of *n* to 55 years in 1924- *n* descended to its historical minimum, seven years, in 1929. The slowdown of the production due to the war drove *n* to a peak in 1942. From then onwards, the profile of the life expectancy of Venezuela's oil reserves is quite similar to that of Mexico, with a continuous descent until the early 1970s. The cutback in production after the nationalisation in 1976 accounts for the rise of *n* more than any exceptional new discoveries in Venezuela during this last period.

The crucial relevance of *n* to the overall results is revealed in Chapter 5. Therefore it is worth briefly reflecting here on the nature of this variable. To what extent can the life expectancy of the resource be understood as a choice variable? To be sure, the addition of new discoveries to the known stock is a highly uncertain activity that relies a great deal on good fortune.[15] Yet it can be argued that the intensity of exploration activities and of the extraction rate depend upon management decisions. In fact, Pemex adopted a 20 year reserve to production ratio *(n=20)* as official policy during most of the 1950s and 1960s.[16] It is interesting to notice how this policy relates to the result that makes the adjustment term equal to zero in Sefton and Weale model. Section 2.3 showed that if the ratio production to reserves matches the rate of interest, no adjustment to conventional income was needed within this model. This rule is just the inverse of *n*. If we believe that a 5 per cent is a reasonable long run interest rate, the corresponding life expectancy of the resource is precisely 20 years. If the premises of Sefton and Weale model hold it is reasonable to expect Mexican welfare income and conventional

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J. López Portillo, 'Las Reservas Petroleras Mexicanas', *Revista de Economía* II (1938) 7-12 and E. Sangines Villavalva, 'La industria petrolera en México', *Revista de Hacienda* II (1938 Marzo).

[13] For Mexican exploration policies, see Sordo and López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985* Appendix E includes a brief note on Pemex's exploration policies.

[14] A.R. Martínez, *Venezuelan Oil Development and Chronology* (London, 1989), p.39-41.

[15] United Nations. Department of Economic and Social Affairs, *Petroleum Exploration: Capital Requirements and Methods of Financing*, p.1.

[16] See PEMEX, (Petróleos Mexicanos), *Informe del Director General, 1953-1960* (México D.F., 1953-1960) and Sordo and López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985*, and Appendix E.

income should differ by much. It is not clear whether the Mexican government took this sort of arguments into account when choosing a 20 years time horizon.

Management can influence the value of *n* by either intensifying exploration activities– thus increasing the probability of new discoveries- or by cutting/accelerating the rate of extraction. Since the value of *n* directly derives from these decisions affecting the magnitude of reserves and production, it is clear that there is some discretion over its value.

The physical account of hydrocarbon resources in Mexico and Venezuela reveals the increasing availability of economically exploitable deposits over time. Over time, both countries have enjoyed similar endowments with some advantage for Mexico, which is mostly due to the huge discoveries of the early 1970s. This fact, in conjunction with the slower pace of exploitation in Mexico, gives Mexican reserves a longer life expectancy than Venezuelan ones for most of the century. The effects and implications of these facts for the valuation of the resource and its depreciation value will be further developed in Chapter 5.

4.2 Oil Prices

The pricing of crude oil is one of the most controversial issues relating to the international petroleum industry. Even inside the American oil industry, which has the most elaborate price reporting and statistical series of any oil business in the world, it is not easy to get rational discussion of the way in which these prices are formed.[17] An additional difficulty consists in deciding what prices to use: posted prices, realised prices, discounted prices, etc. Posted prices are the most relevant to our discussion since they are the real foundation of revenue of the host governments of producing countries. Historically speaking, posted prices originated in the United States and they were the buyer's price, not the seller's prices. That is, refiners, who thus defined the prices they were willing and prepared to pay for crude oils at the wellhead from any producers connected to their pipeline gathering system, announced them. After transportation costs were added, posted prices were determined at export terminals on the U.S Gulf Coast.[18] One should be aware of the fact that realised prices were well under posted prices, and therefore using posted prices will overestimate the actual

[17] J.E. Hartshorn, *Oil Companies and Governments* (London, 1967)p.128. However, something can be said about some of the variables that influence the price of oil. For definitions and the geographical distribution of different types of oil, see G. Jenkins, *Oil Economist's Handbook 1985* (1985). See also the brief summary presented in Appendix E.

[18] T. Rifai, *The Pricing of Crude Oil* (London, 1974), p. 8.

value of the resource. In any case one should also be aware that a price per barrel, whether posted, realised or discounted, is based on averaging: the average of the price during each year (oil prices vary daily), the average of the prices in different markets, the average of the price of different qualities of oil. Therefore, it is just an approximation to the actual value of oil produced in a year. A brief description of the oil price series available for Mexico and Venezuela and contrasts between them is presented in this section.

No historical series of Mexican crude oil prices has been available previously. The construction of the price series presented here, is one of the original contributions of this research. From nationalisation in 1938 until 1975, official price series for Mexican crude oil do not exist.[19] Arguably, the reason is that most crude oil was for internal consumption. Therefore, there was no market price but only a transfer price within Pemex units. Regrettably, the transfer price was never calculated as such.[20] Nevertheless, Mexico continued to export a small surplus of crude oil each year after nationalisation.[21] The Banco Nacional de Comercio Exterior S.A. (National Bank of Foreign Trade Co), systematically recorded the value and volume of crude oil exported from 1935 to 1973.[22] Therefore, the price per barrel of Mexican oil can be inferred from these series after converting units (cubic meters, tonnes, dollars, etc.). The time series has been constructed from assembling value and volume data from production (1901-1937) and for exports of crude oil (1938- 1975) plus the official price list from 1975. The complete price series has been cross checked with New York posted prices and Venezuelan oil market prices, which can provide a 'market' consistency to the series once one accounts for the differences in quality and the transport costs.

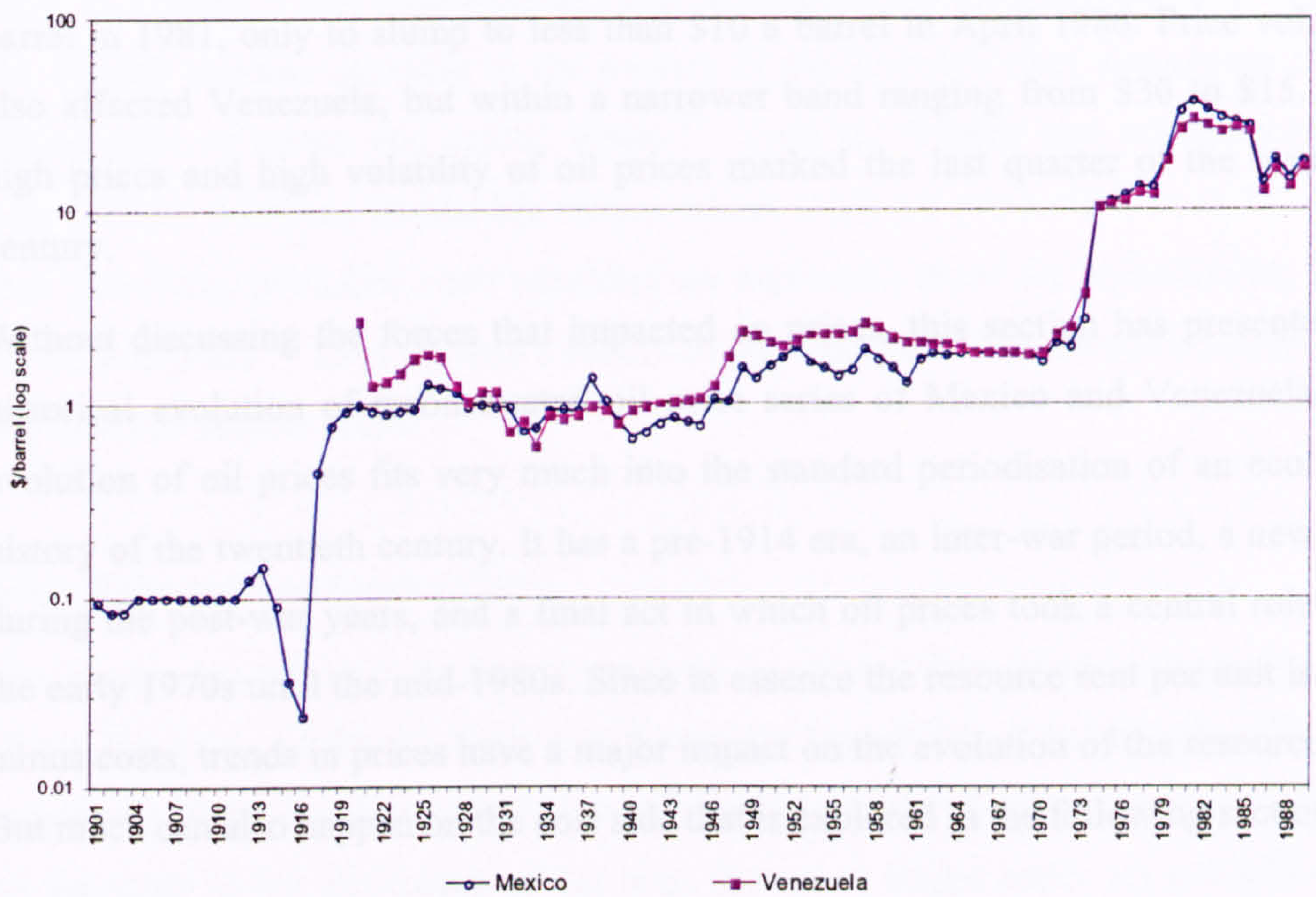
An oil price series for Venezuela is readily available from 1917 to 1990. That is not to say that it is free of problems for the purpose of this research. Tax-reference prices and exchange rates complicate the matter. From 1966, taxes were computed at the new higher rate, based on the tax reference price or the realised price, whichever was the higher. Tax reference prices for crude oils were set according to a mathematical

[19] P. Muñoz and J.C.Boué former employees of Pemex, in a private communication to the author.
[20] Still in 1980 'Pemex does not give any data regarding the value of crude and gas at well', México. Secretaría de Programación y Presupuesto, *La industria petrolera en México* (México D.F., 1980), p.11.
[21] The amount exported is generally smaller than ten percent of the total amount of crude oil produced. Elaborated products were also exported in small amounts.
[22] Banco Nacional de Comercio Exterior S.A., *6 años en el comercio exterior de México* (México D.F., 1964).
Banco Nacional de Comercio Exterior S.A., *Comercio Exterior de México* (México D.F., Volumes for the period 1948-1973).

formula articulated on basic gravity differentials. [23] For the calculation of the rent, however, realised prices are used here.

The recent history of oil prices is well known, and almost everybody can identify the early 1970s as the crucial benchmark. This is easily identifiable in the graphical representation of oil prices throughout the century presented in Figure 4.2-1.

Figure 4.2-1 Oil prices in Mexico and Venezuela. 1920-1989 (dollars per barrel)



Sources: see Appendix F

However, the period before 1970 also has some interesting features. Before the First World War oil was an extremely cheap product. It was only after the onset of the war that the barrel of oil achieved the $1 mark, and this is the time when Venezuela joined the market. This price remained as the highest achieved until the onset of the Second World War. The price then rose to a new level of between $1.5 and $2.5, which remained relatively stable until the 1970s. The conventional wisdom about oil prices over the 1950s and 1960s was that, it was in fact difficult to find an export product less subject to violent fluctuations than petroleum.[24] Throughout that period, Mexican oil

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[23] Rifai, *The Pricing of Crude Oil* .

[24] International Bank for Reconstruction and Development (IBRD), *The Economic Development of Venezuela* (Baltimore, 1961), p.21. The report continues: '...and the establishment in 1960 of the OPEC may reinforce these stabilizing tendencies'. It took thirteen more years to prove the analysis wrong.

received a lower price than Venezuelan oil, due to quality. Most Mexican oil was heavy and therefore of lower value than the medium-to-heavy Venezuelan oil.[25] For almost three-quarters of the twentieth century, the price of a barrel of oil fluctuated within an extremely narrow band at a very low price.

The oil crisis of the early 1970s swept away this long tradition of stable oil prices. It also altered the ranking of the two countries under scrutiny; from 1974, the Mexican price per barrel surpassed that of Venezuela. The gap widened during the second round of the crisis, when the roller coaster of oil prices took Mexican oil to almost $40 a barrel in 1981, only to slump to less than $10 a barrel in April 1986. Price volatility also affected Venezuela, but within a narrower band ranging from $30 to $15. Both high prices and high volatility of oil prices marked the last quarter of the twentieth century.

Without discussing the forces that impacted on prices, this section has presented the historical evolution of reconstructed oil price series of Mexico and Venezuela. The evolution of oil prices fits very much into the standard periodisation of an economic history of the twentieth century. It has a pre-1914 era, an inter-war period, a new level during the post-war years, and a final act in which oil prices took a central role from the early 1970s until the mid-1980s. Since in essence the resource rent per unit is price minus costs, trends in prices have a major impact on the evolution of the resource rent. But much can also happen on the cost side that is explored in the following section.

[25] US Tariff Commission, 'Production cost of petroleum products and of refined petroleum products'. (Washington, D.C., 1932), p.51.

4.3 Cost Side of the Equation

Ideally, marginal cost is required for the calculation of Hotelling rents. Although, the empirical data covers a whole range of costs: 'operating costs', 'costs of extraction', 'average production costs', 'development costs', etc., no marginal costs are included. Some authors have attempted to estimate marginal costs, but most studies use average costs as a proxy.[26] The most common way to estimate the resource rent is to calculate the surplus revenue accruing to the owners of the resource after accounting for the contribution of labour and capital inputs.[27] Even so, reliable cost estimates are not easy to find. Adelman started his chapter about crude oil production costs by stating that 'few if any published costs estimates are explained; fewer are reproducible; nearly all are irrelevant'.[28] Dealing with a historical data set and a State owned company does not improve matters either.

Some Reflections on Labour Costs

The payment to labour is the first component discounted from gross income in order to obtain the value of the resource rent. Since the size of the costs directly affects the magnitude of the resource rent, it is mandatory to explore the possible bias introduced by the costs in the calculation of the rent. Historical wages series are available from official sources for both Mexico and Venezuela.

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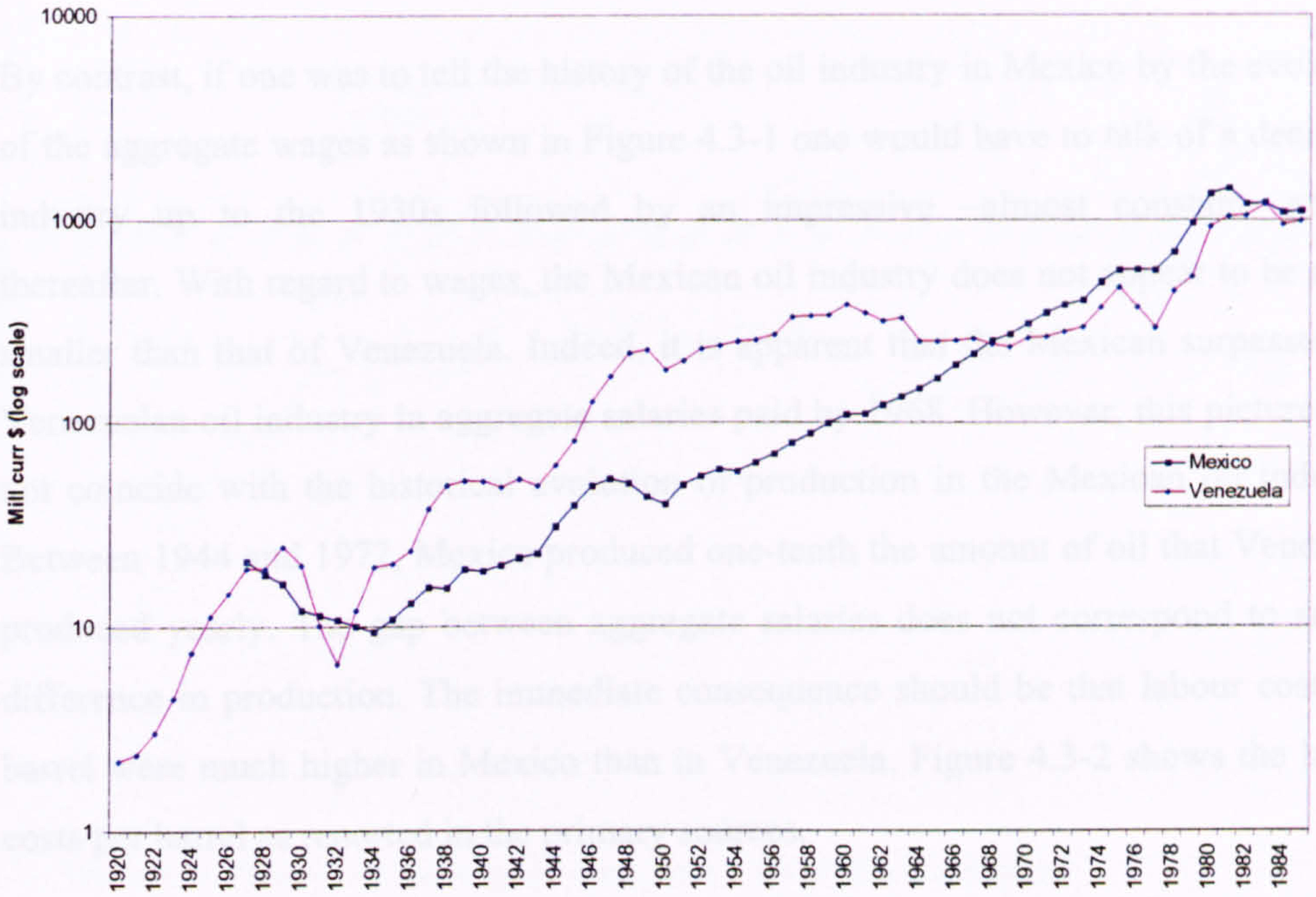
[26] These exceptions together with the underlying assumptions and implications of using average costs as a proxy for marginal costs were noted in Chapter 2.
[27] G.D. Santoprieto, 'Alternative Methods for estimating resource rent and depletion costs: the case of Argentina's YPF', *Resources Policy* 24 (1998) 1, p.39.
[28] From Chapter 2, 'Crude oil Production Costs' in M.A. Adelman, *The World Petroleum Market* (Baltimore, 1972).

Figure 4.3- 1:
Total wages paid in the oil industry: Venezuela and Mexico, 1920-1985



Sources : For Venezuela labour costs 1921-1991 A. Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991), pp. 139-141.
For Mexico labour costs 1934-1936 México. Secretaría de Patrimonio Nacional, *El Petróleo de México* (México D.F., 1940 1st ed., 1963), pp.477-510. For the year 1937 PEMEX, (Petróleos Mexicanos), *Informes del Director General Senador Antonio J.Bermúdez 1947-1952* (México D.F., 1952), 1938-1992 México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994), p.573.

The profile of Venezuela's aggregate wages in the oil industry in Figure 4.3-1 depicts the history of the oil industry faithfully.[29] It shows the explosive development of the industry in the early 1920s, the effects of the Great Depression and the expansion of the oil industry during the 1940s and 1950s. The relatively smooth transition to a mature industry in the 1960s is clearly reflected in the slowdown of the growth of aggregate wages during this period. Between 1973 and 1975 the inflationary effect of the oil shock is also visible. The nationalisation, however, offers a more distinct profile than all the other oil-related variables when it comes to aggregate wages. By 1976, most of the data series relating to oil in Venezuela slow down and some even

[29] See Chapters 1 and 3.

plummeted.[30] However, aggregate wages after 1976 experienced a growth rate similar to that of the 1950s. This effect will have obvious consequences to the calculation of the rent: higher payments to labour imply a lower rent.

By contrast, if one was to tell the history of the oil industry in Mexico by the evolution of the aggregate wages as shown in Figure 4.3-1 one would have to talk of a declining industry up to the 1930s followed by an impressive –almost constant- growth thereafter. With regard to wages, the Mexican oil industry does not appear to be much smaller than that of Venezuela. Indeed, it is apparent that the Mexican surpassed the Venezuelan oil industry in aggregate salaries paid by 1968. However, this picture does not coincide with the historical evolution of production in the Mexican oil industry. Between 1944 and 1972, Mexico produced one-tenth the amount of oil that Venezuela produced yearly. The gap between aggregate salaries does not correspond to such a difference in production. The immediate consequence should be that labour costs per barrel were much higher in Mexico than in Venezuela. Figure 4.3-2 shows the labour costs per barrel as reported in the primary sources.

According to official figures, Mexico's labour cost per barrel far exceeds the labour costs of Venezuela -as much as ten times by the late 1960s, when the gap was widest. In Mexico, the nationalisation of 1938 resulted in growth of the labour cost per barrel to the extent that, by the late 1940s, it almost equalled the price of a barrel of oil. Indeed already by 1942, the labour cost per barrel was double that of 1937. It is worth remembering that one of the main reasons put forward for the nationalisation was to improve the status of oil workers.[31] The labour cost per barrel also increased sharply in Venezuela after the 1976 nationalisation. In fact, labour costs per barrel went in Venezuela above those in Mexico in 1982, for the first time since both countries entered world oil markets at the beginning of the century.

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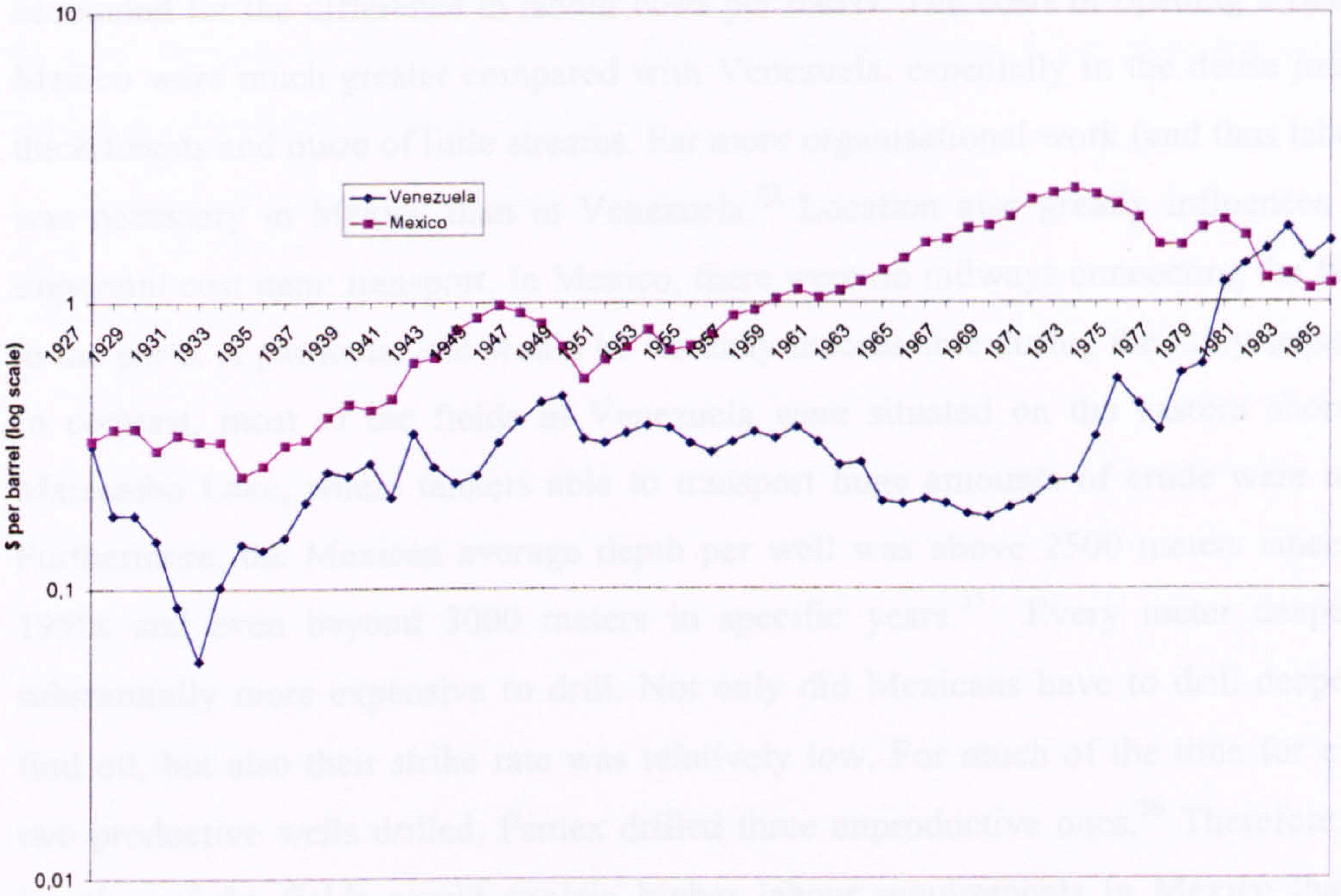
[30] In particular production, exploration activities slowed down after nationalisation in Venezuela. Recall related sections earlier in this Chapter.

[31] See V. Novelo, *La difícil democracia de los petroleros* (México, D.F., 1991); R. Ramirez Heredia, *La otra cara del petróleo* (México, D.F., 1979); S.L. Adleson, 'The Cultural Roots of the Oil Workers' Unions in Tampico1910-1925", in Brown and Knight (eds.), *The Mexican Petroleum Industry in the Twentieth Century* (Austin, 1992).

Figure 4.3- 2:
Labour costs per barrel of oil produced: Venezuela and Mexico, 1927-1985



Sources: as Figure 4.3-1 for wages and appendix A for production figures;
Note: For Mexico, the figures from 1975 to the end of the series are a three-year moving average in order to smooth the effects of the shocks on the peso/dollar exchange rate.

Prima facie, the comparison between the labour costs per barrel of oil produced in Venezuela and Mexico points to the inefficiency of the Mexican oil industry. Some possible driving forces behind this result that are worth exploring include the differences in the volume produced, the different physical characteristics of oil production in both countries, the appropriation of rents by the labour force (through extra wages or extra workers) and qualifications regarding the data available.

The immense volume of oil produced in Venezuela compared with Mexico and the different location of the oil fields may account for part of the difference in labour costs per barrel. It is plausible to assume that the amount of people needed in a well is more or less fixed, regardless of the amount of oil the well is able to produce. After all, final output depends on the geophysical conditions of the oil field. Then the high volume per well in Venezuela will have pushed down the average labour cost per barrel since its fields were better endowed.[32] Therefore, the high volume would be responsible in part for the lower cost per barrel in Venezuela.

[32] It is possible to argue on the contrary that the poor performance of Mexican oil fields was due to the lack of investment in more advanced technologies. For instance, Pemex stopped to using gas injection in

It has also been argued that the different location of the fields may partly have accounted for the difference in labour costs per barrel. The costs of opening a field in Mexico were much greater compared with Venezuela, especially in the dense jungle, thick forests and maze of little streams. Far more organisational work (and thus labour) was necessary in Mexico than in Venezuela.[33] Location also greatly influences one important cost item: transport. In Mexico, there were no railways connecting the fields to the ports. A particular site would be virtually inaccessible during the rainy season.[34] In contrast, most of the fields in Venezuela were situated on the eastern shore of Maracaibo Lake, where tankers able to transport huge amounts of crude were used. Furthermore, the Mexican average depth per well was above 2500 meters since the 1950s and even beyond 3000 meters in specific years.[35] Every meter deeper is substantially more expensive to drill. Not only did Mexicans have to drill deeper to find oil, but also their strike rate was relatively low. For much of the time for every two productive wells drilled, Pemex drilled three unproductive ones.[36] Therefore, the location of the fields would explain higher labour requirements in Mexico than in Venezuela, and also would partly justify higher overall operation costs (which are analysed below). Nevertheless, some authors have suggested that oil operations in Mexico were in any case less profitable than they would have been had they taken place in Venezuela.[37] Therefore, one has to consider the hypothesis of Mexican labour-inefficiency argument.

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some fields. Estimates for Poza Rica fields considered that 'with no-gas injection the ultimate recovery was 1360 mill barrels, with injection of 40 mm c.f./day the ultimate recovery rose to 1740mill barrels'. PEMEX, (Petróleos Mexicanos), 'Estimated Oil, Gas and Condensate production at the end of 1949 and June 1950'. (México D.F., 1951). Nevertheless, the fact is that Venezuelan wells were far more productive than Mexican, pushing average costs per barrel down.

[33] W.C. Gordon, *The Expropriation of Foreign-Owned Property in Mexico* (Washington D.C, 1941), p.84. (Parentheses added). The author refers to the comparison of Mexico with the USA. The lower cost of exploration and development in Venezuela compared to Mexico were already identified in Chapter 1.

[34] Gordon, *The Expropriation of Foreign-Owned Property in Mexico*, p.84.

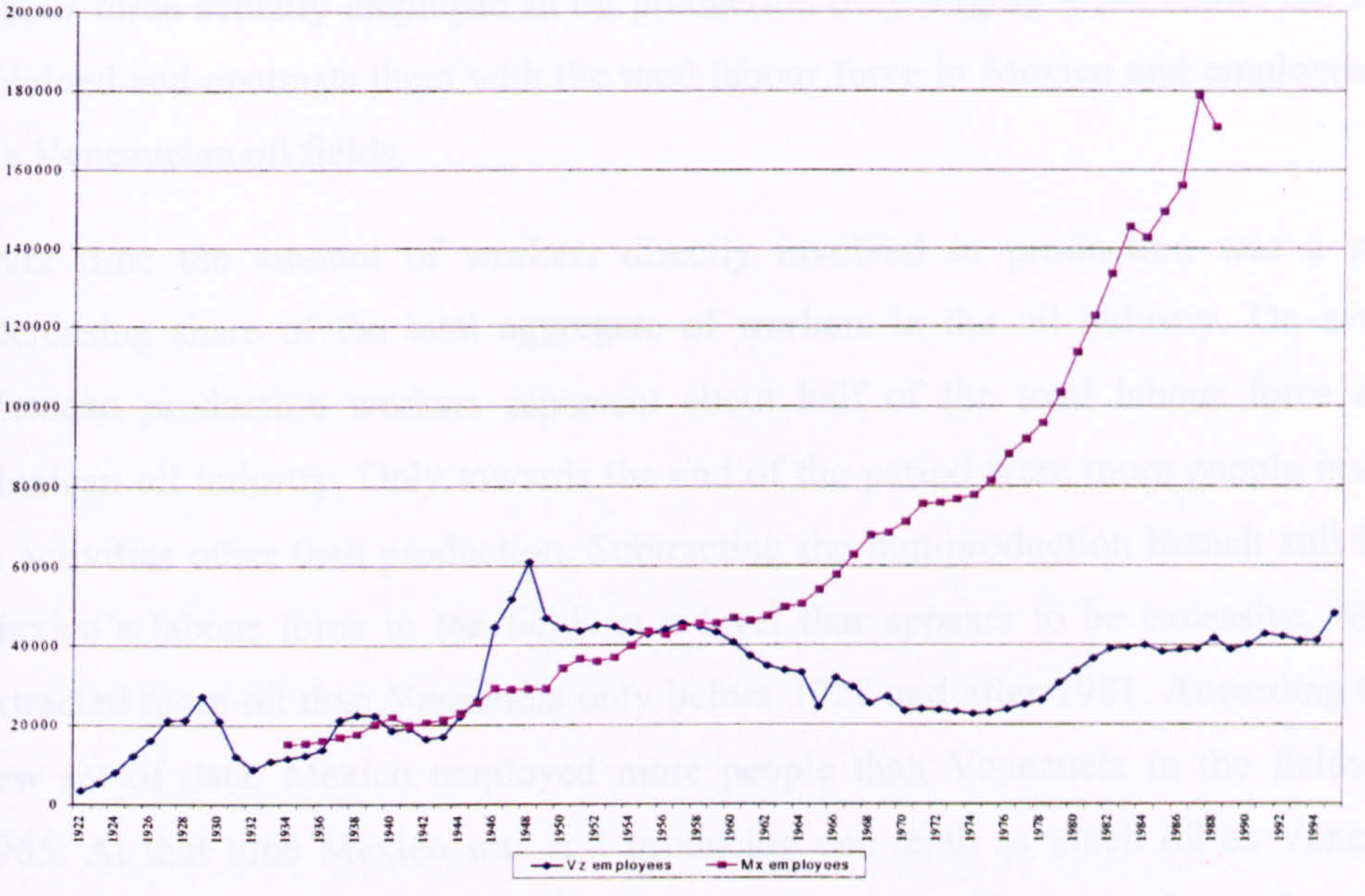
[35] Data compiled from the following sources, México. Secretaría de Hacienda y Crédito Público. Dirección General Técnica de Ingresos. Oficina de Investigaciones Económicas, *La Industria del Petróleo en México*; México. Secretaría de la Economía Nacional. Dirección General de Estadística, *México en cifras* (México D.F., 1938); México; PEMEX, (Petróleos Mexicanos), *Informe del Director General, 1953-1960* (México D.F., 1953-1960); 1947-1952; PEMEX, (Petróleos Mexicanos), *Anuario Estadístico 1988* (México D.F., 1988); PEMEX, (Petróleos Mexicanos), 'Memoria de Labores 1973', in Instituto Mexicano del Petróleo (ed.), *Memorias de Labores 1965-1973*, Vol. I (1984) and Rippy, *Oil and The Mexican Revolution*. Data available upon request from the author.

[36] For exploration issues see Appendix E. Suffices to mention here that mismanagement and lack of the appropriate human resources have been raised as explanations for Pemex's low exploration success. These arguments can also explain part of the overall cost difference between Mexico and Venezuela.

[37] L. Randall, *The Political Economy of Mexican Oil* (New York, 1989), p.2 (see p.195 for the estimation). In a pure econometric exercise, Randall finds that oil operations in Mexico were 18 percent less profitable than they would had been in Venezuela from 1976 to 1984, controlling for percentage changes in output per well. Even though her findings are weak, since does not account for other factors

One possibility is that the Mexican oil industry was using an amount of labour above the efficient level. That is, the labour force was appropriating part of the resource rent via over staffing. In order to explore this possibility Figure 4.3-3 plots the official figures of employees in the oil industry.

Figure 4.3-3: Labour force employed in oil industry: Venezuela and México, 1922-1995



Sources: Mexican labour force for 1934-1935 from México. Secretaría de Hacienda y Crédito Público. Dirección General Técnica de Ingresos. Oficina de Investigaciones Económicas, *La Industria del Petróleo en México* (México, D.F, 1938), pp.68-70, and 1938-1988 from México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* , p.573. Venezuelan labour force from Baptista, *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)* , cuadro B-5

Indeed, the total number of workers in the Mexican oil industry is above the total number of workers in the Venezuelan industry for most of the period excluding the years 1945 to 1955, which corresponds to the expansion of Venezuelan oil industry. The Mexican labour force was double that of Venezuela in 1976 and it was four times greater by the 1990s. Considering Mexico's production was much smaller (one-tenth of Venezuela's) for most of the period, this is surprising. The Mexican oil industry seems to have employed far more people than would have been efficient.

However, these results have been derived from the aggregated data set. The Mexican data presented so far did not distinguish between the different branches of the industry. The figures of the labour force for Mexico include all the workers of Pemex, regardless of their activity within the firm. By contrast, the Venezuelan figures reflect only employment in the production branch of the industry. Since the resource rent

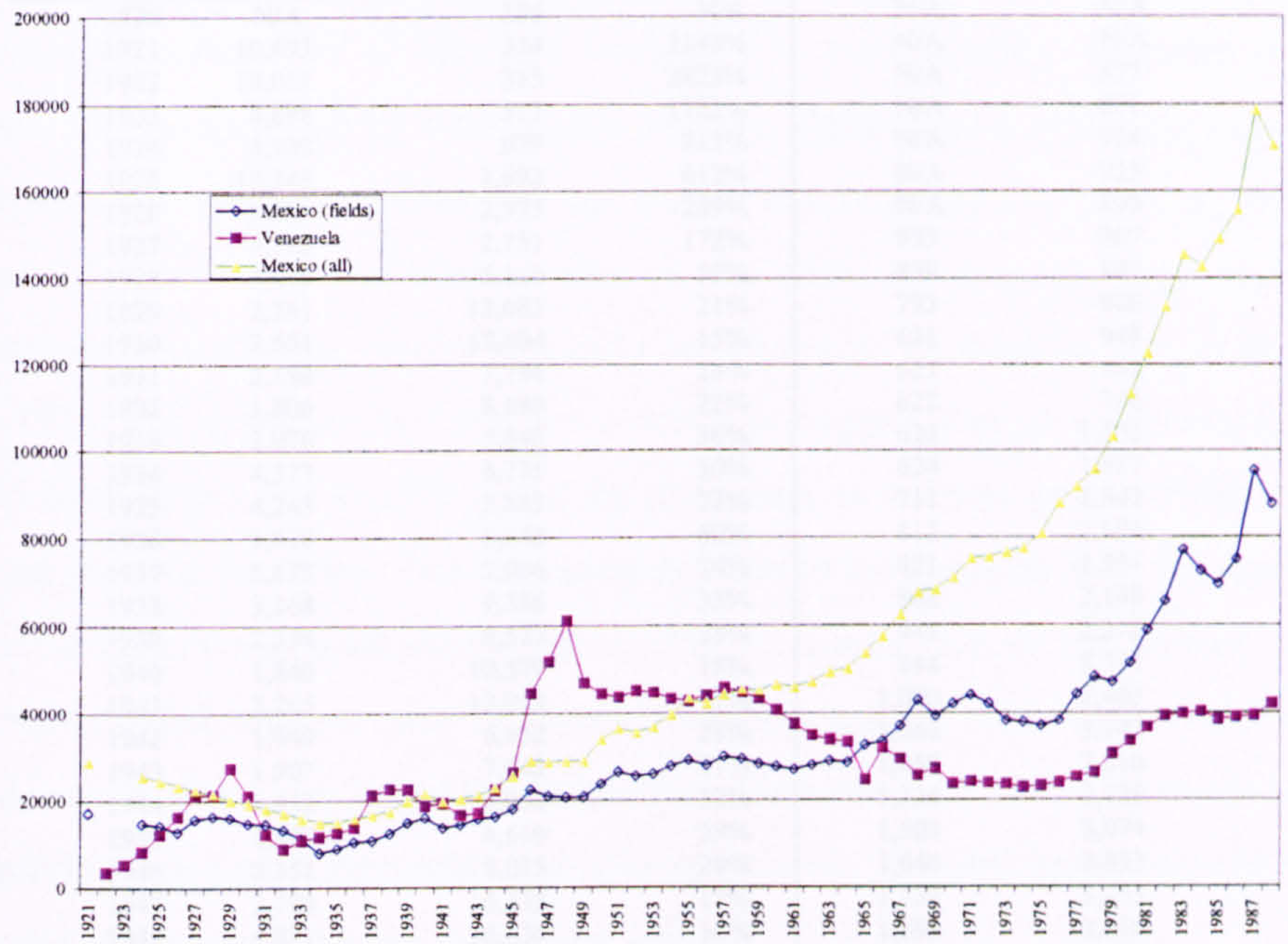
such as the location of the fields, the depth of the well, etc, it is worth exploring the wage inefficiency calculation depends crucially on the costs of extracting the resource, one needs to make sure that only the labour costs of extracting the resource are included.

The data series on exploration, production, refining and some scattered data on employment in Mexican oil fields can be used to estimate the size of the Mexican labour force actually employed in oil production only. Figure 4.3-4 shows the results obtained and contrasts them with the total labour force in Mexico and employment in the Venezuelan oil fields.

Over time the amount of workers directly involved in production was a slowly decreasing share of the total aggregate of workers in the oil industry. On average, Mexican production workers represent about half of the total labour force of the Mexican oil industry. Only towards the end of the period were more people involved in activities other than production. Subtracting the non-production branch still leaves Mexico's labour force in the fields at a level that appears to be excessive. Mexico extracted more oil than Venezuela only before 1927 and after 1981. According to this new set of data, Mexico employed more people than Venezuela in the fields from 1965. At that time Mexico was still producing one-tenth as much oil as Venezuela. One can conclude that the Mexican unions obtained benefits in the form of expanded employment.

hypothesis.

Figure 4.3- 4:
Employees in oil fields Vs total numbers of employees in the oil industry.
Mexico and Venezuela 1921-1989



Sources: as Figure 4.3-3 for total employees. See Appendix G for the estimation of the labour force in the oil fields for Mexico

The other possibility is that Mexican oil workers were appropriating part of the resource rent through extra wages, thanks to the bargaining power of the Oil Workers Union.[38] To explore this hypothesis, we would ideally like to compare the wage received by the oil workers with their marginal productivity. Unfortunately, with the data available, we can only compare average productivity of labour with average wages in both countries. The results are shown in Table 4.3-1. Starting from a very similar wage level in the late 1920s, Venezuelan average wages took off in the early 1930s whereas Mexican average salary remained stationary for the first half of the decade. This is in line with the arguments used by the Mexican government motivating the expropriation on grounds of the low salaries paid by the foreign companies.[39]

[38] See for instance, chapter 10, ' The Oil workers' strike of 1937' in M. Rippy, *Oil and The Mexican Revolution* (Leiden, 1972) for an overview of the Union role in the nationalisation.

[39] 'Despite the fact that the oil workers were probably the best paid group in Mexico from the point of view of daily wages in pesos, government experts argued that the high cost of living in the oil zones meant that, in reality, the oil workers were receiving lower wages than workers either in the mines or on the National Railroads of Mexico.' Gordon, *The Expropriation of Foreign-Owned Property in Mexico* , p.112. By contrast, the Venezuelan worker, entirely unfamiliar with petroleum work, was not very efficient at first; tasks requiring technical skills had to be performed by foreigners. The oil workers, however, were slowly turning into the elite of the Venezuelan labour force, for they received free medical treatment, housing, training and a wage far in excess of that paid elsewhere in the Republic. E. Lieuwen, *Petroleum In Venezuela: A History*, Vol. 47 (Berkeley, 1954) p.50.

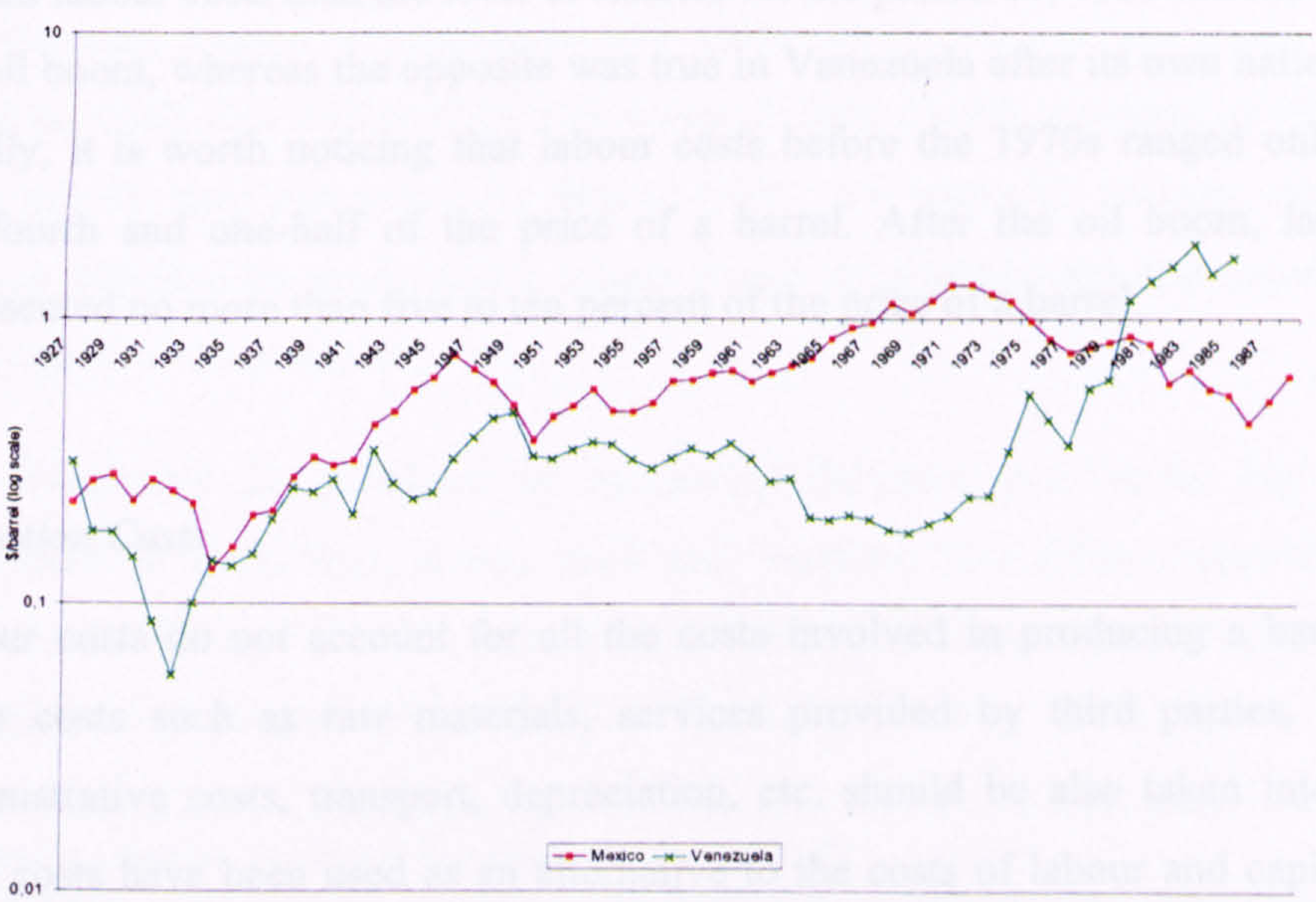
Table 4.3- 1: Average productivity Vs average wage per worker in the oil industry: Venezuela and Mexico, 1920-1985

	Annual average productivity per worker			Annual average wage per worker		
Year	Mexico US dollars	Venezuela US dollars	Ratio Mx/Vz	Mexico US dollars	Venezuela US dollars	Ratio Mx/Vz
1920	N/A	388	N/A	N/A	N/A	N/A
1921	10,493	334	3143%	N/A	N/A	N/A
1922	10,011	355	2823%	N/A	877	N/A
1923	8,898	517	1722%	N/A	871	N/A
1924	8,938	979	913%	N/A	924	N/A
1925	10,345	1,692	612%	N/A	925	N/A
1926	8,586	2,975	289%	N/A	899	N/A
1927	4,726	2,751	172%	933	907	103%
1928	3,019	5,146	59%	839	907	92%
1929	2,761	13,087	21%	793	906	87%
1930	2,591	17,604	15%	621	948	65%
1931	2,188	7,754	28%	621	843	74%
1932	1,806	8,187	22%	622	746	83%
1933	2,076	5,846	36%	623	1,103	56%
1934	4,377	8,721	50%	624	1,687	37%
1935	4,243	5,865	72%	711	1,642	43%
1936	3,610	6,048	60%	812	1,696	48%
1937	5,875	7,966	74%	921	1,751	53%
1938	3,268	9,386	35%	868	2,148	40%
1939	2,354	8,527	28%	941	2,272	41%
1940	1,840	10,379	18%	844	2,717	31%
1941	2,265	13,058	17%	1,000	2,463	41%
1942	1,949	6,932	28%	1,042	3,142	33%
1943	1,907	7,043	27%	1,058	2,816	38%
1944	1,932	6,052	32%	1,334	2,725	49%
1945	1,888	6,619	29%	1,503	3,074	49%
1946	2,351	8,015	29%	1,646	2,833	58%
1947	2,783	16,235	17%	1,788	3,253	55%
1948	4,371	26,636	16%	1,695	3,610	47%
1949	4,034	24,878	16%	1,464	4,854	30%
1950	4,841	25,661	19%	1,146	4,110	28%
1951	5,171	27,778	19%	1,332	4,633	29%
1952	6,003	32,599	18%	1,502	5,122	29%
1953	4,632	34,566	13%	1,578	5,369	29%
1954	4,623	36,193	13%	1,424	5,826	24%
1955	4,358	40,340	11%	1,449	5,944	24%
1956	4,887	47,443	10%	1,639	6,127	27%
1957	5,727	62,013	9%	1,784	7,259	25%
1958	5,528	58,430	9%	1,929	7,526	26%
1959	5,256	60,404	9%	2,187	7,820	28%
1960	4,706	63,384	7%	2,346	9,409	25%
1961	6,802	66,914	10%	2,392	9,286	26%
1962	7,354	72,977	10%	2,582	9,090	28%
1963	7,191	98,102	7%	2,714	9,735	28%
1964	7,512	75,618	10%	2,941	7,571	39%
1965	6,741	80,887	8%	3,083	10,251	30%
1966	6,687	90,971	7%	3,345	7,988	42%
1967	6,707	88,290	8%	3,477	8,775	40%
1968	6,164	104,522	6%	3,757	9,522	39%
1969	6,898	98,900	7%	3,995	8,664	46%
1970	6,842	104,981	7%	4,324	11,106	39%
1971	8,322	130,455	6%	4,651	11,076	42%
1972	9,662	130,924	7%	5,056	11,856	43%
1973	16,018	197,250	8%	5,268	12,707	41%
1974	58,215	480,003	12%	6,341	16,381	39%
1975	79,220	374,769	21%	6,974	20,081	35%
1976	93,103	358,149	26%	6,494	15,615	42%
1977	108,280	335,573	32%	6,166	11,700	53%
1978	121,653	284,574	43%	7,290	17,183	42%
1979	209,857	421,942	50%	9,412	17,179	55%
1980	458,844	535,021	86%	11,942	27,738	43%
1981	537,856	577,017	93%	11,637	28,543	41%
1982	516,404	473,302	109%	9,037	26,918	34%
1983	388,048	433,027	90%	8,336	30,148	28%
1984	392,869	452,147	87%	7,634	23,652	32%
1985	385,855	405,503	95%	7,429	25,924	29%

Sources: for the average productivity of labour oil production from Appendix A and prices from Appendix F divided by the labour force in oil fields shown in Figure 4.3-4. For the average wages the aggregate wages as in Figure 4.3-1 divided by the corresponding labour force from Figure 4.3-4.

The average Mexican salaries grew more after the nationalisation of the industry, but still remained far from the average wage received by Venezuelan oil workers. The average annual wage of a Mexican worker was about one-third the average Venezuelan wage in nominal terms for most years after nationalisation. Nonetheless, the average productivity of Mexican workers was much smaller –between one tenth and one fourth- than that of Venezuelan workers. Furthermore, while the relative size of the Mexican average productivity per worker continuously decreased as percentage of that of Venezuela, the relative size of the Mexican average wage rather than diminishing accordingly, maintained and even increased its relative size for the period 1940-1970. The evidence in Table 4.3-1 seems to suggest that Mexican average wage should have been even smaller given the difference in average productivity of labour between the two countries. The reasoning appears to turn around from the mid-1970s. The Mexican average productivity per worker increased sharply and almost achieved Venezuelan level, however the Venezuelan average salaries continued doubling those of Mexican workers. In fact, it has been argued that the Venezuelan oil union obtained its benefits from high wages while the Mexican unions obtained benefits in the form of expanded employment for the 1970s and 1980s.[40]

Figure 4.3- 5: Labour costs of production per barrel of oil. Mexico and Venezuela 1920-1988



Sources: for wages Figures 4.3-1 and for labour force Figure 4.3-4. Appendix A for oil production.

[40] L. Randall, *The Political Economy of Mexican Oil*, p.12.

How are these qualifications to the data likely to affect the calculation of the resource rent? The repercussions on labour cost per barrel are noticeable. Taking account only of employees in the production branch of the industry, Mexico's oil production was still more labour intensive than Venezuela's. Figure 4.3-5 again compares labour costs per barrel in both countries, but now on the basis of labour involved in production. Mexican production costs per barrel are still the higher of the two. Although the gap has closed considerably compared with Figure 4.3-2 (which used the official aggregate data on labour costs), Mexico's labour costs per barrel surpassed Venezuela's until the early 1980s. This last fact can be explained by the changes in production that occurred in those years. While Mexico's production shot up dramatically (thus pushing down average costs per barrel), Venezuela's oil production slowed down due to the effects of nationalisation (causing an increase in the average labour costs per barrel).

When calculating the rent we should bear in mind that part of the rent is likely to have been appropriated by labour via wage premia and over-employment, particularly in the case of Mexico. In both cases, after nationalisation, the number of people employed and the average wage paid increased without a proportional increase in production. However, it is fair to say that in Mexico over-employment was more important to the overall labour costs than the level of salaries for the period between nationalisation and the oil boom, whereas the opposite was true in Venezuela after its own nationalisation. Finally, it is worth noticing that labour costs before the 1970s ranged only between one-fourth and one-half of the price of a barrel. After the oil boom, labour costs represented no more than five to ten percent of the price of a barrel.

Operation Costs

Labour costs do not account for all the costs involved in producing a barrel of oil. Other costs such as raw materials, services provided by third parties, insurance, administrative costs, transport, depreciation, etc. should be also taken into account. Such costs have been used as an alternative to the costs of labour and capital for the calculation of the resource rent. Traditionally, production costs have been divided into three components:[41]

1- Operating costs- normally referred to as production costs, assuming all equipment is in place.

2- Development costs -the installation of new productive capacity in already known pools, whether new or already partly developed. With the exception of exploration, all investment is included, below and above ground, including the costs of such facilities as marine terminals and jetties.

3- Exploration costs- the cost of discovery of new fields and of new pools in existing fields.

Actual cost data are usually proprietary to the resource-extracting firms or simply unknown.[42] Few if any of the published costs estimates are ever explained. Hence, it is difficult to know whether the cost series available refer to production, development or exploration altogether, or to random sums of items belonging to different categories. In any case, aggregate data on operating costs have proved difficult to find. And even when one can identify published data series there may be huge differences between different sources. This is an old problem. Already in the 1930s, governments were trying to improve the inspection systems of the books of the companies in order to establish their capacity to pay royalties, but always found strong opposition from the firms.[43] Cost of production was difficult for the committee of the Mexican expropriation to identify.[44] Government and the industry sources differed in their ways of allocating capital expenditures and their results cannot be compared.[45] The operating costs data collected for this research were mostly provided by the industry. Theoretically they comprised by labour costs, raw materials, energy expenditures, services provided by third parties, transport and the depreciation and amortisation of fixed capital and equipment.

Notwithstanding the problems of comparing different cost series due to likely differences in definitions across time and location, this section presents several comparisons of costs between Mexico and Venezuela. Some scattered data regarding operating/development/exploration, i.e. production costs, were found for both

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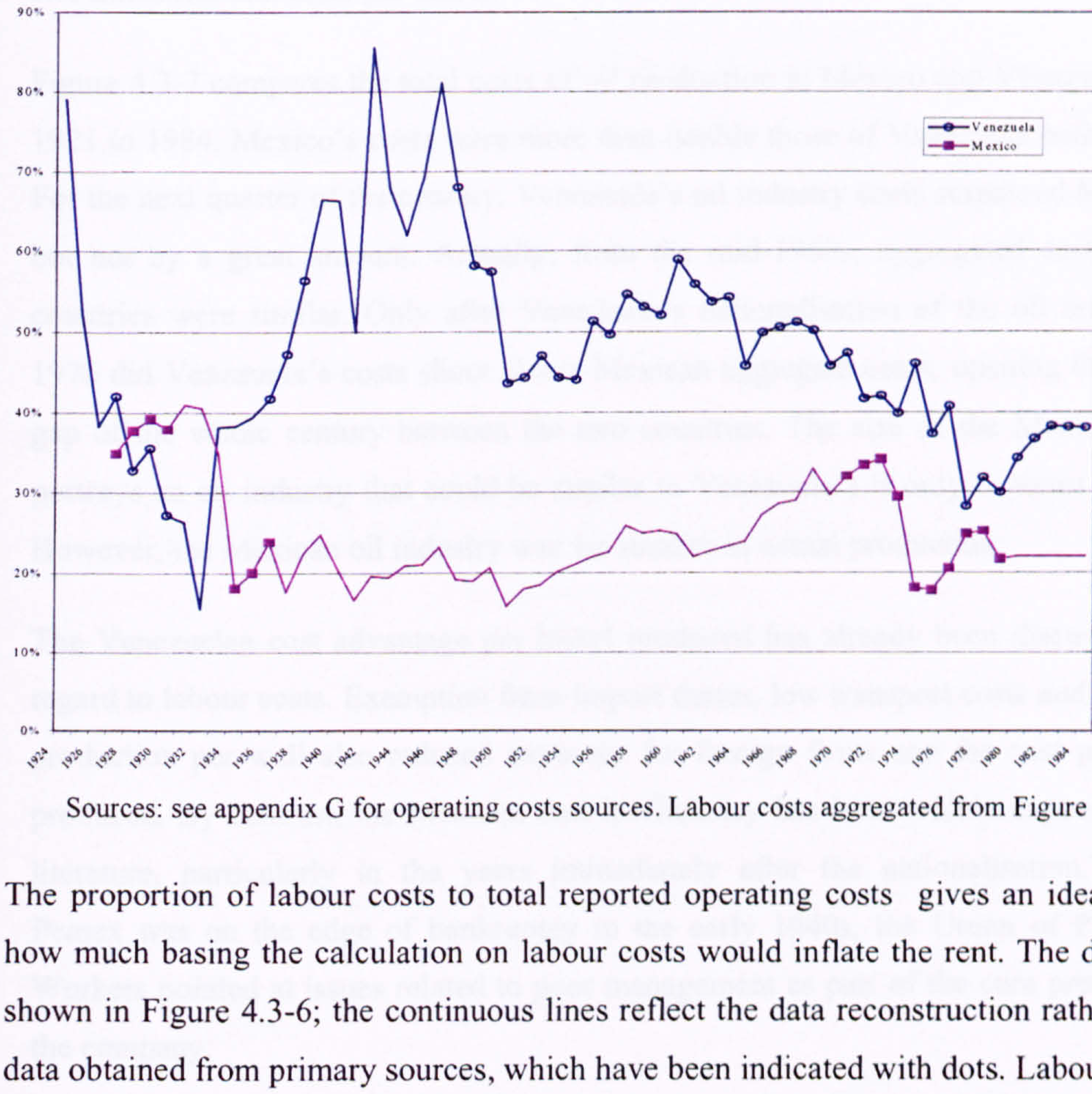
[41] Based on Adelman, *The World Petroleum Market*, pp.46-77.
[42] R. Pindyck, 'The optimal exploration and production of non-renewable resources', *Journal of Political Economy* 86 (1978),S. Farrow, 'Testing the efficiency of extraction from a stock of resource', *Journal of Political Economy* 93 (1985).
[43] Gordon, *The Expropriation of Foreign-Owned Property in Mexico* , pp. 111-112 and chapter 4 in Lieuwen, *Petroleum in Venezuela: A History*.
[44] México. Secretaría de Patrimonio Nacional, *El Petróleo de México*. The discrepancies between company accountants and official experts regarding the yearly costs of the companies are stunning. No effort is here made to justify either set of figures. The final settlement between government and companies indicates that the truth was probably somewhere between the two sets of figures.
[45] México. Secretaría de Programación y Presupuesto, *La industria petrolera en México* (México D.F., 1979).

countries.[46] These comparisons further illuminate the final estimates of the resource rent, since by explaining the difference in the costs we can get a better grasp on the factors that underpinned the value of the resource rent.

Figure 4.3- 6:
Labour costs share on production operating costs. Mexico and Venezuela, 1924-1985



Sources: see appendix G for operating costs sources. Labour costs aggregated from Figure 4.3-5

The proportion of labour costs to total reported operating costs gives an idea of by how much basing the calculation on labour costs would inflate the rent. The data are shown in Figure 4.3-6; the continuous lines reflect the data reconstruction rather than data obtained from primary sources, which have been indicated with dots. Labour costs comprised approximately one-half of Venezuelan production costs, and peaked at 80 percent in the second quarter of the century. In contrast, Mexico's wages and salaries represented only about a quarter of all Mexican oil production costs for most of the period considered.[47] It is also noticeable that the steady increase of the share of

[46] See Appendix G for data sources. Throughout this section both terms, production/operation costs, are used without actually implying a different category of costs. Both names involve the concept of all the costs involved in getting oil out of the ground.

[47] These results are in line with the estimates of Arps, who calculated current costs in the US industry in the 1950s to be 20 to 30 percent for labour and 30 to 50 percent for repairs and maintenance. Other expenses included insurance, damage, power, waste disposal and oil treatment. The results are also consistent with those of Hanson who estimated that other local costs in Venezuela were almost equal to wages and salaries for the period 1950-1957. See J.J. Arps, 'Valuation of Oil and Gas Reserves', in Frick (ed.), *Petroleum Production Handbook*, Vol. II (New York, 1962) pp. 23-24, as quoted by P.G. Bradley, *The economics of crude petroleum production*, Vol. 48 (Amsterdam, 1967), p.21 and J.A. Hanson,

Mexican labour costs in total costs of production from the 1950s contrasts with the declining share of Venezuela's salaries in total costs from the 1960s. The result is the reduction of the gap between the two countries. The immediate implication of Figure 4.3-6 is that Mexican costs other than wages and salaries were proportionally greater than in Venezuela. In order to confirm this, we shall look at the aggregate costs for the two industries and costs per barrel.

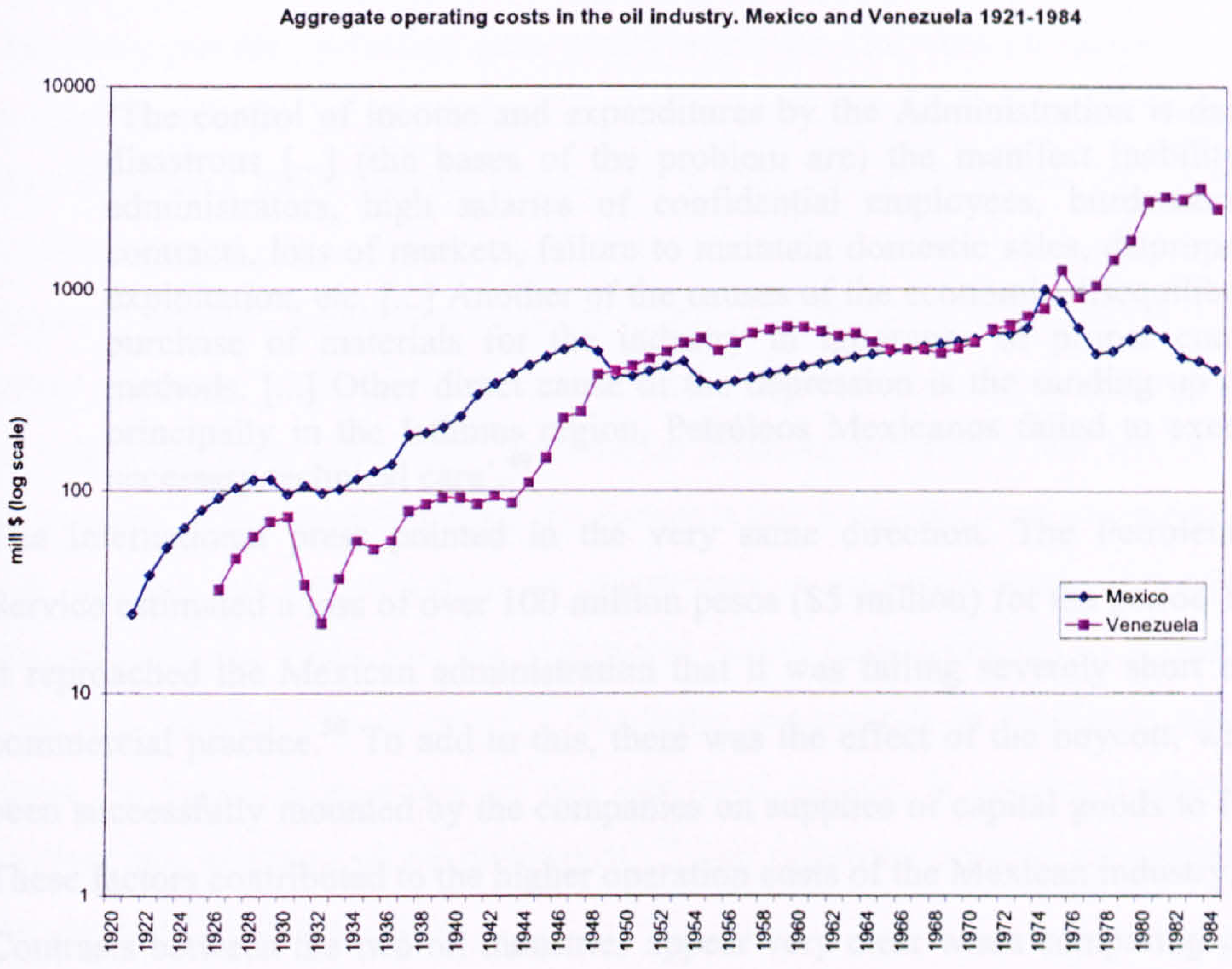
Figure 4.3-7 compares the total costs of oil production in Mexico and Venezuela from 1921 to 1984. Mexico's costs were more than double those of Venezuela before 1949. For the next quarter of the century, Venezuela's oil industry costs surpassed Mexico's, but not by a great amount. Actually, from the mid-1960s, aggregated cost in both countries were similar. Only after Venezuela's nationalisation of the oil industry in 1976 did Venezuela's costs shoot above Mexican aggregate costs, opening the widest gap of the whole century between the two countries. The size of the Mexican costs portrays an oil industry that could be similar to Venezuela's if only in terms of costs. However, the Mexican oil industry was far smaller in actual production.

The Venezuelan cost advantage per barrel produced has already been discussed with regard to labour costs. Exemption from import duties, low transport costs and the huge production per well also reduced expenses for foreign firms and the cost per barrel produced. By contrast, the Mexican cost inefficiency has been widely exposed in the literature, particularly in the years immediately after the nationalisation.[48] When Pemex was on the edge of bankruptcy in the early 1940s, the Union of Petroleum Workers pointed at issues related to poor management as part of the core problems of the company:

'Cycles of Economic Growth and Structural Change since 1950', in Martz and Myers (eds.), *Venezuela: The Democratic Experience* (Caracas, 1st ed., 1977), p.66.

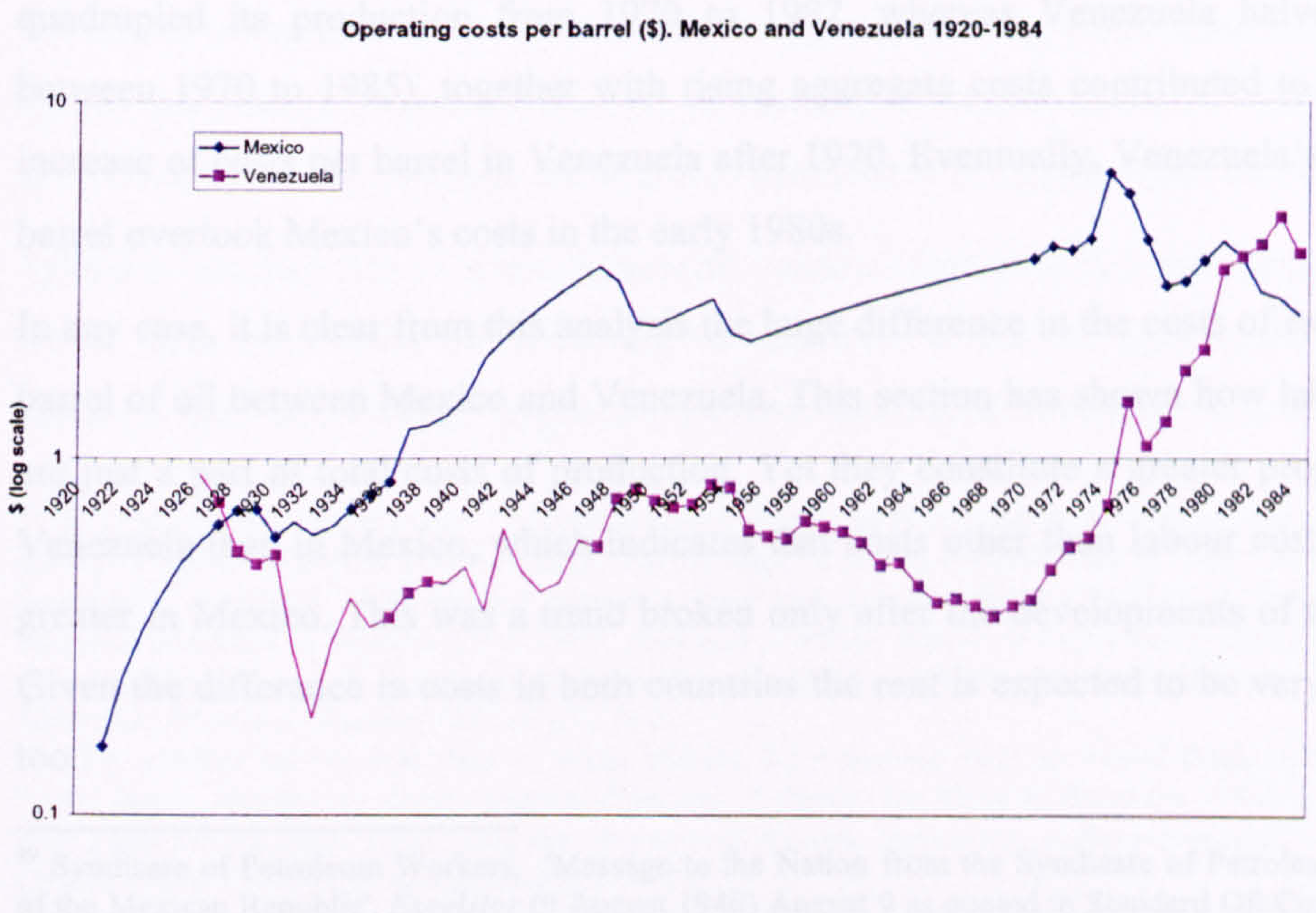
[48] See, among others, Standard Oil Company, *The Reply to Mexico* (New York, 1940); Syndicate of Petroleum Workers, 'Message to the Nation from the Syndicate of Petroleum Workers of the Mexican Republic', *Excelsior* (9 August 1940) August 9; 'Mexico's unsolved problem'. In *The Petroleum Press Service*. (London, 1941); J.R. Powell, *The Mexican Petroleum Industry 1938-1950* (Berkeley, 1956); G. Philip, *Oil And Politics In Latin America. Nationalist Movements And State Companies* (Cambridge, 1982) and Randall, *The Political Economy of Mexican Oil* . Some of the financial problems of Pemex are presented in Appendix E regarding exploration investments.

Figure 4.3- 7: Aggregate operating costs of oil production. Mexico and Venezuela 1921-1984



Sources: See appendix G

Figure 4.3- 8: Operating costs per barrel produced . Mexico and Venezuela 1920-1984



Sources: See appendix G for costs and appendix A for production

> 'The control of income and expenditures by the Administration is daily more disastrous [...] (the bases of the problem are) the manifest inability of the administrators, high salaries of confidential employees, burdensome sales contracts, loss of markets, failure to maintain domestic sales, disproportionate exploitation, etc. [...] Another of the causes of the economic disequilibria is the purchase of materials for the industry in ignorance of proper commercial methods. [...] Other direct cause of the depression is the sanding up of wells, principally in the Isthmus region. Petróleos Mexicanos failed to exercise the necessary technical care'.[49]

The international press pointed in the very same direction. The Petroleum Press Service estimated a loss of over 100 million pesos ($5 million) for the period 1938-40. It reproached the Mexican administration that it was falling severely short of sound commercial practice.[50] To add to this, there was the effect of the boycott, which had been successfully mounted by the companies on supplies of capital goods to Pemex.[51] These factors contributed to the higher operation costs of the Mexican industry.

Contrasts between the two oil industries appear very clear when comparing costs per barrel. Figure 4.3-8 shows the costs per barrel in both countries for the period 1920-1984. According to this data set, Mexico's cost per barrel produced was already twice that of Venezuela by the late 1930s. By 1945, producing a barrel of oil in Mexico was over six times more expensive, and was almost ten times as costly by the end of the 1960s. The opposite tendencies in the amount of oil produced (Mexico more than quadrupled its production from 1970 to 1982, whereas Venezuela halved output between 1970 to 1985), together with rising aggregate costs contributed to the sharp increase of costs per barrel in Venezuela after 1970. Eventually, Venezuela's costs per barrel overtook Mexico's costs in the early 1980s.

In any case, it is clear from this analysis the huge difference in the costs of extracting a barrel of oil between Mexico and Venezuela. This section has shown how labour costs are just a part of total costs of production. Yet they constitute a greater proportion in Venezuela than in Mexico, which indicates that costs other than labour costs are also greater in Mexico. This was a trend broken only after the developments of the 1970s. Given the difference in costs in both countries the rent is expected to be very different too.

[49] Syndicate of Petroleum Workers, 'Message to the Nation from the Syndicate of Petroleum Workers of the Mexican Republic', *Excelsior* (9 August 1940) August 9 as quoted in Standard Oil Company, *The Reply to Mexico* extracts from pages 116-119. Parentheses added.
[50] 'Mexico's unsolved problem', in *The Petroleum Press Service*, No, 7, July 1941.
[51] Powell, *The Mexican Petroleum Industry 1938-1950.*

Capital Costs

Deducting just the production costs would reflect the view that the entire surplus from production should be counted as depletion costs. In general, applications of the Hotelling-based methods have allowed for a return on fixed assets, thus dividing the surplus between physical and natural capital. Including a return on capital requires the choice of a rate of return on associated capital. The choice of this return is to a certain extent arbitrary. While the US Department of Commerce includes a 6 percent return in its calculations, the UK Office for National Statistics assumes a real rate of return of 15 percent.[52] The rationale behind the former is that 6 percent is approximately the 45-year average real rate of return on investments in corporate bonds and equities, or alternatively, the return that the investment would have produced in another sector. That is a 'normal' rate of return.[53] The latter corresponds to the figure safeguarded under the United Kingdom's oil and gas fiscal regime. It can be considered as a 'normal rate of return on oil investment'.[54] The following paragraphs explore further the choice of the rate of return.

Economists define investment as the act of incurring an immediate cost in the expectation of future rewards. Those rewards are a return on the capital invested. The direct relationship between uncertainty and return is well known. However, according to Dixit, most investment decisions have another two important characteristics in varying degrees.[55] First, the investment is partially or completely *irreversible.* In other words, the initial cost of investment is at least partially sunk; you cannot recover it all should you change your mind. Second, you have some choice about the *timing* of your investment. You can postpone the action to get more information about the future.

Taking a 'normal' rate of return forgets an essential fact: at such a rate, no investment would have been made for extracting the resource. Given the sunk costs in the oil industry, the risk involved (especially in underdeveloped countries) and the level of

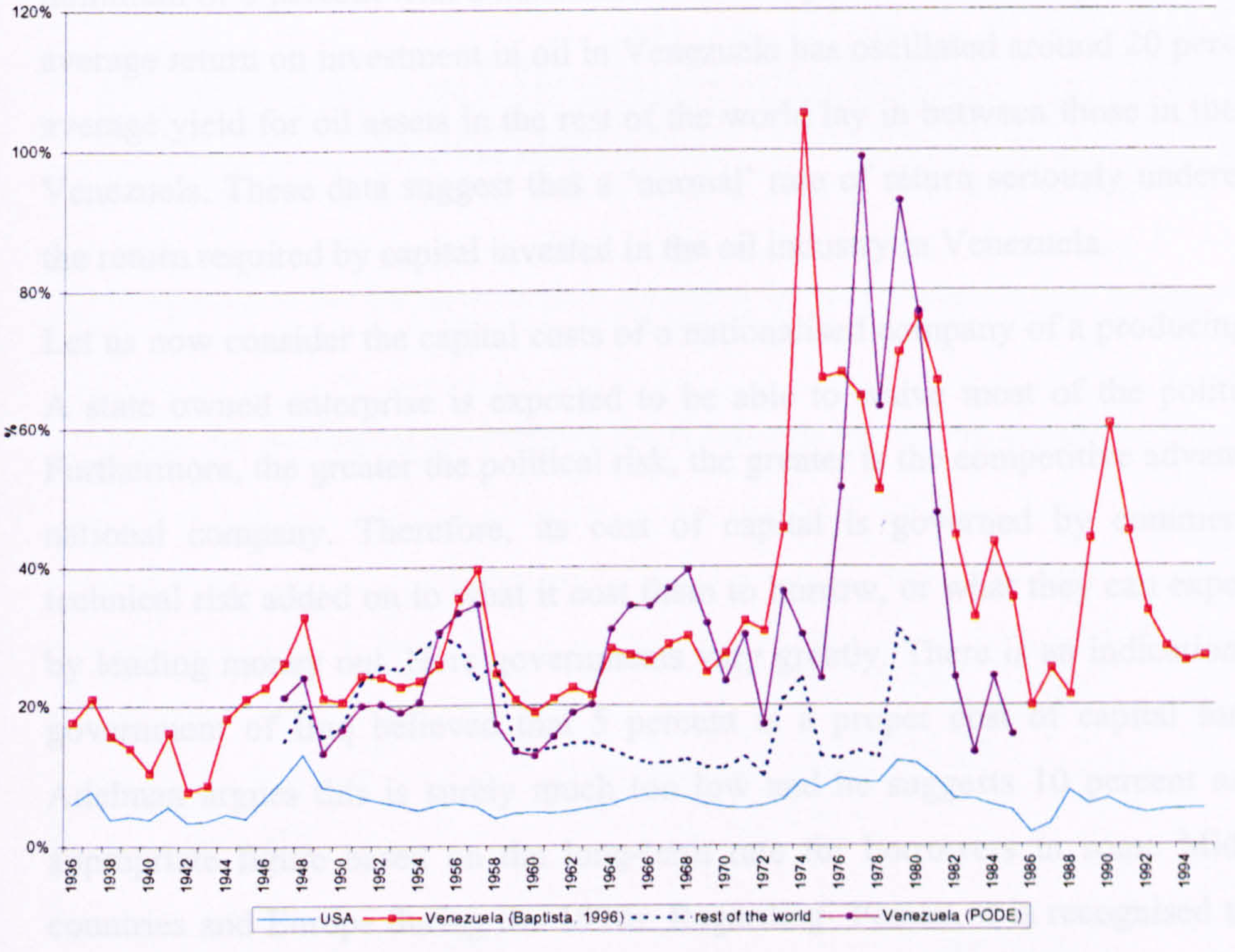
[52] US Department of Commerce, 'Accounting for mineral resources: issues and BEA's initial estimates', *Survey of current business* (1994, April). Normal rates of return are also used by other studies; see for example, L. Lindholt, 'On Natural Resource Rent and the Wealth of a Nation. A Study Based of National Accounts in Norway 1930-1995', *Statistics Norway. Research Department Discussion Papers* 281 (2000), p.8 and P. Vaze, 'Environmental Accounts- Valuing the Depletion of Oil and Gas Reserves', *Economic Trends* (1996, April) 510.

[53] Other guesses for 'normal' rate of return include the 4 percent used by World Bank studies such as World Bank, *Monitoring Environmental Progress: A Report on Work in Progress.* (Washington, D.C., 1995) and World Bank, *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development*, Vol. 17 (Washington, D.C., 1997).

[54] According to Lindholt, 'On Natural Resource Rent and the Wealth of a Nation. A Study Based of National Accounts in Norway 1930-1995', p.25, the Norwegian estimates of oil wealth by the Ministry of Energy and Industry and Ministry of Finance use 7 percent as working assumption.

uncertainty of initial oil investments, higher returns were required to attract investment. A former president of Gulf stated in 1961 that in purchasing oil and gas reserves, his company would not be interested in a 6 percent rate of return on a discounted cash-flow basis, would regard 7.9 percent as borderline, and would be sufficiently interested in 9 percent to make a thoughtful investigation. For exploration and development combined, he thought an individual investor would require perhaps 10 to 20 percent (after taxes).[56] Therefore, to use the 'normal' rate of return may be to underestimate the real rate of return needed to generate the investment for depleting the resource, thus including part of the return legitimately belonging to the investors in the resource rent.

Figure 4.3- 9: After tax returns in oil industry: USA, Venezuela and rest of the world, 1936-1994



Sources: USA, rest of the world and Venezuela from Baptista, *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)* , cuadro 1.
Venezuela(PODE) for the years 1947-1955 took from the 'return on capital' entry, from 'financial summary of the Venezuela petroleum industry, 1947-1961', in Venezuela. Ministry of Mines and Hydrocarbons, *Venezuelan Petroleum Industry. Statistical Data* (Caracas, 1962), p.24. For the rest of the period Venezuela. Ministerio de Energía y Minas, *Petróleo y otros datos estadísticos (PODE)* (Caracas, issued annually since 1958).

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[55] From Chapter 1 in A.K. Dixit and R.S. Pindyck, *Investment Under Uncertainty* (Princeton, 1992).
[56] Sidney A. Swenrud, testifying before the Federal Power Commission in September 1961 as quoted in N.I. Eggleston, 'Methods and procedures for estimating fair market value of petroleum properties', *Journal of Petroleum Technology* (May 1964). The ultimate source is Adelman, *The World Petroleum Market* , pp. 53-54.

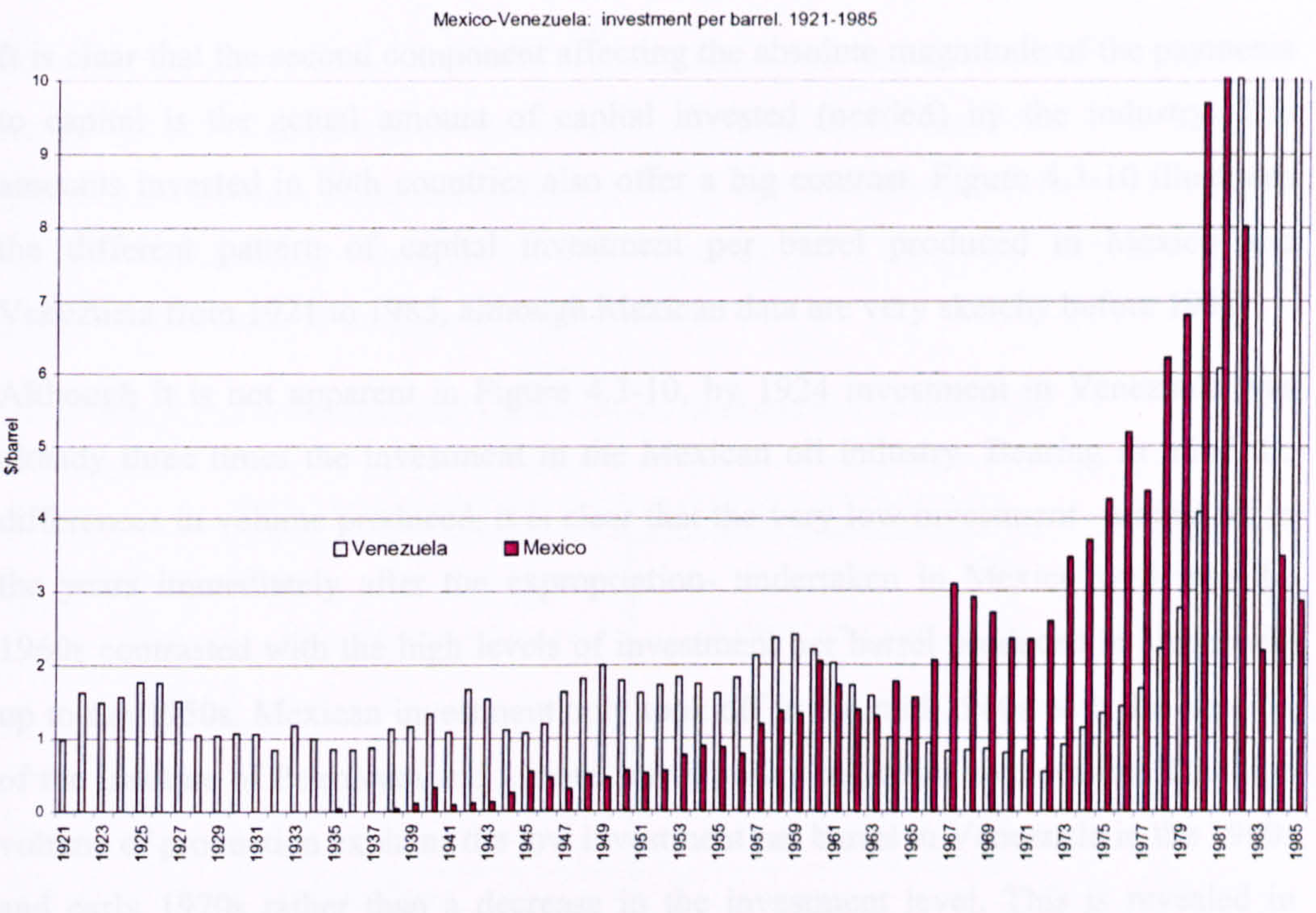
This view is confirmed by Figure 4.3-9, which contrasts after-tax rates of return on capital investment on oil industry in Venezuela (from two different sources), the United States and an average of the rest of the world excluding the United States.

It is clear from Figure 4.3-9 that the returns on oil investment in Venezuela and in the rest of the world have been above the returns within the US. The after-tax rate of return on capital investment in the oil industry within the US has been between a lower limit of 2 percent and an upper limit of 14 percent. The average return in the US turns out to have been very close to the traditional 5 to 6 percent 'normal' rate of return. However, the reported after-tax return on capital invested in Venezuela had an exceptional minimum of 8 percent with a maximum over 100 percent. According to these data, the average return on investment in oil in Venezuela has oscillated around 20 percent. The average yield for oil assets in the rest of the world lay in between those in the US and Venezuela. These data suggest that a 'normal' rate of return seriously underestimates the return required by capital invested in the oil industry in Venezuela.

Let us now consider the capital costs of a nationalised company of a producing nation. A state owned enterprise is expected to be able to waive most of the political risk. Furthermore, the greater the political risk, the greater is the competitive advantage of a national company. Therefore, its cost of capital is governed by commercial and technical risk added on to what it cost them to borrow, or what they can expect to get by lending money out. Here governments vary greatly. There is an indication that the government of Iraq believed that 5 percent is a proper cost of capital for them.[57] Adelman argues this is surely much too low and he suggests 10 percent as a more appropriate figure based on the long-term rate for borrowers in some Middle East countries and Europe during the 1970s. Regarding Pemex, it is recognised that 'new investments were financed almost in their entirety by long-term or short-term loans and by arrears of debts to the State' which may suggest that the cost of capital for Pemex was close to the normal rate of return.[58] Nevertheless, even if the political risk is waived, uncertainty, irreversibility and timing issues also apply in state owned enterprises. Hence a 'normal rate of return on oil investment' cannot be ruled out as appropriate even in this case.

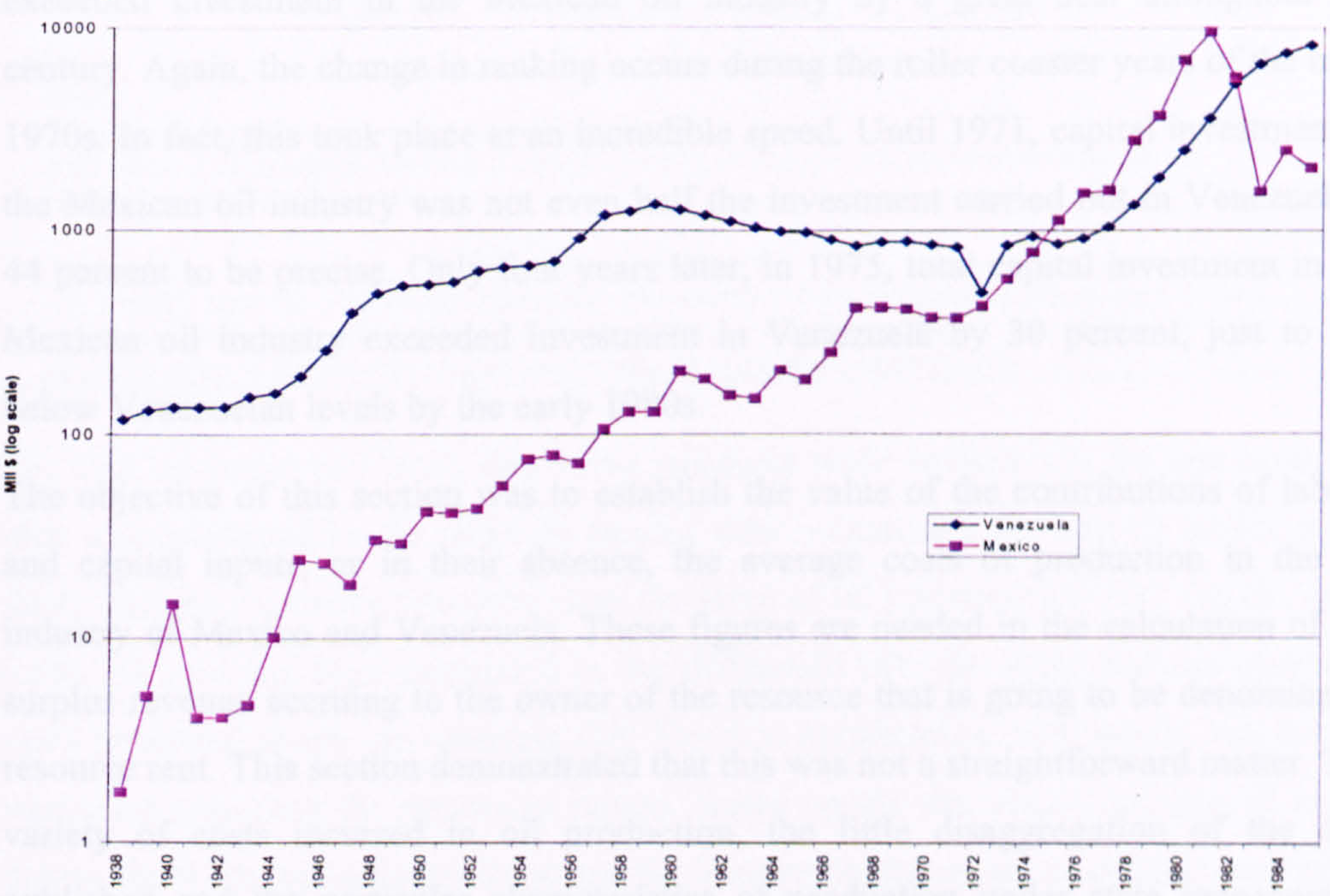
[57] Based upon Adelman, *The World Petroleum Market*, p.56.
[58] United Nations. Department of Economic and Social Affairs, *Petroleum Exploration: Capital Requirements and Methods of Financing* (New York, 1962), p.17.

Figure 4.3- 10: Capital investment per barrel. Mexico and Venezuela, 1921-1985



Notes and Sources: See appendix H for investment figures and appendix A for production.

Figure 4.3- 11: Capital investment in the oil industry. Mexico and Venezuela 1938-1985



Source: Appendix H

It is clear that the second component affecting the absolute magnitude of the payments to capital is the actual amount of capital invested (needed) by the industry. The amounts invested in both countries also offer a big contrast. Figure 4.3-10 illustrates the different pattern of capital investment per barrel produced in Mexico and Venezuela from 1921 to 1985, although Mexican data are very sketchy before 1938.

Although it is not apparent in Figure 4.3-10, by 1924 investment in Venezuela was already three times the investment in the Mexican oil industry. Bearing in mind the differences in volume produced, it is clear that the very low investment –almost nil in the years immediately after the expropriation- undertaken in Mexico well into the 1960s contrasted with the high levels of investment per barrel produced in Venezuela up to the 1950s. Mexican investment only took off in the mid-1960s with the creation of the Institute of Petroleum and a more active policy regarding exploration. The high volume of production explains the low investment per barrel in Venezuela in the 1960s and early 1970s rather than a decrease in the investment level. This is revealed in Figure 4.3-11, which shows the total investment in millions of dollars for both countries over the same period. In absolute numbers, capital investment in Venezuela exceeded investment in the Mexican oil industry by a great deal throughout the century. Again, the change in ranking occurs during the roller coaster years of the mid-1970s. In fact, this took place at an incredible speed. Until 1971, capital investment in the Mexican oil industry was not even half the investment carried out in Venezuela – 44 percent to be precise. Only four years later, in 1975, total capital investment in the Mexican oil industry exceeded investment in Venezuela by 30 percent, just to fall below Venezuelan levels by the early 1980s.

The objective of this section was to establish the value of the contributions of labour and capital inputs, or in their absence, the average costs of production in the oil industry of Mexico and Venezuela. These figures are needed in the calculation of the surplus revenue accruing to the owner of the resource that is going to be denominated resource rent. This section demonstrated that this was not a straightforward matter. The variety of costs incurred in oil production, the little disaggregation of the data published and the particular characteristics of production under state management complicated the estimation of the factor payments. Nevertheless, series of labour costs, capital payments and average costs of operation have been produced. It is time to calculate the resource rent.

4.4 The Resource Rent

The previous sections have presented a description of the basic components needed for the calculation of the resource rent. Given the complications associated to the data set, several permutations are considered as possible approximations to the resource rent. Table 4.4-1 summarises the different alternatives that have been used in the calculation of the resource rent for Mexico and Venezuela.

Table 4.4-1:
Resource rent calculation: permutations considered and nomenclature

	Permutation (a)		Permutation (b)	
Aggregated rent	$N_t(a_r) = p*q - cl - r*k$		$N_t(b) = p*q - oc$	
Rent per unit	$u_t(a_r) = \dfrac{N(a_r)}{q}$		$u_t(b) = \dfrac{N(b)}{q}$	
	Calculated for: $r = 6\%$ $r = 15\ \%$ r = return reported by the companies (Venezuela only)			
	Mexico t= 1935-1987	Venezuela t= 1920-1985	Mexico t= 1921-1987	Venezuela t= 1920-1985

Notes:
N aggregated resource rent; *u* rent per unit (per barrel);
p oil price; *q* oil produced (barrels); *cl* cost of labour in oil fields; *r* rate of return; *k* fixed capital investment; *oc* operation costs

Examples of labels herein:
Vz [N(a6)] reads as Venezuela's aggregated rent resulting from permutation (a), using a normal return to capital of 6 percent. If no number attached, e.g. *N(a)*, the companies' rate of return is used. *Mx[u(b)]* refers to the Mexican rent per unit calculated using permutation (b), etc.

For both countries two basic alternative measures were devised. On the one hand, the rent was calculated as the standing surplus after subtracting the cost of labour in oil fields and the payments to capital from the price of oil [permutation *(a)*]. On the other hand, the rent has been calculated as the difference between price and the operation costs presented above [permutation *(b)*]. The first permutation, *N(a)* herein, has further variations regarding the returns to capital. Based on the discussion on rates of return above, three alternatives are considered for Venezuela: the return of capital reported by the companies, a 'normal' rate of return of 6 per cent, and a 'normal return to oil investment' of 15 per cent. For Mexico the rates of return considered are a 'normal' 6 per cent return and a 'normal return to oil investment' of 15 per cent.

This section presents the results of these permutations using the data set compiled in this chapter for Mexico and Venezuela.

The Resource Rent in Venezuela 1920-1985

Aggregated rents and rents per unit calculated under the different permutations for Venezuela's oil are reported in Table 4.4-2. The upper value of the resource rent is generally obtained when applying a 'normal' rate of return to capital. The lower value is obtained from permutation (b) for the first half of the century, whereas from the mid 1950s, is generally obtained when the actual rate of return reported by the companies is used. The shift seems to coincide with the increasing returns reported by the companies from the 1950s. The mid value is always obtained when the 'normal rate of return to oil' applied.

It is possible to identify distinct phases in the evolution of the rents in Venezuela. The first years of the oil industry in Venezuela result in negative rents. In fact, the case of net returns turning negative has been raised in a number of environmental accounting exercises.[59] In the case of Venezuela the start up costs of the industry explain this result. The references about the early days of the oil industry cited in Chapters 1 and 3 argued that it took some years before Venezuelan oil fields were profitable. The historiography identified the year 1922 as the turning point, and indeed, for all but one of the permutations, it is the last year with negative rents. The second phase in the evolution of the resource rents in Venezuela goes from 1925 to the mid 1940s. For these years the rent fluctuates much more than in subsequent periods. This may be indicating the instability –in prices, returns and labour costs- of an infant industry, but also reflecting the effects of the historical events –1930 crisis and the Second World War-. In a third phase, the rent increases during the late 1940s to a fairly stable level throughout the 1950s and 1960s up to the big jump of 1973-1974 that marks the beginning of the last phase. These last two phases are strictly linked to the evolution of the oil prices (see Section 4.2 above, Figure 4.2-1 in particular).

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[59] P. Bartelmus, 'The value of nature: valuation and evaluation in environmental accounting', in *Environmental Accounting in Theory and Practice*, Vol. 11 (London, 1998), p.278 cites A.Born's evaluation of Canadian resources as example. L. Lindholt, 'On Natural Resource Rent and the Wealth of a Nation. A Study Based of National Accounts in Norway 1930-1995', *Statistics Norway. Research Department Discussion Papers* 281 (2000), identifies negative rents when estimating the rents associated to Norwegian fish stocks. M. Lindmark, *Towards Environmental Historical National Accounts for Sweden. Methodological Considerations and Estimates for the 19th and 20th Centuries.*, Vol. 21 (1998), p.78 obtains negative rents for Swedish iron ore for the early 1930s.

Table 4.4-2:
Venezuela's resource rent under different permutations, 1920-1985

year	Aggregated rent, *N*				Rent per unit, *u*				As percentage of price per barrel			
	N(a) Mll.Blv.	N(a6) Mll.Blv	N(a15) Mll.Blv	N(b) Mll.Blv	u(a) Blv.	u(a6) Blv.	u(a15) Blv.	U(b) Blv.	u(a)	u(a6)	u(a15)	u(b)
1920	-4.8	-4.8	-4.8	-17.1	-9.5	-9.5	-9.5	-34.1				
1921	-4.4	-4.4	-5.1	-18.1	-3.1	-3.1	-3.7	-12.9				
1922	-2.0	-2.0	-3.7	-17.2	-0.9	-0.9	-1.7	-7.8				
1923	7.4	7.4	4.4	-14.3	1.7	1.7	1.0	-3.3	22%	22%	13%	
1924	38.1	38.1	31.5	4.2	4.2	4.2	3.5	0.5	47%	47%	39%	5%
1925	114.6	114.6	98.4	68.1	5.8	5.8	4.9	3.4	63%	63%	54%	37%
1926	235.7	235.7	206.0	162.2	6.6	6.6	5.8	4.5	71%	71%	62%	49%
1927	261.1	261.1	218.4	152.0	4.3	4.3	3.6	2.5	67%	67%	56%	39%
1928	427.3	427.3	375.2	256.7	4.0	4.0	3.5	2.4	76%	76%	67%	46%
1929	634.0	648.3	581.7	459.9	4.7	4.8	4.3	3.4	77%	79%	71%	56%
1930	702.9	678.4	608.2	439.7	5.2	5.0	4.5	3.3	85%	82%	73%	53%
1931	451.7	399.7	332.1	302.2	3.9	3.4	2.8	2.6	89%	79%	66%	60%
1932	619.6	557.3	496.3	493.5	5.3	4.8	4.3	4.2	96%	87%	77%	77%
1933	267.3	232.8	176.2	161.1	2.3	2.0	1.5	1.4	82%	72%	54%	50%
1934	370.9	350.5	303.6	244.4	2.7	2.6	2.2	1.8	81%	77%	67%	54%
1935	390.6	377.6	332.7	289.0	2.6	2.5	2.2	1.9	80%	78%	68%	59%
1936	408.7	408.8	362.7	312.8	2.6	2.6	2.3	2.0	77%	77%	68%	59%
1937	430.0	433.2	384.5	328.5	2.3	2.3	2.1	1.8	73%	74%	65%	56%
1938	367.9	352.5	293.0	276.4	2.0	1.9	1.6	1.5	68%	65%	54%	51%
1939	299.8	304.2	238.1	219.7	1.5	1.5	1.2	1.1	59%	60%	47%	43%
1940	305.1	326.1	257.5	243.8	1.7	1.8	1.4	1.3	58%	62%	49%	46%
1941	432.0	495.2	426.7	421.3	1.9	2.2	1.9	1.9	63%	72%	62%	61%
1942	178.6	256.8	188.2	171.8	1.2	1.7	1.3	1.2	39%	56%	41%	37%
1943	265.1	371.7	295.0	301.7	1.5	2.1	1.6	1.7	46%	65%	52%	53%
1944	492.9	593.9	513.8	494.7	1.9	2.3	2.0	1.9	59%	71%	62%	59%
1945	668.5	745.3	648.2	606.2	2.1	2.3	2.0	1.9	63%	70%	61%	57%
1946	923.2	1,035.6	905.6	802.9	2.4	2.7	2.3	2.1	61%	68%	60%	53%
1947	1,365.9	1,699.6	1,502.3	1,586.3	3.1	3.9	3.5	3.6	58%	72%	64%	67%
1948	2,308.6	2,803.2	2,556.7	2,477.9	4.7	5.7	5.2	5.1	63%	77%	70%	68%
1949	2,255.7	2,469.1	2,200.9	2,126.8	4.7	5.1	4.6	4.4	67%	74%	66%	63%
1950	2,515.2	2,832.7	2,561.0	2,288.2	4.6	5.2	4.7	4.2	70%	79%	72%	64%
1951	2,600.2	3,033.7	2,754.2	2,438.2	4.2	4.9	4.4	3.9	68%	79%	72%	63%
1952	2,943.1	3,439.4	3,123.1	2,846.3	4.5	5.2	4.7	4.3	67%	79%	72%	65%
1953	3,139.2	3,614.3	3,284.9	2,902.5	4.9	5.6	5.1	4.5	69%	79%	72%	63%
1954	3,389.6	3,928.8	3,593.7	3,163.3	4.9	5.7	5.2	4.6	69%	80%	73%	64%
1955	3,706.0	4,668.5	4,316.1	4,155.8	4.7	5.9	5.5	5.3	65%	82%	76%	73%
1956	4,020.2	5,415.2	4,956.6	4,874.7	4.5	6.0	5.5	5.4	61%	83%	76%	74%
1957	4,966.2	6,878.3	6,277.0	6,427.2	4.9	6.8	6.2	6.3	60%	83%	76%	77%
1958	5,099.3	5,888.5	5,261.6	5,387.4	5.4	6.2	5.5	5.7	69%	80%	72%	73%
1959	4,915.2	5,467.5	4,789.4	4,954.6	4.9	5.4	4.7	4.9	71%	78%	69%	71%
1960	4,732.5	5,210.7	4,572.1	4,810.3	4.5	5.0	4.4	4.6	69%	76%	67%	71%
1961	4,872.3	5,506.1	4,907.0	5,059.6	4.6	5.2	4.6	4.8	70%	79%	70%	73%
1962	5,350.1	6,150.3	5,592.0	5,680.0	4.6	5.3	4.8	4.9	71%	82%	75%	76%
1963	5,258.3	6,071.1	5,550.4	5,560.8	4.4	5.1	4.7	4.7	71%	82%	75%	75%
1964	7,767.4	9,152.5	8,653.4	8,173.2	6.3	7.4	7.0	6.6	73%	86%	82%	77%
1965	7,487.2	9,045.5	8,551.9	8,263.4	5.9	7.1	6.7	6.5	71%	86%	82%	79%
1966	7,317.6	8,751.6	8,295.8	7,960.6	5.9	7.1	6.7	6.5	72%	86%	82%	78%
1967	7,636.9	9,096.6	8,671.7	8,294.6	5.9	7.0	6.7	6.4	73%	86%	82%	79%
1968	7,782.6	9,434.0	8,990.5	8,671.1	5.9	7.2	6.8	6.6	72%	87%	83%	80%
1969	7,826.7	9,110.9	8,663.9	8,185.9	6.0	6.9	6.6	6.2	75%	87%	83%	78%
1970	8,683.2	9,519.5	9,088.4	8,532.0	6.4	7.0	6.7	6.3	79%	87%	83%	78%
1971	10,681.7	11,803.6	11,385.9	10,466.8	8.2	9.1	8.8	8.1	81%	89%	86%	79%
1972	11,084.3	11,390.9	11,143.4	9,890.5	9.4	9.7	9.5	8.4	87%	89%	87%	77%
1973	16,166.1	17,605.1	17,178.3	16,015.6	13.2	14.3	14.0	13.0	84%	92%	90%	84%
1974	44,891.6	46,156.1	45,686.0	44,641.1	41.3	42.5	42.1	41.1	93%	96%	95%	93%
1975	36,412.3	37,274.3	36,840.9	34,298.2	42.5	43.5	43.0	40.1	92%	94%	93%	87%
1976	35,552.5	37,870.0	37,409.2	35,881.9	42.4	45.1	44.6	42.8	89%	95%	94%	90%
1977	36,757.3	42,188.3	41,662.7	39,348.5	45.0	51.7	51.1	48.2	84%	96%	95%	90%
1978	34,045.3	38,338.2	37,662.5	34,682.0	43.1	48.5	47.7	43.9	84%	94%	93%	85%
1979	54,422.3	63,254.1	62,337.5	58,633.8	63.3	73.6	72.5	68.2	82%	96%	94%	89%
1980	75,104.2	84,938.3	83,690.1	78,184.4	94.7	107.1	105.5	98.6	84%	95%	93%	87%
1981	83,813.2	92,116.1	90,320.7	85,619.5	109.0	119.8	117.5	111.3	86%	94%	92%	88%
1982	69,602.6	74,947.4	72,278.0	69,453.5	100.7	108.5	104.6	100.5	86%	92%	89%	85%
1983	61,358.2	63,992.7	60,657.9	57,921.1	93.4	97.4	92.3	88.2	86%	90%	85%	81%
1984	89,561.8	97,190.6	93,405.6	90,502.4	135.9	147.5	141.7	137.3	85%	92%	89%	86%
1985	81,892.4	86,336.0	82,187.4	95,064.7	133.6	140.8	134.1	155.1	86%	91%	86%	99%

Sources: own elaboration from the data in previous sections. Labels as defined in Table 4.4-1.

A noticeable characteristic of the numbers in Table 4.4-2 is that rent accounted for the principal share of the price of a barrel of oil throughout the century for all permutations. The share tended to increase over time. From the 1940s the rent per unit systematically accounted for more than 60 percent of the price. By 1960, the rents calculated represented more than 70 percent of the price and the highest proportions, around 95 percent, were obtained for the late 1970s.[60] The implicit consequence is that costs of production declined systematically relative to the price of oil. This evolution of the costs contrast to the constant or increasing costs generally assumed in the theoretical discussions of resource rents. The absence of technological change in the theoretical models would in part explain the difference between the historical and the theoretical evolution of costs and rents.

In nominal levels, the rents per unit, *u*, were less than 7 bolivars ($2 approx.) per barrel for all the period previous to the oil shock. In 1973, *u* ranked between 13.0 and 14.3 bolivars ($3.10- $3.4). The value rose to levels between 41.1 and 42.5 bolivars ($9.7-$10.1) in 1974. By 1981 the rents peaked at 109.0 - 119.8 bolivars ($25.4-$27.9), very close to the range obtained in 1985 ($22.2-$25.8). These results are very similar to Repetto's findings for Indonesia's oil rent, particularly for those obtained from permutation (b), which is equivalent to Repetto's calculation.[61]

The profile of the aggregated rents, *N*, shares the basic characteristics of the underlying per unit rent just described but the amount of oil extracted has a separate impact on the nominal value of *N*. For instance, while *u* remained almost unchanged from the late 1940s to the 1960s, the value of *N* in1948 had doubled by 1956 and tripled by 1969 as a consequence of the rapid increase in oil production. The opposite occurred during the 1970s when at the same time as prices (thus rent per unit) increased, production slowed down. Price and quantity produced are the driving forces defining the nominal value of the rents. While the former was the crucial variable for *u*, the latter had a bigger impact in *N*.

[60] These figures are consistent with the general views generated in the late 1970s and 1980s. 'The difference between market value and production costs is extremely high for oil today –the value attributable to the resource itself is rarely less than 80 % of current market price and often greater than 95%'.R. Stauffer, *Accounting for "Wasting Assets". Income Measurement for Oil and Mineral-Exporting Rentier States*, Vol. 25 (Vienna, 1984), p.8.

[61] R. Repetto, *Wasting Assets: Natural Resources in the National Income Accounts* (Washington, D.C., 1989). He found the rent to be $2.90 for 1973, $9.06 for 1974 and for the last year of the study, 1984, rent was $24.30.

The Resource Rent in Mexico 1921-1987

Aggregated rents and rents per unit calculated under the different permutations for Mexico's oil are reported in Table 4.4-3. As in the case of Venezuela the upper value of the resource rent is obtained when applying a 'normal' rate of return to capital, the mid value when the 'normal return to oil' applied and the lower value is obtained by permutation (b).

It is possible to identify general phases in the evolution of the rents in Mexico. From the peak of production in 1921 until well into the 1940s, Mexico's per unit and aggregated rents continuously decreased. The decreasing production and increasing costs (particularly salaries) reported in the previous sections account for this result. As in the case of Venezuela, the 1950s represent a relatively stable period. However, during the 1960s rents start to decrease again. The investment programmes initiated in those years account for this fact.[62] The trend changed abruptly in 1970 with the sharp increase in rents that continued until the 1980s.

The main characteristic of Table 4.4-3 is that permutation (b) delivers negative figures from the very date of the nationalisation up to 1973. *N*(b) is positive from 1921 up to 1938, becoming seriously negative until the late 1940s when it starts recovering only to fall again from the early 1960s. It has been just mentioned that negative resource rents have been reported elsewhere in the literature. Real losses are normally associated with a down turn of the market when assets may continue to be exploited, despite actual losses, in the hope of better times ahead (price increases or higher quality discoveries).[63] As a consequence, negative rents have been considered as temporary exceptions to otherwise positive resource rents. From the exposition in Chapter 3 and the analysis of costs in this chapter, it is possible to argue that the negative rents in Mexico are the result of the exploitation strategy followed by Mexico's government rather than the result of market fluctuations. When market forces do not rule (or operate in an imperfect fashion) negative rents can became the rule rather than the exception as the Mexican example demonstrates. Nevertheless, resources continued to be depleted regardless of the efficiency of the exploitation. Such depletion should still be accounted for, but negative rents, as Lindmark pointed out, are difficult to interpret in the context of environmental accounting.[64]

[62] See the investment section above and Appendix E for exploration investment.
[63] P. Bartelmus, 'The value of nature: valuation and evaluation in environmental accounting', in *Environmental Accounting in Theory and Practice*, Vol. 11 (London, 1998), p.278.
[64] Lindmark, *Towards Environmental Historical National Accounts for Sweden.*, p.78.

Table 4.4-3:
Mexico's resource rent under different permutations, 1920-1985

	Aggregated rent, *N*			Rent per unit, *u*			As percentage of price per barrel		
year	N(a6) Mill. pesos	N(a15) Mill. pesos	N(b) Mill. pesos	u(a6) pesos	u(a15) Pesos	u(b) Pesos	U(a6)	u(a15)	u(b)
1921			304.57			1.57			83%
1922			244.36			1.34			73%
1923			205.18			1.37			72%
1924			152.74			1.09			56%
1925			179.87			1.56			60%
1926			115.46			1.28			51%
1927	126,45	126,45	68.29	1,97	1,97	1.07	80%	80%	43%
1928	73,62	73,62	26.84	1,47	1,47	0.54	72%	72%	26%
1929	65,60	65,60	24.66	1,47	1,47	0.55	71%	71%	27%
1930	61,55	61,55	29.81	1,56	1,56	0.75	76%	76%	37%
1931	55,52	55,52	23.82	1,68	1,68	0.72	72%	72%	31%
1932	49,63	49,63	11.46	1,51	1,51	0.35	66%	66%	15%
1933	57,86	57,86	11.65	1,87	1,87	0.38	70%	70%	14%
1934	109,04	109,04	27.06	2,86	2,86	0.71	86%	86%	21%
1935	113.97	113.42	22.37	2.83	2.82	0.56	83%	83%	16%
1936	104.53	103.93	7.79	2.55	2.53	0.19	77%	77%	6%
1937	192.95	192.28	25.42	4.12	4.11	0.54	84%	84%	11%
1938	133.20	132.48	-33.58	3.46	3.44	-0.87	73%	73%	-18%
1939	107.63	105.20	-111.80	2.51	2.45	-2.61	59%	58%	-61%
1940	81.55	74.44	-197.21	1.85	1.69	-4.48	51%	47%	-124%
1941	83.32	81.52	-250.73	1.94	1.89	-5.83	55%	54%	-166%
1942	61.64	59.84	-233.72	1.77	1.72	-6.71	46%	44%	-173%
1943	63.35	61.28	-270.65	1.80	1.74	-7.70	44%	42%	-186%
1944	43.81	39.40	-348.56	1.15	1.03	-9.13	29%	26%	-231%
1945	26.51	15.98	-459.44	0.61	0.37	-10.55	16%	10%	-279%
1946	69.53	59.45	-512.74	1.41	1.21	-10.41	27%	23%	-202%
1947	95.60	87.68	-664.90	1.70	1.56	-11.81	34%	31%	-236%
1948	306.36	290.79	-540.08	5.24	4.97	-9.23	59%	56%	-104%
1949	412.22	391.43	-507.79	6.77	6.43	-8.34	62%	59%	-76%
1950	737.08	704.86	-495.54	10.18	9.73	-6.84	74%	71%	-50%
1951	854.98	823.03	-506.02	11.06	10.65	-6.55	72%	70%	-43%
1952	967.04	933.47	-462.21	12.51	12.08	-5.98	73%	71%	-35%
1953	656.61	613.05	-720.64	9.07	8.46	-9.95	63%	59%	-69%
1954	957.91	880.69	-678.52	11.45	10.53	-8.11	66%	60%	-47%
1955	997.48	908.47	-812.49	11.16	10.16	-9.09	63%	57%	-51%
1956	1,081.69	1,000.51	-833.56	11.93	11.04	-9.19	63%	59%	-49%
1957	1,395.71	1,276.19	-442.24	15.81	14.46	-5.01	65%	60%	-21%
1958	1,228.90	1,083.82	-820.10	13.14	11.59	-8.77	22%	19%	-15%
1959	987.68	843.23	-1,207.47	10.25	8.75	-12.53	53%	45%	-65%
1960	664.06	435.73	-1,644.27	6.70	4.40	-16.60	41%	27%	-101%
1961	1,342.55	1,134.20	-1,375.45	12.57	10.62	-12.88	59%	50%	-60%
1962	1,548.65	1,374.05	-1,407.11	13.85	12.28	-12.58	60%	54%	-55%
1963	1,507.72	1,339.33	-1,621.65	13.13	11.66	-14.12	58%	51%	-62%
1964	1,474.52	1,244.30	-1,718.31	12.76	10.77	-14.87	55%	47%	-64%
1965	1,354.98	1,148.61	-1,881.12	11.49	9.74	-15.95	49%	42%	-68%
1966	1,212.38	931.49	-2,107.52	10.01	7.69	-17.40	43%	33%	-75%
1967	1,185.42	721.56	-2,452.14	8.91	5.42	-18.43	38%	23%	-79%
1968	981.42	514.50	-2,812.35	6.89	3.61	-19.76	30%	16%	-85%
1969	1,121.84	664.55	-3,241.01	7.49	4.43	-21.63	33%	20%	-96%
1970	1,050.03	635.67	-3,525.22	6.70	4.06	-22.50	29%	18%	-98%
1971	1,745.92	1,334.26	-3,084.11	11.20	8.56	-19.78	38%	29%	-67%
1972	2,109.21	1,638.15	-2,703.94	13.07	10.15	-16.76	41%	32%	-53%
1973	4,703.35	4,059.85	-889.35	28.52	24.62	-5.39	62%	53%	-12%
1974	24,029.17	23,152.75	10,995.16	114.50	110.33	52.39	87%	84%	40%
1975	32,123.24	30,864.95	18,525.46	122.80	117.99	70.82	88%	84%	51%
1976	50,602.45	48,450.37	36,886.92	172.64	165.29	125.84	91%	87%	66%
1977	100,964.59	97,758.16	83,752.71	281.95	273.00	233.89	93%	90%	77%
1978	122,561.50	116,918.23	101,609.99	276.91	264.16	229.57	92%	88%	76%
1979	209,874.85	202,362.37	178,320.15	390.88	376.89	332.11	93%	90%	79%
1980	517,399.55	503,209.79	477,722.70	730.18	710.15	674.18	96%	93%	88%
1981	740,845.46	719,755.58	681,302.35	877.87	852.87	807.31	96%	93%	88%
1982	1,881,754.29	1,852,534.08	1,783,200.50	1,877.18	1,848.03	1,778.87	97%	96%	92%
1983	4,429,150.09	4,408,110.88	4,255,133.04	4,552.49	4,530.86	4,373.62	99%	98%	95%
1984	2,331,022.40	2,312,098.64	2,070,376.97	2,378.98	2,359.66	2,112.97	96%	96%	86%
1985	8,148,324.36	8,091,513.57	7,767,675.40	8,486.66	8,427.49	8,090.21	98%	97%	94%
1986	7,847,933.75	7,759,218.68	7,124,104.01	8,856.60	8,756.49	8,039.74	97%	95%	88%
1987	23,235,250.45	22,989,274.15	21,177,741.37	25,056.37	24,791.12	22,837.60	97%	96%	88%

Sources: own elaboration from the data in previous sections. Labels as defined in Table 4.4-1. For 1927-1934, permutation (a) only accounts for labour costs.

Permutation (b) regains positive rent values from 1974 up to the end of the period considered. These values are very similar to the obtained by permutation (a) for the same years. Permutation (a) obtained positive rents for all the years considered. In relative terms, $u(a_r)$ represented roughly the same share of the price of a barrel of oil in Mexico as it did in Venezuela at the beginning and the end of the period considered. For the years in between 1940 and 1970 the share of $u(a_r)$ on the price is smaller than in the case of Venezuela, but still the rent represented more than half the price per barrel for the majority of years.

In nominal terms, the rent accruing to Mexican oil fluctuated widely, yet on average the oil rent per unit in Mexico stayed below $1 before the oil shock. Both the higher factor costs and the lower price of Mexican oil account for this result. The oil boom catapulted Mexican rents to a level that surpassed other oil-producing countries' rents. In 1970 the rent per unit still ranged 4.06 to 6.7 pesos ($0.3-$0.5). It rose to 110.33-114.5 pesos ($8.30-$9.44) by 1974 reaching 730.18 (approx. $31) in 1980. Nevertheless, the poor quality of the data underlying the calculation should be acknowledged and these results must be taken with caution.

From the calculation of the resource rent of Mexico and Venezuela in this section we learned that the quantity extracted and, most importantly, the price of oil have the greatest weight in determining the nominal value of the rent. The choice of the rate of return on capital has only a marginal impact on the final values, even more so in the case of Mexico where capital investment (thus payments) had a very small significance overall. It is also noticeable that the relative size of the resource rent with respect to the price of oil has been very high historically. It is widely recognised for the last third of the twentieth century that the rent is the most important component of the price of a barrel of oil. The results of this section demonstrate that it has also been the case from the early days of the oil industry. A simple but crucial observation also derives from these rents: they neither are constant nor grow at the rate of interest over time. That is rents do not behave in accordance to the theoretical models reviewed in Chapter 2. At front, that is not much of a problem because most theoretical models depend on a number of assumptions that are not quite true. Only if the assumptions become crucial to the results this observation can invalidate the model.

The rents calculated in this section along with the data about the variation of reserves and the life expectancy of the resource presented above are the basic inputs for the calculations in Chapter 5. Despite the concerns regarding the quality of the underlying data, the resource rents for Venezuela and Mexico calculated in this section appear fairly robust, consistent with similar exercises on the literature and with the history of each country. Even the negative rents obtained for Mexico by one of the permutations, are not surprising in the context of the history of Mexican oil industry described in previous chapters. On the one hand, the negative rents obtained for Mexico under permutation (b) seem to indicate that the Mexican strategy is expensive in its own way, if not in terms of resource depletion (for the pace of extraction was slower for sometime), definitely in terms of efficiency. On the other hand, Mexico's case is exceptional to a degree, although not a unique case. Negative rents are more common than theoretical models acknowledge. The possibility of a long-standing negative rent requires further investigation by environmental accounting theory, for the depletion continues to take place but no cost can be assigned to it if the resource rent is the basic input to valuation methods.

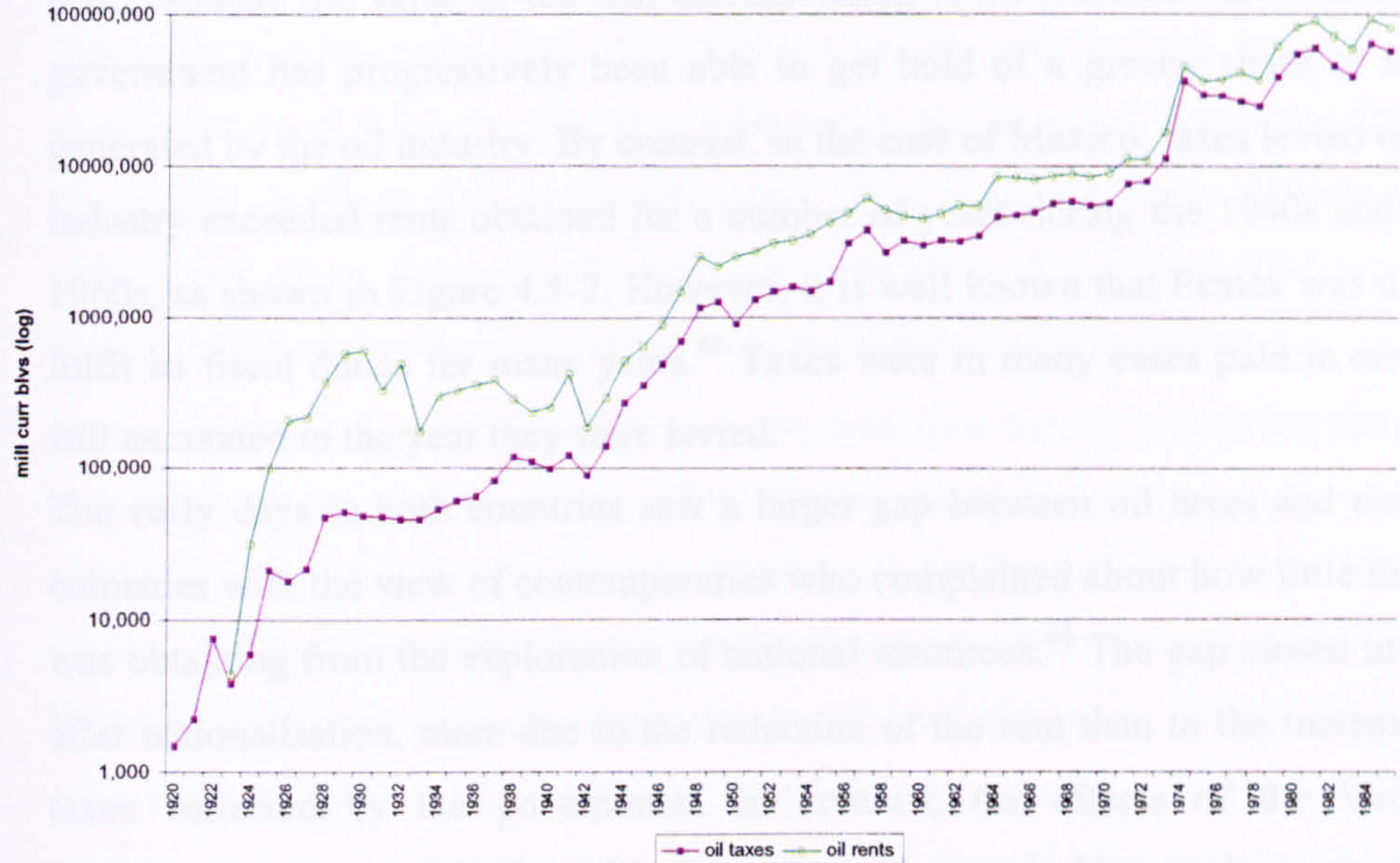
4.5 Oil Taxes and Rents

Chapter 2 noted that taxes have been considered the best proxy for the resource rent when the government fully participates in the production process.[65] In Chapter 3 we saw how scholars that evaluated the so called 'sowing oil' policies in Venezuela also preferred to concentrate on the analysis of the collection of taxes and its expenditure in order to assess the transformation of the transitory income from oil into permanent wealth for the nation.[66] It is therefore worthwhile to contrast the results of environmental accounting with these approaches since they share at last one objective, that is, obtaining a better account of the true economic performance of these economies. Having gone this far in the calculation of the resource rent in Mexico and Venezuela along the lines proposed by the environmental accounting literature, it is now time to assess how comparable the environmental accounting methods are to the traditional procedure. The most straightforward method of checking to whether taxes make a good substitute for the resource rent is to compare their magnitude in Figures 4.5-1 and 4.5-2.

[65] R. Stauffer, *Accounting for 'Wasting Assets'. Income Measurement for Oil and Mineral-Exporting Rentier States*, Vol. 25 (Vienna, 1984), p.19 and also B. Mommer, ' Integrating the oil. A structural analysis of petroleum in the Venezuelan economy', *Latin American Perspectives* 23 (1996 summer) 90, p.141.

[66] Among others, see, History, p.119; T.E. Carrillo Batalla, *La evaluación de la inversión del ingreso fiscal petrolero en Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]* (Caracas, 1968); C. Balestrini, '¿Cuál ha sido el papel cumplido por la explotación petrolera en el proceso de modernización de la sociedad venezolana?', in Mieres (ed.), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989).

Figure 4.5- 1: Oil taxes and rents. Venezuela 1920-1989 (mill. bolivars at current prices)



Sources and notes: Sources and notes: resource rents as in Section 4.4, for the sake of clarity only *N(a)15* permutation is plotted here. Oil taxes compiled from the sources in Appendix C.

Figure 4.5- 2: Oil taxes and rents. Mexico 1912-1989. (mill. pesos at current prices)

Sources and notes: Sources and notes: resource rents as in Section 4.4, only *N(a)* permutation is plotted here (for 1912-1935 the continuous line is only a guess-estimate of the rents since data are missing for the calculation .Oil taxes compiled from the sources in Appendix C.

It is clear from this comparison between taxes and rents that the government was only able to appropriate part of the oil rents. Oil fiscal revenues systematically underestimate the value of the rent corresponding to oil resources in Venezuela. The government has progressively been able to get hold of a greater share of the rents generated by the oil industry. By contrast, in the case of Mexico, taxes levied on the oil industry exceeded rents obtained for a number of years during the 1940s and the late 1960s, as shown in Figure 4.5-2. However, it is well known that Pemex was unable to fulfil its fiscal duties for many years.[67] Taxes were in many cases paid in arrears but still annotated in the year they were levied.

The early days in both countries saw a larger gap between oil taxes and rents. This coincides with the view of contemporaries who complained about how little the nation was obtaining from the exploitation of national resources.[68] The gap closed in Mexico after nationalisation, more due to the reduction of the rent than to the increase of the taxes collected by the government. In contrast, the effects of the Venezuelan Hydrocarbons Law of 1943, which sharply raised taxes in Venezuela are very visible in this comparison; the gap between taxes and rents narrowed rapidly from that year onwards.[69]

The conclusion of this section is that both governments managed to capture a bigger share of the rent as the century went by, but neither was able to capture the whole of the rent at any point in time. Hence, taxes fall short as proxy for the resource rent. They only measure how good governments are at seizing rents, but do not show the part of the rent that labour (via extra wages or extra labour) and/or capital (via extra profits) managed to acquire. Authors using taxes as proxy for the rents generated in the oil sector run a serious risk of underestimating the rent effects.[70]

[67] According to Philip, G., *Oil and Politics in Latin America. Nationalist Movements And State Companies* (Cambridge, 1982), p. 338, Pemex could not meet its commitments to the state and owed arrears of tax. From 1954 the company presented losses in its accounts. New investments were financed almost in their entirety by long-term or short-term loans and by arrears of debt to the state. 'On December 31 1958, the accumulated deficit totalled 215 million pesos', United Nations. Department of Economic and Social Affairs, *Petroleum Exploration: Capital Requirements and Methods of Financing* (New York, 1962), p.17.

[68] This has been already mentioned generally in Chapter 1, and more specifically in Chapter 3.

[69] References to the 1943 Law can be found above in Chapters 1 and 3.

[70] It would be the case of Stauffer, *Accounting for 'Wasting Assets'. Income Measurement for Oil and Mineral-Exporting Rentier States* and Mommer, ' Integrating the oil. A structural analysis of petroleum in the Venezuelan economy', p.141.

4.6 Conclusions

This chapter presented the calculation of the oil resource rents of Mexico and Venezuela for the period 1920-1985. It discussed not only the data, but also the most suitable ways of using the available information and provided sensitivity analysis of the crucial variables. Oil stocks and flows, price and costs series derived from the chapter are major items for the potential generation of environmental accounts of Mexico and Venezuela as the one depicted in Figure 2.2-2 for example.

In the process of generating the resource rent, the chapter compared the two oil industries in quantitative terms. The chapter made obvious how the contrasting production strategies presented in the previous chapter translate into very different rent results. The negative rents obtained for Mexico under permutation (b) seem to indicate that the Mexican strategy was expensive in terms of efficiency. This observation also rises interesting economic questions. Was Mexico's strategy sensible in limiting its production because costs were so high? Should it have limited its output to zero? Or were the high costs of production a consequence of the policy? Was Mexico inefficient because of the closure to foreign investment and foreign markets? Nevertheless, these questions are far beyond the scope of this research. What it can be established with the data presented is that the strategy chosen by the Mexican government could have been better implemented. It is plausible to argue that at the time of the nationalisation Mexico 'simply ran out of oil deposits that could be extracted at competitive costs, given prices, technology and competitive sources.' [71] However, the data presented suggests that for most of the period after the nationalisation costs could have been reduced by changing policies (for instance, reducing the labour force and increasing production to take advantage of economies of scale).

The possibility of a long-standing negative rent also requires further investigation by environmental accounting theory, for the depletion continues to take place but no cost can be assigned to it if the resource rent is the basic input to valuation methods.

The chapter also showed how taxes fall short as proxy for the resource rent. They only measure how good governments are at seizing rents, but do not show the part of the rent that labour (via extra wages or extra labour) and/or capital (via extra profits) managed to acquire.

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[71] S.H. Haber, N. Mauer and A. Razo, 'When Institutions do not Matter: The Rise and Decline of the Mexican Oil Industry', *Paper presented at the Economic History Seminar at UC Berkeley, September 2001* (no published).

Several remarks need to be made in relation to the contrast between the actual behaviour of some of the variables over time and the assumptions generally adopted in theoretical models of resource depletion. The most noticeable is the mismatch between the historical evolution of the resource rents and the assumptions in the literature. The models based on Hotelling's principle, assume prices over time while the rate of extraction and the stocks remain constant. It is remarkable that at some point in history, oil prices were thought to be relatively stable, almost constant, while production has never been constant, even at times of little or no discoveries. The absence of technological change in the theoretical models would in part explain the difference between the historical and the theoretical evolution the rents. This divergence between the theoretical assumptions and the actual behaviour of the variables is likely to have an impact on the results offered by the methods. This will be explored in Chapter 5, for which the results of this chapter are basic inputs.

'Although minerals are probably the easiest environmental asset to include in environmental accounts, the practice of valuing reserves and the depletion of those reserves has nevertheless met with frustration'.[1]

Chapter 5

Value and Depreciation of Oil Resources under Different Methods. Venezuela and Mexico 1920s-1980s

'Ex post and ex ante analyses are not alternatives. They should be viewed as complementary techniques for improving our knowledge. The ex ante analysis is a prediction of what is expected to happen; the ex post analysis is a check on what actually did happen.'[2]

It is particularly important that the economic analysis of environmental and resource policies includes an ex post perspective. Our knowledge of the physical and economic systems on which ex ante analyses are based today is extremely limited. It is necessary both to develop more comprehensive models and also to put more effort in the verification of these models through ex post comparisons of the predictions with the results.

It must be emphasised that the ex post verification of the analytical models used in resource valuation is not simply a comparison of actual results with predictions. As shown in Chapter 2, ex ante models are based upon some view of the future with projections of economic magnitudes. The additional complication in ex post analysis is to distinguish the effects of our inability to anticipate the future accurately from the analytical failure of the models. In other words, to what extent the difference between what is expected to happen and what actually did happen is due to unexpected changes

[1] G.A. Davis and D.J. Moore, 'Valuing mineral stocks and depletion in green national income accounts', *Environment and Development Economics* 5 (2000), p.110.

[2] A.M. Freeman, *The Measurement of Environmental and Resource Values: Theory and Methods* (Resources for the Future, Washington D.C., 1993), p.14. Most of the introduction of this chapter derives from this source.

that could not be anticipated, and which ones to flaws in the models – imperfect underlying theory, missing variables, misleading assumptions, etc. The real benefit of ex post analysis is in making the most of the opportunity to improve on the analytical models used as much as in understanding the path that history took.

At the core of this chapter is the quest for a value of the petroleum resources from which an estimate of depletion/depreciation can be derived to produce better indicators of economic performance. It should be clear from the start that the depreciation measures wholly depend on the value assessed for the resource in the first place, or the assumptions made regarding such value. This chapter demonstrates that although in practice the methods described in Chapter 2 may avoid such calculation, all methods make some assumption regarding the value of the resource. 'While it is perfectly legitimate for theoreticians, assuming away these messy details can lead practitioners into trouble.'[3]

Given the nature of the methods and aiming to build on previously presented materials, this chapter first gives the figures for depreciation obtained through the net price method when applied to the historical data of Mexico and Venezuela. It is then recognised that the net price is just an approximation, very much restricted by the underlying assumptions, to the change in value of the resources (where value is estimated as the present value). Therefore, the second section deals with the actual calculation of the present value of oil resources in both countries using the data compiled in the previous chapter. The value of the resources has also been approximated by the Hotelling Valuation Principle, which will be compared with the actual present value. The empirical implementation of the algebra of the present value is problematic. Different possible solutions have further implications for the value of the resource, the depreciation that derives from it and the results provided by other methods, particularly that of the user costs. The latter is discussed in the third section, and its results are highly dependent on the assumptions made to obtain the present value.

Finally, the imputed income method is implemented as specified by Sefton and Weale. This is a pioneer calculation since this method has not found yet is way into the empirical attempts of environmental accounting. Its main implication is that while the net price is the correct adjustment for closed economies, open economies need to impute an income to the stock targeted for exports; in the case of a pure resource

[3] J.R.Vincent, 'Green accounting: from theory to practice', *Environment and Development Economics* 5 (2000), p.20.

exporter the user costs approximates this result greatly. This suggests a different type of adjustment for each of our two case studies.

5.1 The results of the Net Price Method

Equation 2.3-3 defined the present value of a natural resource, V_t, as the sum of the expected net revenue flows discounted at nominal or real interest rates for the life of the asset, which in its compact form can be expressed as:

$$V_t = \sum_{n=0}^{R_t/q_t} \frac{N_{t+n}}{(1+i)^n} \qquad [5.1.1]$$

For our purposes, the value of the natural capital asset (oil) in a year is taken to be the present value of the sum of future expected rents over the lifetime of the resource. Therefore, in the above equation, N_t is the resource rent as specified in the previous chapter. The expected life of the resource for a given year t is given by n and i is the social discount rate.

Natural resource wealth is usually defined as the present discounted value of all future resource rents.[4] According to the depreciation approach, the change in value/wealth from V_t to V_{t+1}, due to use/depletion during the year, represents the depreciation of the mineral asset that should have not been accounted as income. Therefore, it needs to be discounted from traditional indicators of economic performance.

Chapter 2 also showed how, under very strong assumptions, $\Delta V_t = -(p_t - MC_t)\, q_t$.[5] That is, depreciation can be approximated by the Hotelling rent. Yet, as was said above, many early applied studies and most current work estimate depreciation through the net price method using average (AC_t) instead of marginal costs (MC_t).[6] The net price is nothing but the value of the rent (N) calculated in section 4.4, where permutation (b) possibly remains closer to the original method advocated by Reppetto and associates since it does not include the payment to man-made capital.[7] Figure 5.1- 1 compares the net price per barrel (u_t), and Figure 5.1-2 the aggregated net price (N_t) - u_t multiplied by the production in a given year q_t- for both countries.

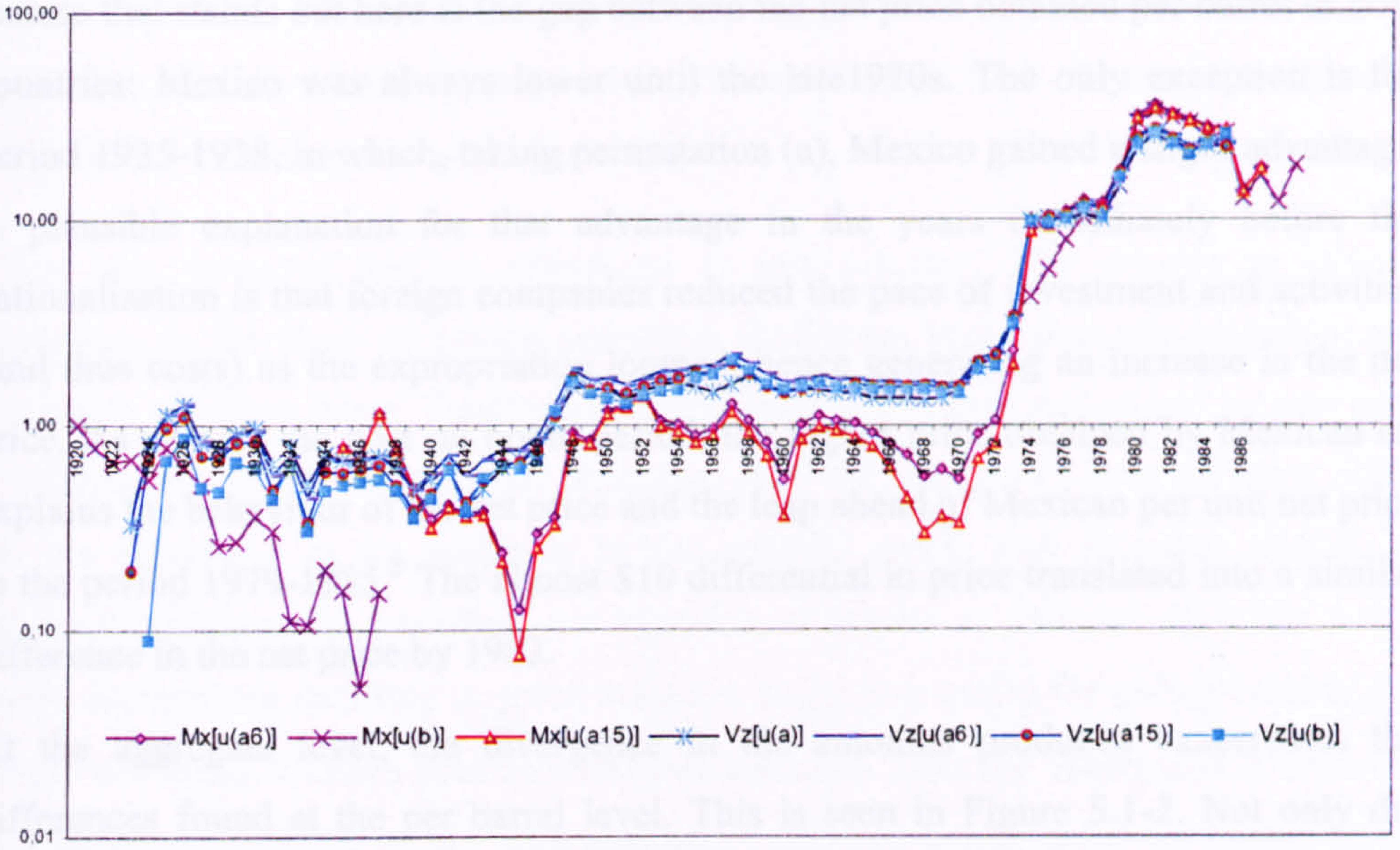
[4] L. Lindholt, 'On Natural Resource Rent and the Wealth of a Nation. A Study Based of National Accounts in Norway 1930-1995', *Statistics Norway. Research Department Discussion Papers* 281 (2000), p.6.

[5] Optimal management, endogenous prices and endogenous costs being the most restrictive assumptions.

[6] The exceptions to the general use of AC_t have been noted in section 2.3.

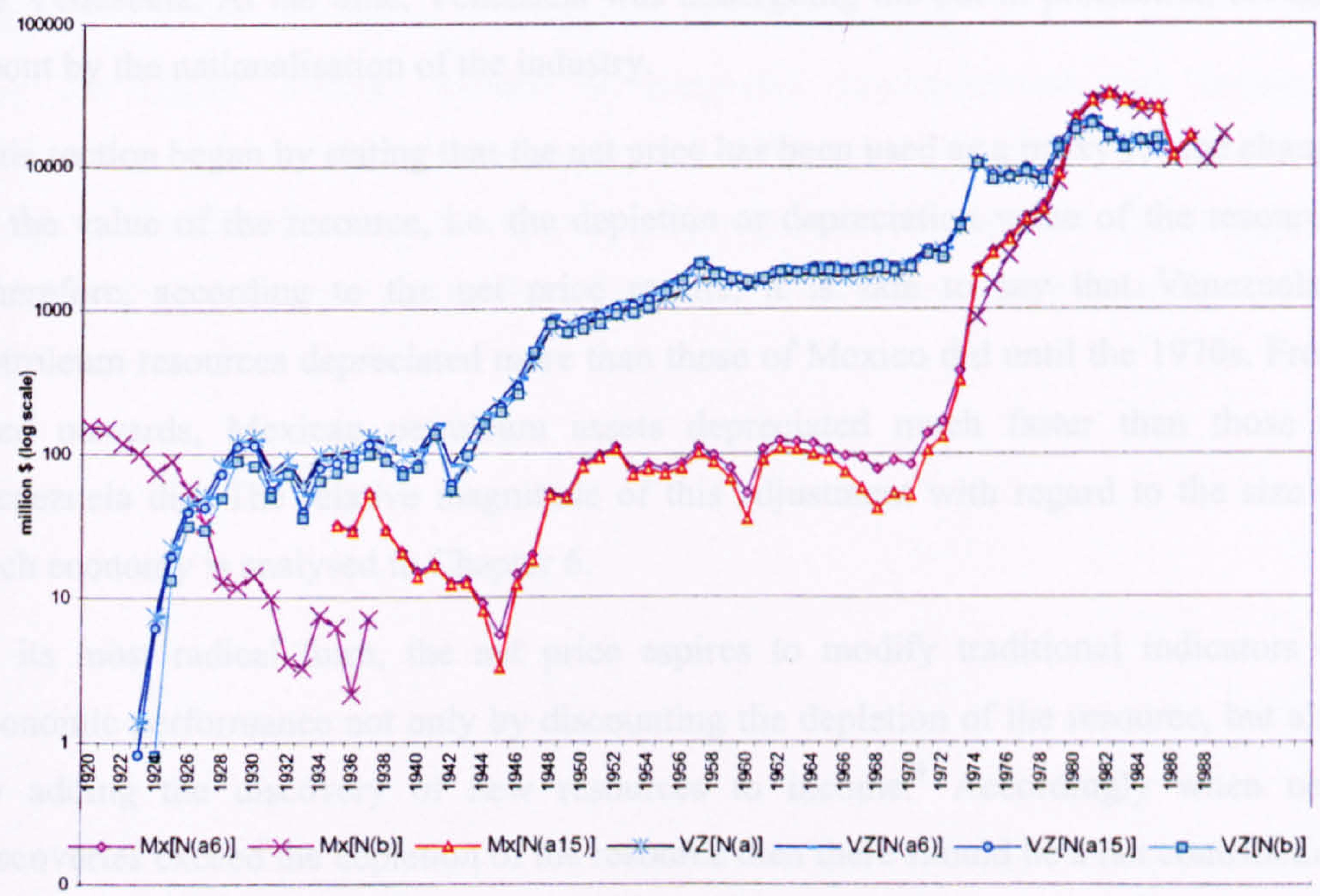
[7] R. Repetto, *Wasting Assets: Natural Resources In the National Income Accounts* (Washington, D.C., 1989).

Figure 5.1-1: Net price per unit *(u)* of oil in Mexico and Venezuela 1924-1987 ($ per barrel)



Sources: rents calculated in section 4.4. Labels defined in Table 4.4-1. Note that permutation (b) for the case of Mexico cannot be plotted from 1937 to 1974 because of its negative values.

Figure 5.1-2: Net price *(N)* of oil in Mexico and Venezuela 1924-1985 (million $)



Sources: rents calculated in section 4.4. Labels defined in Table 4.4-1.

Figure 5.1-1 contrasts the net price per barrel in Mexico and Venezuela. The main characteristics of each rent were analysed in the previous chapter. Nevertheless, the feature that stands out here is the gap between the net price obtained per barrel in both countries: Mexico was always lower until the late1970s. The only exception is the period 1935-1938, in which, taking permutation (a), Mexico gained a slight advantage. A plausible explanation for that advantage in the years immediately before the nationalisation is that foreign companies reduced the pace of investment and activities (and thus costs) as the expropriation loomed, hence generating an increase in the net price. As regards the post oil boom period, the higher price obtained by Mexican oil explains the behaviour of the net price and the leap ahead of Mexican per unit net price in the period 1979-1985.[8] The almost $10 differential in price translated into a similar difference in the net price by 1982.

At the aggregate level, the divergence in the amounts produced exacerbates the differences found at the per barrel level. This is seen in Figure 5.1-2. Not only did Venezuela have a higher net price per unit, but also a far greater production until the mid-1970s. Therefore the gap widens considerably only to narrow rapidly between 1973 and 1976. By then, the sudden expansion in Mexican oil production, combined with higher net and absolute prices resulted in an aggregate net price far greater than for Venezuela. At the time, Venezuela was undergoing the cut in production brought about by the nationalisation of the industry.

This section began by stating that the net price has been used as a proxy for the change in the value of the resource, i.e. the depletion or depreciation value of the resource. Therefore, according to the net price results, it is safe to say that Venezuela's petroleum resources depreciated more than those of Mexico did until the 1970s. From then onwards, Mexican petroleum assets depreciated much faster than those of Venezuela did. The relative magnitude of this adjustment with regard to the size of each economy is analysed in Chapter 6.

In its most radical form, the net price aspires to modify traditional indicators of economic performance not only by discounting the depletion of the resource, but also by adding the discovery of new resources to income.[9] Accordingly when new discoveries exceed the depletion of the resource then there should be a net contribution

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[8] See section 4.2.

[9] Such was the procedure used by the World Resource Institute for greening the national accounts of Indonesia, see R. Repetto, *Wasting Assets: Natural Resources In the National Income Accounts* (Washington, D.C., 1989).

to income. This calculation simply involves multiplying u_t by the net change in volume of proven reserves over the accounting period. In our case this involved combining the data in Figure 5.1-1 with the data provided in Figure 4.1-2. The results of the net price applied to the net variation of reserves are shown in Table 5.1-1. Observe the volatility of the series both in terms of levels and signs.

There are, however, serious objections to this practice. The attempt to include variations in the stock of natural resources challenges both accounting practice and economic common sense. Traditional accounting practice does not record income until it materialises. In addition, capital formation does not necessarily have the same effect on the economy, as do additions to the mineral stock, and therefore should be accounted differently. Including net variation of stocks in national accounts would cause fluctuations resulting in green accounts being less useful for policy-making and macro-economic analysis than conventional accounts. Take the example of the Bureau of Economic Analysis, whose environmentally adjusted accounts for the United States for the period 1958-1991 included the Alaskan oil finds of 1970 as capital formation. The result was a serious distortion of GDP growth, wiping out the 1970 recession and causing an apparent recession in 1971. Thus, when including mineral additions as capital formation, the aggregate GDP series may become more volatile and may not accurately reflect movements in production and employment.[10] It is for these reasons that the United Nations System of Integrated Environmental and Economic Accounting omits additions in the production accounts but captures them in the assets accounts. Similar effects can be expected if the numbers in Table 5.1-1 were to be used for generating environmentally adjusted accounts for Mexico and Venezuela.

[10] W.D. Nordhaus and E.C. Kokkenlenber (eds.), *Nature's Numbers: Expanding the U.S. National Economic Accounts to Include Environment* (Washington D.C., 1999), p.11. By his part, S. El Serafy, 'Green accounting and economic policy', *Ecological Economics* 21 (1997) 3, p.222, ft.11. reported that the procedure for adjusting the US accounts in respect to natural resources for the first quarter of 1994 included the net variation in stocks, an initiative that has been subsequently abandoned.

Table 5.1-1: Strict net price method: unit net price times net variation of reserves (NPR)
Mexico and Venezuela 1925-1985 (mill current US dollars)

Year	Mx[NPR(a6)] Mill curr US$	Mx[NPR(b)] mill curr US$	Mx[NPR(a15)] mill curr US$	Vz[NPR(a)] mill curr US$	Vz[NPR(a6)] mill curr US$	Vz[NPR(a15)] mill curr US$	Vz[NPRu(b)] mill curr US$
1925		3		93	93	80	55
1926		2		139	139	122	96
1927		2		92	92	77	54
1928		1		86	86	75	52
1929		1		99	102	91	72
1930		1		306	295	264	191
1931		1		202	179	149	135
1932		0		246	221	197	196
1933		0		158	138	104	95
1934		1		225	213	184	148
1935	3	1	3	259	250	221	192
1936	3	0	3	201	201	179	154
1937	4	1	4	208	210	186	159
1938	6	-1	6	188	180	149	141
1939	-21	22	-20	141	143	112	103
1940	12	-29	11	278	297	234	222
1941	0	0	0	319	365	315	311
1942	4	-15	4	202	290	213	194
1943	8	-33	8	247	347	275	281
1944	69	-548	62	321	387	335	322
1945	-4	72	-2	244	271	236	221
1946	-14	106	-12	135	152	133	118
1947	-17	119	-16	83	104	92	97
1948	-19	34	-18	528	641	584	566
1949	239	-295	227	895	980	873	844
1950	-49	33	-47	732	824	745	666
1951	398	-235	383	460	537	487	431
1952	466	-223	450	227	265	240	219
1953	-8	9	-8	1,469	1,691	1,537	1,358
1954	319	-226	293	1,238	1,435	1,313	1,156
1955	180	-147	164	2,281	2,874	2,657	2,558
1956	199	-153	184	2,208	2,975	2,723	2,678
1957	525	-166	480	2,595	3,594	3,279	3,358
1958	732	-488	645	1,959	2,262	2,021	2,070
1959	228	-279	195	444	494	432	447
1960	235	-583	154	587	646	567	597
1961	204	-209	172	-774	-875	-780	-804
1962	20	-18	18	-110	-126	-115	-117
1963	149	-160	132	296	342	312	313
1964	79	-92	66	262	308	292	275
1965	-108	150	-92	74	89	84	82
1966	223	-388	172	-510	-610	-578	-555
1967	92	-190	56	-1,228	-1,463	-1,394	-1,334
1968	24	-70	13	-380	-460	-438	-423
1969	24	-69	14	-1,066	-1,241	-1,181	-1,115
1970	-1	4	-1	-1,645	-1,804	-1,722	-1,617
1971	-125	222	-96	298	329	317	292
1972	-42	54	-32	-234	-241	-235	-209
1973	100	-19	87	14,904	16,231	15,837	14,765
1974	3,124	1,429	3,010	0	0	0	0
1975	5,551	3,201	5,333	-1,712	-1,752	-1,732	-1,612
1976	53,056	38,675	50,800	-1,316	-1,402	-1,385	-1,328
1977	60,168	49,911	58,257	-2,431	-2,790	-2,756	-2,603
1978	294,331	244,016	280,778	2,437	2,744	2,696	2,482
1979	84,480	71,778	81,456	3,652	4,245	4,183	3,935
1980	477,241	440,644	464,153	25,735	29,105	28,677	26,791
1981	425,573	391,369	413,458	11,637	12,790	12,541	11,888
1982	0	0	0	104,352	112,365	108,363	104,128
1983	14,903	14,318	14,833	28,496	29,720	28,171	26,900
1984	-20,944	-18,602	-20,774	48,577	52,714	50,661	49,087
1985	-23,249	-22,163	-23,087	28,949	30,520	29,053	33,605

Sources: Figure 5.1-1 and Figure 4.1-2. Labels: Mx for Mexico, Vz for Venezuela, NPR for net price using net reserves, rent permutations as defined in Table 4.4-1.

The net price in its simplest form has been severely criticised for overestimating both the value and the depreciation of non-renewable resources.[11] The criticisms come from theoretical speculation regarding the mismatch between the assumptions made by the net price method (see Chapter 2) and alternative, more realistic, assumptions regarding the future paths of prices, costs and depletion rates. It is worth recalling here that the net price has also been criticised for being based on the assumption that none of the resource is exported abroad. That is precisely why the description of the strategies taken by Mexico and Venezuela and the data set assembled in Chapter 4 can help to shed light on this debate. We can now test the actual path taken by the present values and its variation through time, hence directly addressing the issue of depreciation of the resources. It will then be possible to assess whether the net price overestimates the depreciation, by how much, and under what circumstances.

5.2 Implementing the Present Value method

It is often argued that the implementation of the present value method depends too much on the expected rate of change of oil prices and of the cost of developing the reserves.[12] To be sure, those authors that have attempted to apply this method had no other option but to impose strict assumptions regarding the expected behaviour of prices, costs and quantities produced, which are underpinned by implicit assumptions regarding technological stagnation. Assumptions of constant rates of extraction and constant (or semi-constant) rents are commonplace.[13]

In fact, just as the net price tries to approximate the change in value from t to $t+1$ by avoiding the calculation of the value of the resources, the value of the resource itself has its own short cut in the Hotelling Valuation Principle (HVP). According to the latter, the value of the resource is the result of multiplying the Hotelling rent per unit (which we approximated with u_t, in Figure 5.1-1), by the reserves remaining in the current year.

[11] G.A. Davis and D.J. Moore, 'Valuing mineral stocks and depletion in green national income accounts', *Environment and Development Economics* 5 (2000), p.111; also see Seroa and Ferraz in the same issue of the journal on the 'tendency' to exaggerate depreciation.
[12] Some authors explicitly refuse to apply this approach given the difficulty of having to speculate about future values for prices, quantities, costs of extraction, etc. Examples are T.M. Crowards, 'Natural Resource Accounting: A Case Study of Zimbabwe', *Environmental and Resource Economics* 7 (1996), p.214 and G.D. Santoprieto, 'Alternative Methods for estimating resource rent and depletion costs: the case of Argentina's YPF', *Resources Policy* 24 (1998) 1, p.41.
[13] P. Vaze, 'Environmental Accounts- Valuing the Depletion of Oil and Gas Reserves', *Economic Trends* (1996, April) 510, p.41 and M. Common and K. Sanyal, 'Measuring depreciation of Australia's non-renewable resources: a cautionary tale', *Ecological Economics* (1997) 26, p.26.

However, the availability of historical data enables the calculation of the present value by using actual prices and costs series. This is the equivalent of having perfect foresight from every point in time. It is interesting to contrast the results of both alternatives (keeping the rent constant versus using the actual data assuming perfect foresight) in order to evaluate the potential divergence between the ex-ante and the ex-post results. If they differ by a great deal, those reluctant to apply this method would have one more argument in their favour: that the assumptions bias the results considerably. If, on the contrary, actual data and assumed values result in similar present values, then the method will be endorsed. Speculating about the validity of the present value results under different assumptions has further relevance to the user costs and the net price approaches, since both are based on the present value results (see Chapter 2).

This section elaborates on the results of implementing equation [5.1-1] under a variety of assumptions. This first exercise provides us with the present value of the resources, which we can then compare with the HVP. Once the value is known, its change over time can be calculated. Hence the depreciation value can be estimated using the present value method.

The Value of the Resource

Having all the historical variables calculated in Chapter 4 in hand, one can calculate the present value implementing equation 5.1-1 assuming perfect foresight. Take the example of 1920, the first year for which the rent has been calculated for Venezuela. In that year, the amount of oil known in the reserves was enough to sustain current production for another 21 years ($n = 21$). Therefore, V_{1920} is the sum of the discounted resource rents obtained for every year up to 1941. Algebraically:

$$\textit{PV1:} \quad V_{1920} = N_{1920} + \frac{N_{1921}}{(1+i)} + \frac{N_{1922}}{(1+i)^2} + ... + \frac{N_{1941}}{(1+i)^{21}} \qquad [5.2\text{-}1]$$

Following this procedure, V_{1972} turns to be the last year for which enough data are available to produce a present value of all 'future' rents. From that year onwards, the time horizon expands beyond 1985, the last year for which the rent has been calculated for Venezuela.[14] Under this perfect foresight scenario the rent, the quantity extracted

[14] Given that this approach tries to emulate a perfect foresight scenario, it is relatively weak to constrain the time horizon of the reserves to those known in any given year. In a perfect foresight scenario, both Mexicans and Venezuelans would have known their reserves would last longer than the historical data set suggest in any specific year. One could place the aggregate oil available to both economies during the century at the start of their production period and start the depletion from then on. As shown in

and the time horizon change from year to year according to the historical data set.[15] In equation 5.2-1, *PV1* adds up the discounted values of the total aggregated rents obtained historically.

However, the most common approach in the literature when implementing the present value method has been to assume that the resource rent remains constant and that extraction occurs at a constant rate until the resource is exhausted.[16] Such an approach presupposes constant prices for oil and constant costs of extraction. To calculate V_{1920}, it entails adding up the discounted value of the rent of 1920 for the 21 years the resource was expected to last. The equation to be used would then be:

$$PV2:\ V_{1920} = N_{1920} + \frac{N_{1920}}{(1+i)} + \frac{N_{1920}}{(1+i)^2} + \ldots\ldots + \frac{N_{1920}}{(1+i)^{21}} \qquad [5.2\text{-}2]$$

Using this approach permits to extend the results to the very last year for which the value of N is known; that is 1985. In equation 5.2-2, *PV2* calculates the present value of the production of 1920 should the rent and the quantity extracted remain as in the year in question until the expected exhaustion of the resource. That is a different concept from *PV1*, which calculates the present value of the aggregate rents generated in 'future' years, with different rents and quantities from those produced in the year in question.

A further implementation of equation 5.1-1 is still possible. It calculates the present value of the quantity extracted in year t. This is the present value of the expected rents the amount currently extracted would produce in the years to come, allowing the rent

Table 4.1-1, Mexican aggregate production until 1985, plus the reserves in that year, amounted to a total of 83,561million barrels, which can be thought to be available for disposal during the period 1901-1985. Venezuela totals about 68,747 million barrels for the period 1917-1985. That would imply discounting over 2000 years in order to calculate the present values at the beginning of the century!
Alternatively, one could grant a 20-year time horizon throughout the period. This is not the equivalent to an infinite time horizon, but it is long enough to avoid worrying about immediate exhaustion. Calculated this way, the present values for both Mexican and Venezuelan oil reserves continuously rise over time leaving no room to calculate a depreciation value.

[15] Only the social discount rate does not change from year to year. A sensitivity test is performed later in the section to account for this.

[16] Vaze, 'Environmental Accounts- Valuing the Depletion of Oil and Gas Reserves', , p.41 says 'for operationalise this analysis it is assumed that the reserves are depleted a constant rate and that unit rents either stay constant or rise at 3 percent real'. That is, production is set constant. Common and Sanyal, 'Measuring depreciation of Australia's non-renewable resources: a cautionary tale', , p.26 also set the rate of extraction equally for all the years considered. Other implementations of present value methodology applied to resource rents under these very same assumptions are the ones by World Bank, *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development*, Vol. 17 (Washington, D.C., 1997), p.32; L. Lindholt, 'On Natural Resource Rent and the Wealth of a Nation. A Study Based of National Accounts in Norway 1930-1995', *Statistics Norway. Research Department Discussion Papers* 281 (2000), p.6; And the US Bureau of Economic Analysis net present value estimates according to W.D. Nordhaus and E.C. Kokkenlenber (eds.), *Nature's Numbers: Expanding the U.S. National Economic Accounts to Include Environment* (Washington D.C., 1999), chapter 3.

per unit (prices and costs) to vary. The justification for this permutation stems from the fact that the theoretical implementation is rather incoherent. It uses n as the lifetime of the resource every year and yet allows the rents to include all the production of future years, which would be impossible to produce with the current reserves. However, this third permutation allows for the constraint of the life expectancy and also for the continuation of the production as in the current year but accepts that prices and cost vary in the future. So, for our example of Venezuela in 1920, the present value under this variant would be:

$$PV3:\ V_{1920} = u_{1920} \cdot q_{1920} + \frac{u_{1921} \cdot q_{1920}}{(1+i)} + \frac{u_{1922} \cdot q_{1920}}{(1+i)^2} + ... + \frac{u_{1941} \cdot q_{1920}}{(1+i)^{21}} \qquad [5.2\text{-}3]$$

where u_t represents the rent per unit and q the quantity extracted. This is a much more logical way of calculating the present value of year t than *PV1* and *PV2*. By multiplying the current production by the present value of the *rent per unit* (rather than by calculating the present value of the *aggregated rents* as in *PV1*), it captures the wealth (i.e. the present value) of the current year's production, should it be sustained until the exhaustion of the reserves currently known. This approach allows changes in prices, costs and discoveries as they occur by allowing the rent per unit to change over time unlike in *PV2*. Table 5.2-1 summarises the underlying assumptions behind each of the three implementations.

The variables needed to execute the formulae in Table 5.2-1, namely Nt (under its different permutations) and n, are available from the previous chapter. Nevertheless, the social discount rate, i, is again a choice variable. The best possibility is to perform a sensitivity test in order to make explicit the bias introduced by this variable in the calculations. For this purpose, three alternative social discounts have been considered 3, 6 and 15 per cent.

For *PV1* and *PV3*, 1972 turns out to be the last year for which sufficient data is available to produce a present value discounting actual rents. From that year onwards, the time horizon expands beyond the last year for which N_t is available for each of the countries. On its part, *PV2* can be calculated until the end of the period since in this implementation the rents of the current year are projected into the future.

Table 5.2 -1: Underlying assumptions for three implementations of the Present Value Method

Variable		*PV1* *Theoretical definition*		*PV2* *Common implementation*		*PV3* *Alternative implementation*	
N (u)	Price	Changes from t to $t+n$		Kept constant as in t		Changes from t to $t+n$	
N (u)	Costs	Change from t to $t+n$		Kept constant as in t		Changes from t to $t+n$	
N (q)	Quantity	Changes from t to $t+n$		Kept constant as in t		Kept constant as in t	
Reserves (n)		Changes from t to $t+n$		Changes from t to $t+n$*		Changes from t to $t+n$	
Social discount		Kept constant		Kept constant		Kept constant	
Algebraically		$V_t = \sum_{n=0}^{n} \frac{N_{t+n}}{(1+i)^n}$		$V_t = \sum_{n=0}^{n} \frac{N_t}{(1+i)^n}$		$V_t = q_t \sum_{n=0}^{n} \frac{u_{t+n}}{(1+i)^n}$	
It generates...		...the present value of the *aggregated rents generated every year to come*		...the present value of the *aggregated rents generated in the current year*		...the present value of the *current year's production*	
		Mexico max $t+n$=1987 t=1935-1972	Venezuela max $t+n$=1987 t=1920-1972	Mexico t=1920-1987	Venezuela t=1935-1985	Mexico max $t+n$=1987 t=1935-1972	Venezuela max $t+n$=1985 t=1920-1972

* When this equation is implemented for forecasting purposes, reserves are normally kept to the level of the initial year through the period. So the present value for 1921 would be discounted for 20 years, for 1922 for 19 and so on and so forth. In contrary in this historical exercise, additions to reserves are allowed as they occurred. Every year is a starting point in itself, with its own production, prices, costs and reserves available for the calculation of the present value. This produces a different path from the forecast exercises

Sources: own elaboration.

For exposition purposes only the results for the representative *Nt* are presented numerically in Tables 5.2-2 and 5.2-3.[17] This can be done with confidence since the graphical representation in Figures 5.2-1 and 5.2-2 demonstrate that the differences accruing to the different rent assumptions are negligible when compared to the differences of implementing alternative present value formulations.

The first result of this exercise is that the various implementations of the present value have different sensitivities to the social discount rate used. The results of both countries show that the most sensitive of the three approaches to the change in the preference for the future is *PV1*. The different present values also react differently to variations over time of *Nt* and *n*. While changes in the value of the rent of the current year have the greatest impact on *PV2*, the other two implementations, *PV1* and *PV3*, are more affected by changes in the life expectancy of the resource in a context of increasing rents over time. More crucially, the three algebraic expressions produce very different descriptions of the level and the evolution of *Vt*.

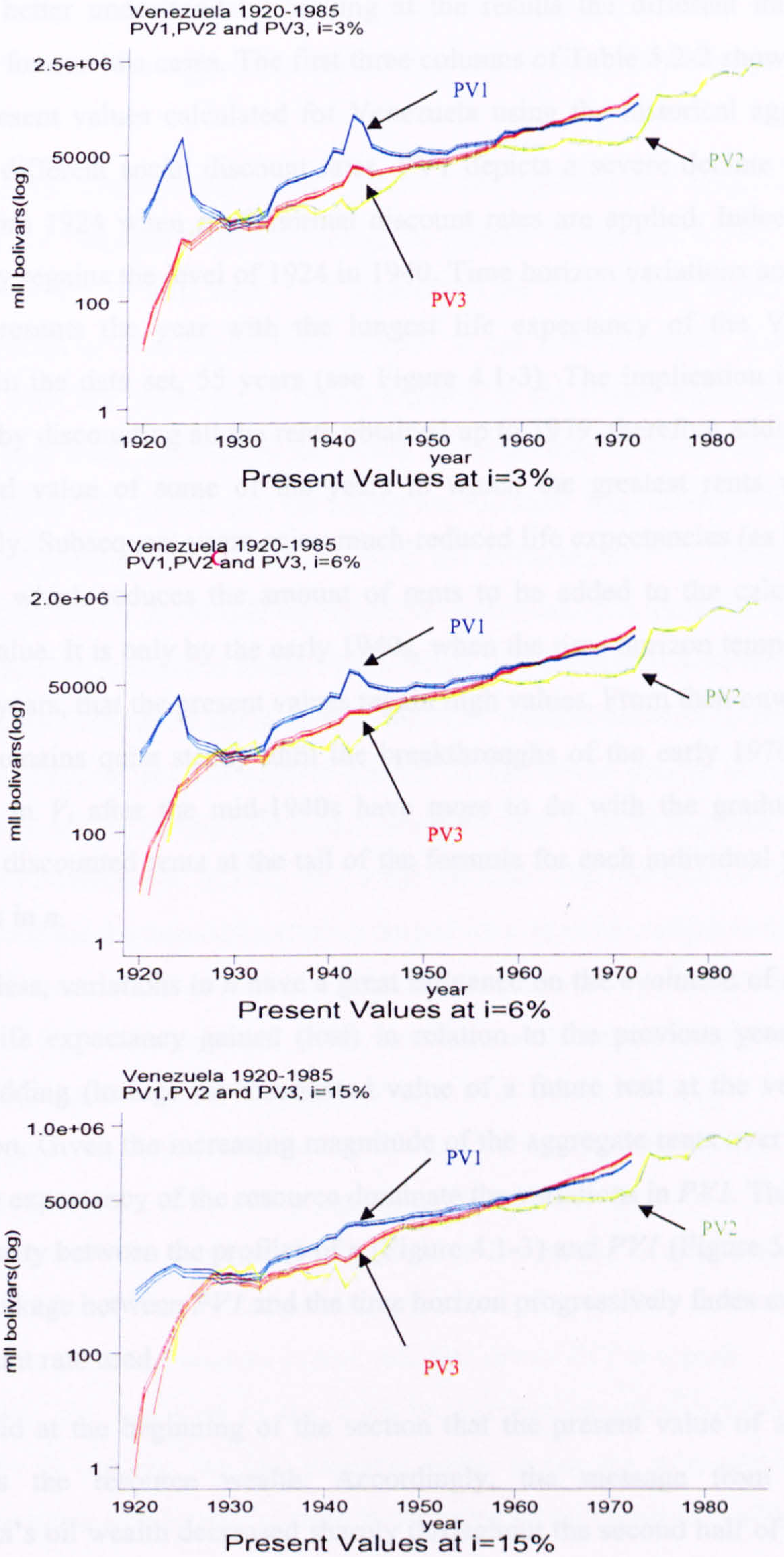
[17] Evaluating the three algebraic expressions of the present value for the different variants of *Nt* and *i* generated a matrix of results of 36 columns for Venezuela and 27 columns for Mexico.

Table 5.2-2: Present values of Venezuelan oil resources, 1920-1985. Different implementations and discount rates.

Year	PV1			PV2			PV3		
	i=3	*i=6*	*i=15*	*i=3*	*i=6*	*I=15*	*i=3*	*i=6*	*i=15*
	Mll. Blvs.	Mll. Blvs	Mll. Blvs	Mll. Blvs	Mll. Blvs	Mll. Blvs	Mll. Blvs	Mll. Blvs	Mll. Blvs
1920	3,680	2,624	1,074				12	8	1
1921	8,108	4,853	1,504				66	46	19
1922	23,732	11,130	2,160				158	102	44
1923	43,156	17,515	2,691	112	72	34	393	239	109
1924	101,595	31,912	3,311	869	534	242	1,395	652	256
1925	9,098	6,099	2,603	1,765	1,333	731	1,079	855	538
1926	5,511	4,351	2,539	3,156	2,504	1,483	1,520	1,282	881
1927	4,589	3,859	2,551	2,826	2,340	1,495	2,084	1,804	1,281
1928	3,734	3,323	2,487	3,575	3,136	2,258	2,955	2,657	2,040
1929	2,358	2,234	1,940	3,246	3,032	2,532	2,512	2,376	2,054
1930	2,733	2,512	2,028	4,397	4,003	3,138	2,729	2,526	2,074
1931	2,812	2,514	1,894	2,918	2,591	1,917	2,270	2,061	1,618
1932	3,234	2,826	2,028	5,088	4,410	3,094	2,410	2,144	1,616
1933	4,263	3,487	2,140	2,050	1,736	1,160	2,521	2,140	1,444
1934	11,597	8,294	3,664	4,300	3,484	2,139	4,739	3,671	2,059
1935	15,452	10,781	4,420	4,909	3,936	2,372	5,847	4,416	2,326
1936	17,683	12,334	4,991	5,351	4,290	2,585	6,386	4,787	2,452
1937	20,376	14,201	5,672	5,673	4,548	2,741	8,054	5,993	2,970
1938	23,502	16,382	6,481	4,323	3,466	2,089	8,602	6,379	3,092
1939	27,593	19,254	7,623	3,513	2,816	1,697	10,053	7,461	3,604
1940	60,989	31,594	10,578	4,977	3,659	1,935	12,609	8,812	3,836
1941	54,570	29,411	11,264	7,654	5,783	3,172	14,342	10,481	4,966
1942	264,228	88,365	17,388	4,538	3,020	1,438	31,026	15,546	4,097
1943	191,730	75,171	18,730	6,736	4,608	2,249	27,571	15,734	5,213
1944	71,807	47,838	18,313	9,215	6,962	3,819	21,700	15,586	7,402
1945	59,891	42,963	19,267	10,292	8,084	4,706	24,038	18,284	9,663
1946	51,060	38,996	20,111	12,829	10,394	6,382	25,855	20,641	12,051
1947	48,201	38,190	21,494	19,436	16,093	10,287	27,497	22,616	14,131
1948	48,099	38,889	22,990	31,438	26,322	17,193	30,167	25,216	16,363
1949	61,462	47,945	26,260	29,846	24,442	15,305	33,651	27,309	16,697
1950	55,550	44,920	26,617	31,491	26,366	17,222	34,330	28,610	18,432
1951	54,578	44,901	27,665	32,045	27,136	18,131	37,277	31,456	20,792
1952	53,379	44,675	28,647	34,210	29,306	20,052	37,730	32,282	22,010
1953	69,144	56,020	33,525	40,391	33,818	22,089	43,646	36,268	23,323
1954	73,778	59,876	36,046	44,188	36,997	24,166	47,719	39,597	25,391
1955	78,018	63,491	38,545	53,071	44,434	29,023	55,202	45,766	29,285
1956	81,921	66,746	40,648	60,947	51,028	33,331	63,864	52,860	33,654
1957	86,801	70,532	42,654	77,182	64,622	42,209	74,330	61,216	38,483
1958	129,803	98,191	50,402	71,353	58,435	36,590	105,157	79,896	41,918
1959	128,278	98,506	51,911	61,965	51,305	32,795	109,384	84,104	44,814
1960	150,840	114,712	58,718	59,154	48,978	31,307	139,686	105,263	52,900
1961	150,656	116,748	62,267	60,336	50,517	32,997	142,376	109,193	56,858
1962	150,121	118,551	65,964	65,063	55,096	36,813	155,154	121,130	65,466
1963	174,339	137,276	75,508	64,579	54,687	36,539	192,405	149,131	78,505
1964	173,852	139,629	80,451	94,790	81,202	55,560	201,555	159,388	87,862
1965	199,376	159,539	90,355	93,677	80,249	54,908	248,223	195,275	105,089
1966	222,965	178,764	101,113	90,872	77,846	53,264	280,781	221,288	118,736
1967	221,109	180,696	106,739	88,908	77,065	54,057	294,806	237,153	133,408
1968	218,810	182,346	112,778	85,681	75,161	54,112	300,878	247,251	146,445
1969	262,499	218,565	134,764	82,569	72,431	52,146	369,530	304,088	180,603
1970	261,451	222,495	145,016	79,852	70,905	52,454	383,600	323,181	204,065
1971	324,075	275,748	180,106	100,037	88,829	65,715	473,957	399,561	253,461
1972	445,074	374,044	237,569	106,199	93,160	67,070	631,128	524,989	323,023
1973				211,225	176,850	115,515			
1974				619,552	507,384	317,711			
1975				584,940	459,403	267,440			
1976				593,964	466,490	271,566			
1977				683,895	531,786	304,657			
1978				637,887	491,179	277,146			
1979				989,763	777,344	452,529			
1980				1,459,858	1,113,362	619,210			
1981				1,663,088	1,244,922	674,167			
1982				1,599,644	1,110,778	549,970			
1983				1,425,003	961,186	463,047			
1984				2,280,256	1,507,382	714,088			
1985				2,118,418	1,358,096	629,219			

Sources and notes: *PV2* from 1920-1924 results in negative figures. The representative permutation of the rent used is Vz[N(a15)], as defined in Table 4.4-1 and listed in Table 4.4-2.

Figure 5.2-1: Present value of Venezuelan oil resources 1920-1985. Implementations *PV1,PV2* and *PV3* at three different discount rates.



Sources and notes: all the permutations of N_t are plotted for each present value implementation. The upper and lower values within each present value mimic the upper and lower values of the corresponding N_t. Calculated from rents obtained in Chapter 4 applied to the formulae in Table 5.2-1.

The consequences of the different implementations for the overall performance of the present value at the time of calculating the resource wealth and its depreciation over time are better understood by looking at the results the different implementations produced for our two cases. The first three columns of Table 5.2-2 show the evolution of the present values calculated for Venezuela using the historical aggregated rents (*PV1*) at different social discount rates. PV1 depicts a severe decline in the present values from 1924 when small/normal discount rates are applied. Indeed, the present value only regains the level of 1924 in 1940. Time horizon variations account for this: 1924 represents the year with the longest life expectancy of the Venezuelan oil reserves in the data set, 55 years (see Figure 4.1-3). The implication is that V_{1924} is obtained by discounting all the rents obtained up to 1979, therefore adding to V_{1924} the discounted value of some of the years in which the greatest rents were obtained historically. Subsequent years enjoy much-reduced life expectancies (as low as 7 years in 1929), which reduces the amount of rents to be added to the calculation of the present value. It is only by the early 1940s, when the time horizon temporarily returns to 30-40 years, that the present values regain high values. From then onwards, the time horizon remains quite steady until the breakthroughs of the early 1970s. Hence, the increases in V_t after the mid-1940s have more to do with the gradual addition of generous discounted rents at the tail of the formula for each individual year than with variations in n.

Nevertheless, variations in n have a great influence on the evolution of *PV1*. An extra year of life expectancy gained (lost) in relation to the previous year's calculation implies adding (losing) the discounted value of a future rent at the very end of the summation. Given the increasing magnitude of the aggregate rents over time, changes in the life expectancy of the resource dominate the variations in *PV1*. This is evident in the similarity between the profiles of n (Figure 4.1-3) and *PV1* (Figure 5.2-1). Observe that the linkage between *PV1* and the time horizon progressively fades away the higher the discount rate used.

It was said at the beginning of the section that the present value of all future rents represents the resource wealth. Accordingly, the message from *PV1* is that Venezuela's oil wealth decreased sharply throughout the second half of the 1920s and during the late 1940s. Less obviously, some years during the 1950s and the early 1960s also show decreasing wealth when measured by this approach. In contrast, the early years of the oil industry and the 1930s are portrayed as periods of rapid increases in of resource wealth. One might expect movements in wealth to correspond to the periods of increasing reserves (adding wealth) and fast depletion of reserves (decreases in wealth). Per contra, the relation is not to the actual level of the reserves – which increases virtually throughout the period- but to how long the reserves were expected to last.[18]

The traditional assumptions that the reserves are depleted at a constant rate and that unit rents stay constant when calculating the present values, that is *PV2*, produce quite different results. To start with, *PV2* reproduces the three stages already identified in the calculation of *N* in the previous chapter. It has three relatively stable levels. The first runs from the beginning of the oil industry to the 1940s, where the curve moves up to the next level, achieved in the 1950s, and from then to the 1970s, where the next step up occurs. The profile and the timing are the same regardless of the discount rate used. These phases were not identifiable in the evolution of *PV1*. Moreover, *PV1* and *PV2* tend to move in completely opposite directions. For instance, *PV1* decreases sharply from the mid-1920s to the 1930s, while *PV2* undergoes a sudden increase. The same happens during the early 1940s. When *PV1* starts decreasing after the peak of 1942, *PV2* experiences the highest growth of the whole period. It may seem as if variations in *n* have an opposite effect; when the time horizon expands, *PV1* increases whereas *PV2* decreases. In fact, this is not the case. The addition of an extra year of life will produce the same effects as in the previous exercise, which is to add one extra discounted rent at the tail of the formula, thus increasing the present value. The variation of *PV2* is entirely due to the variations of the rent. Consider the example of 1942, *PV1* presents a peak for that year as a result of the value of *n* increasing to 41 years. In practical terms it implies the addition of the discounted rents obtained up to the 1980s. However, 1942 is a trough for *PV2* because N_{1942} has a very small value (see Table 4.4-2). The small rent is the result of the cutback in production provoked by the Second World War. Simultaneously, this cut is responsible for the increase of the life expectancy of the resources in that year that drives *PV1* to a peak.

For its part, the evolution of the third implementation considered here, *PV3*, lies somewhere in between the two previous cases. It has the most stable of the three profiles, pointing to a steady increase in the value of the resource wealth of Venezuela from the 1930s to the end of the series in 1972.This is a direct consequence of the formulae employed. *PV3* attempts to estimate the wealth corresponding to the current

[18] Section 4.1 showed reserves levels only declined for the late 1950s and the 1960s.

year's extraction (allowing for future changes in technology) rather than the wealth of all the possible future production or the value of the current production under the assumption of no technological change. Hence, its value lies in between *PV1* and *PV2*. The profile of *PV3* shows an almost uninterrupted path of increasing wealth. In fact, regardless of the social discount rate employed, *PV3* surpasses the value obtained by *PV1* in the early 1960s. The explanation lies in the slowdown in production that occurs after 1970. Both implementations allow the rent per unit to change each year. But while *PV3* maintains the current rate of extraction until the current reserves are exhausted, *PV1* allows the rate of extraction to change as it did historically. In addition, *PV3* uses the high rates of extraction of the 1960s to calculate the present value of the current year's production, whereas *PV1* introduces the smaller output that takes place later on. Therefore, in the presence of diminishing production, *PV3* brings about a higher value than *PV1*.

Starting in the early 1940s, the values shown in each permutation have a tendency to converge. Actually, from the late 1940s and for almost a decade, the values of *PV3* and *PV2* are almost identical. Stable rents explain the similarity of the results. Allowing the rent to vary from year to year, as in *PV3*, is not much different from keeping them constant, as in *PV2*, if the value of rent per unit hardly changes over time. In other words, this is the only period over which the assumptions of *PV2* closely match historical events; thus, the implementation using historical data tends to converge towards *PV2* values. It is, however, quite an exception.

In fact, the year 1957 signals the end of this convergence tendency. All the values for *PV1* and *PV3* after 1958 progressively include the discounted rents of the 1970s and 1980s, while those for *PV2* continue discounting only the current year's rent. Since those 'future' rents, constitute additional terms to the equation over time and are larger than the rents obtained in the 1960s, their addition makes for divergence until the end of the series.

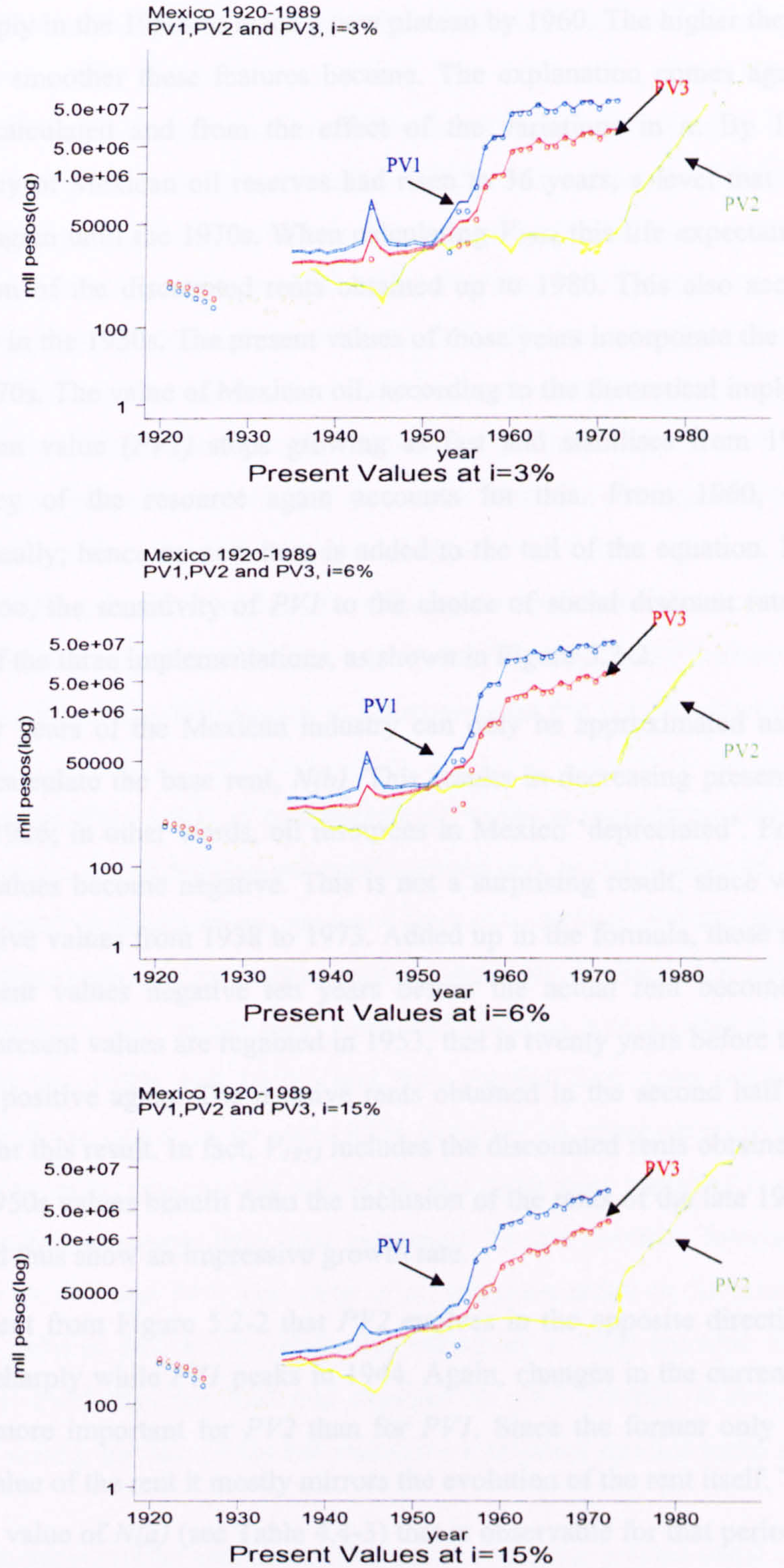
The same exercises have been carried out for the Mexican data set. The results are shown in Table 5.2-3 and Figure 5.2-2.

Table 5.2-3: Present values of Mexican oil resources, 1935-1987. Different implementations and discount rates.

year	PV1			PV2			PV3		
	i=3 Mll. Pesos	*i=6* Mll. Pesos	*i=15* Mll. Pesos	*i=3* Mll. Pesos	*i=6* Mll. Pesos	*i=15* Mll. Pesos	*i=3* Mll. Pesos	*i=6* Mll. Pesos	*i=15* Mll. Pesos
1935	10,480	5,939	1,607	2,348	1,683	862	5,183	3,162	1,101
1936	10,677	6,174	1,716	2,110	1,525	789	5,323	3,294	1,158
1937	9,634	5,863	1,793	3,642	2,702	1,445	5,628	3,628	1,357
1938	11,548	6,853	1,934	2,633	1,919	1,003	5,198	3,269	1,132
1939	9,137	5,857	1,910	1,878	1,432	796	4,854	3,241	1,221
1940	10,790	6,854	2,185	1,463	1,105	606	5,590	3,701	1,357
1941	11,696	7,513	2,466	1,494	1,129	619	5,786	3,870	1,450
1942	15,283	9,427	2,921	1,244	899	465	5,570	3,631	1,318
1943	18,511	11,136	3,396	1,305	935	479	6,334	4,079	1,481
1944	218,916	88,006	8,833	985	679	334	26,496	12,154	2,285
1945	42,957	22,422	5,260	546	391	201	12,508	7,387	2,433
1946	16,989	11,671	4,817	1,280	958	519	8,577	6,171	2,862
1947	15,451	11,280	5,305	1,569	1,220	699	9,298	7,023	3,615
1948	15,273	11,549	5,930	4,695	3,725	2,205	9,629	7,508	4,183
1949	18,072	13,385	6,742	6,982	5,376	3,033	11,060	8,534	4,750
1950	16,030	12,540	7,043	10,875	8,718	5,254	12,028	9,669	5,821
1951	17,009	13,251	7,416	13,102	10,395	6,154	13,050	10,480	6,324
1952	33,871	22,426	9,157	16,379	12,612	7,116	19,411	13,904	6,935
1953	76,296	44,908	12,936	11,454	8,735	4,858	28,785	18,595	7,346
1954	189,359	103,609	22,459	17,181	12,980	7,121	56,805	33,855	10,641
1955	194,053	108,810	24,726	17,400	13,270	7,380	61,472	37,266	11,901
1956	559,715	297,013	53,794	19,401	14,657	8,041	113,691	64,615	16,452
1957	4,941,750	2,392,057	314,204	26,975	19,834	10,487	511,036	255,180	40,387
1958	8,756,851	4,223,803	546,896	23,751	17,463	9,233	913,605	449,669	65,749
1959	9,018,291	4,475,928	627,517	18,644	13,831	7,398	968,483	489,881	76,467
1960	36,512,792	17,161,626	2,061,350	13,124	9,566	5,003	3,969,030	1,876,001	234,310
1961	37,607,492	18,190,618	2,369,788	25,947	19,078	10,087	4,406,615	2,143,094	289,676
1962	38,734,336	19,280,632	2,723,713	29,234	21,686	11,600	4,752,650	2,377,940	347,311
1963	59,120,480	29,549,592	4,225,721	28,461	21,113	11,294	7,433,034	3,728,128	545,496
1964	41,090,060	21,660,380	3,598,328	26,446	19,980	10,961	5,206,837	2,757,478	470,763
1965	42,321,244	22,958,440	4,136,381	23,636	18,026	10,025	5,472,070	2,981,598	550,810
1966	64,597,936	35,189,148	6,420,993	21,148	16,129	8,970	8,561,669	4,677,990	868,940
1967	44,895,920	25,793,296	5,467,179	19,459	15,131	8,668	6,544,681	3,775,392	818,043
1968	68,529,448	39,535,908	8,488,796	16,110	12,527	7,177	10,670,538	6,173,507	1,347,030
1969	70,584,320	41,907,024	9,760,987	17,812	13,989	8,144	11,568,615	6,887,578	1,629,508
1970	49,055,492	30,716,524	8,310,504	15,492	12,419	7,485	8,418,569	5,291,512	1,460,337
1971	74,880,632	47,084,356	12,906,214	25,758	20,650	12,445	12,766,389	8,048,942	2,239,293
1972	77,125,248	49,907,568	14,840,138	29,879	24,208	14,864	13,607,675	8,828,530	2,663,226
1973				66,628	53,982	33,145			
1974				310,888	257,407	164,537			
1975				394,990	330,708	216,012			
1976				907,582	685,681	376,167			
1977				1,657,336	1,288,720	738,300			
1978				3,573,363	2,113,262	939,516			
1979				6,018,280	3,601,752	1,608,722			
1980				15,004,766	8,908,072	3,966,135			
1981				21,599,848	12,773,997	5,679,075			
1982				51,894,380	31,895,690	14,420,164			
1983				123,863,232	75,423,176	33,945,040			
1984				65,188,120	39,694,548	17,864,972			
1985				229,382,960	139,050,496	62,451,640			
1986				226,337,200	134,906,192	60,157,116			
1987				658,278,016	397,299,104	178,090,192			

Sources and notes: The representative permutation of the rent used is Mx[N(a6)], as defined in Table 4.4-1 and listed in Table 4.4-2.

Figure 5.2-2: Present value of Mexican oil resources 1920-1985. Implementations *PV1, PV2* and *PV3* at three different discount rates.



Sources and notes: The results of $N_t(b)$ are represented by dots and its negative results excluded. The upper and lower values within each present value mimic the upper and lower values of the corresponding N_t. Calculated from rents obtained in Chapter 4 applied to the formulae in Table 5.2-1.

Whenever the variation *N(a)* of the rent is available, the present value using the historical data for Mexico *(PV1)* is always positive. *PV1* peaks in 1944, and suddenly rises steeply in the 1950s to reach a new plateau by 1960. The higher the discount rate used, the smoother these features become. The explanation comes again from how *PV1* is calculated and from the effect of the variations in *n*. By 1944, the life expectancy of Mexican oil reserves had risen to 36 years, a level that would not be attained again until the 1970s. When calculating V_{1944}, this life expectancy entails the summation of the discounted rents obtained up to 1980. This also accounts for the steep rise in the 1950s. The present values of those years incorporate the massive rents of the 1970s. The value of Mexican oil, according to the theoretical implementation of the present value *(PV1)* stops growing as fast and stabilises from 1960. The life expectancy of the resource again accounts for this. From 1960, *n* diminishes systematically; hence no new item is added to the tail of the equation. In the case of Mexico too, the sensitivity of *PV1* to the choice of social discount rate is again the highest of the three implementations, as shown in Figure 5.2-2.

The early years of the Mexican industry can only be approximated using operating costs to calculate the base rent, *N(b)*. This results in decreasing present values from 1921 to 1926; in other words, oil resources in Mexico 'depreciated'. From 1927, the present values become negative. This is not a surprising result, since we know *N(b)* has negative values from 1938 to 1973. Added up in the formula, these negative rents turn present values negative ten years before the actual rent becomes negative.[19] Positive present values are regained in 1953, that is twenty years before the actual rent becomes positive again. The massive rents obtained in the second half of the 1970s account for this result. In fact, V_{1953} includes the discounted rents obtained up to 1978. All the 1950s values benefit from the inclusion of the rents of the late 1970s and early 1980s and thus show an impressive growth rate.

It is evident from Figure 5.2-2 that *PV2* evolves in the opposite direction to *PV1*. It declines sharply while *PV1* peaks in 1944. Again, changes in the current value of the rent are more important for *PV2* than for *PV1*. Since the former only discounts the current value of the rent it mostly mirrors the evolution of the rent itself. Therefore, the declining value of *N(a)* (see Table 4.4-3) that is observable for that period, forces *PV2* downward here. The gap between the different implementations becomes wider from 1950 when, by virtue of rather constant rents, *PV2* remains flat while *PV1* and *PV3*

[19] Negative figures cannot be shown in a logarithm scale graph.

shoot up. The result is that, while the latter two are counted in millions from the early 1960s, the former does not even reach 50,000 pesos. According to the common implementation *(PV2)*, the steep growth of Mexican oil resources only occurs after 1970.

Since *PV2* uses the current year's rent discounted as many times as the life expectancy indicates, it depends entirely on the value of *N(b)*. When using the *PV2* formula, a year with negative rent will always have a negative present value and a year with positive rent will result in a positive present value. Therefore, *PV2[N(b)]* is negative for the same years as *N(b);* that is from 1938 to 1973. The use of *N(b)* under the constant extraction assumption, results in decreasing present values for the period before nationalisation. This coincides with the trend of *PV1 N(b)* above. In the period after 1973 present values increase sharply year upon year as a consequence of the increase in oil prices and the subsequent increase of rents.

As noted before, the third permutation offers an intermediate answer. The value of the current year's production, *PV3*, presents a profile closer to *PV1* albeit on a smaller scale, since it includes the changes in prices and cost but not the amounts produced in the future.

The evolution of the value of the Mexican oil varies in accordance with the algebraic expression, i.e. the underlying assumptions used for its calculation. In a static world with no change in future prices, costs and rates of extraction, like the one portrayed by *PV2*, Mexican resources lose value for every year until the Second World War. After a speedy recovery, they regain their value and maintain it at an almost constant level throughout the 1950s and 1960s, and then steadily lose some value towards the beginning of the 1970s. In the mid-1970s, Mexican oil resources undergo a sustained growth of a similar degree to the late 1940s, but much more extended in time.

This evolution diverges from that portrayed by the 'perfect foresight' scenarios described by *PV1* and *PV3*. The value of oil increases rather in the inter-war years. It does not stabilise during the 1950s, but undergoes a sharp increase which is much more short-lived than the final one depicted by *PV2*. Finally, it does not decrease smoothly during the late 1970s but maintains a constant upward trend from the early 1960s.

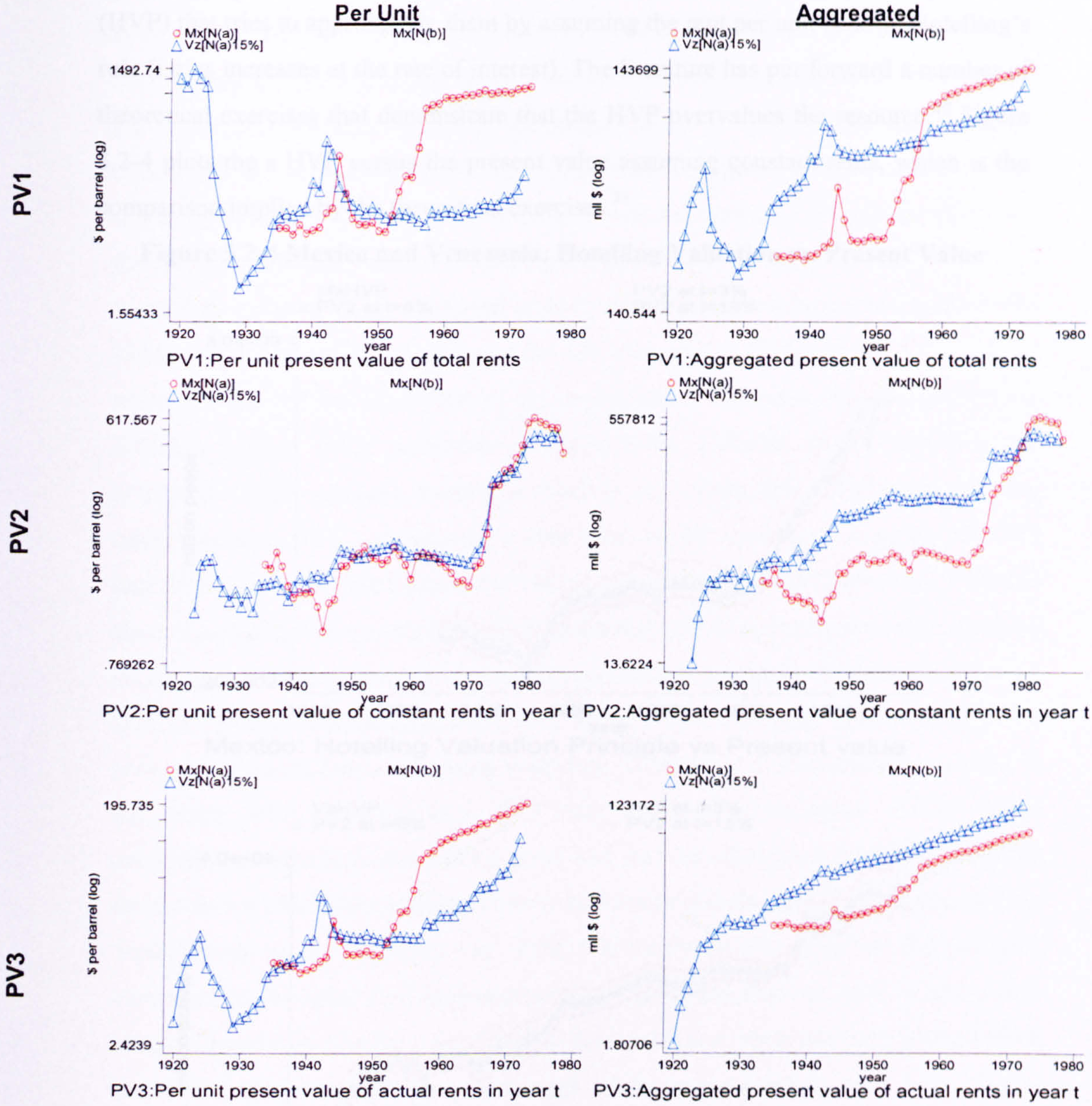
It was mentioned earlier that those reluctant to apply the present value method would have one more argument in their favour if the assumptions greatly bias the results. Indeed, this seems to be the case. The starting assumptions regarding the future behaviour of prices, costs, rates of extraction, etc. greatly influence the value given to the resources at a particular point in time. However, that should not preclude us from using the results obtained by the present value, so long as we are aware of the assumptions underlying the algebra and of the likely effects of changing our assumptions within each implementation.

Notwithstanding these limitations, one can compare the historical value of oil resources in Mexico and Venezuela calculated so far. Figure 5.2-3 shows the per-barrel and aggregated values of both countries using a normal social discount rate for all the three implementations used in this section.

Again the different implementations tell quite different stories both at per unit and aggregate level, most notably regarding the relative value per unit produced in each country. Despite the higher costs of production in Mexico, and the consequent lower rent per barrel, a barrel produced in Mexico has a higher value than in Venezuela from the mid-1950s onwards if we follow *PV1* and *PV3*. Even in the case of *PV2*, whose profile closely follows that of the rents, the gap between values per unit in the two countries is very small. The longer life expectancy of Mexican reserves accounts for this result in the case of *PV2*.

At the aggregate level, each implementation shows a different timing. While *PV1* indicates that Mexican oil resources catch up with Venezuela's petroleum wealth as early as the mid-1950s, *PV2* maintains the gap that does not close until the end of the 1970s. Yet according to *PV3*, Mexican oil wealth never matched that of Venezuela (though the series are only available until 1972).

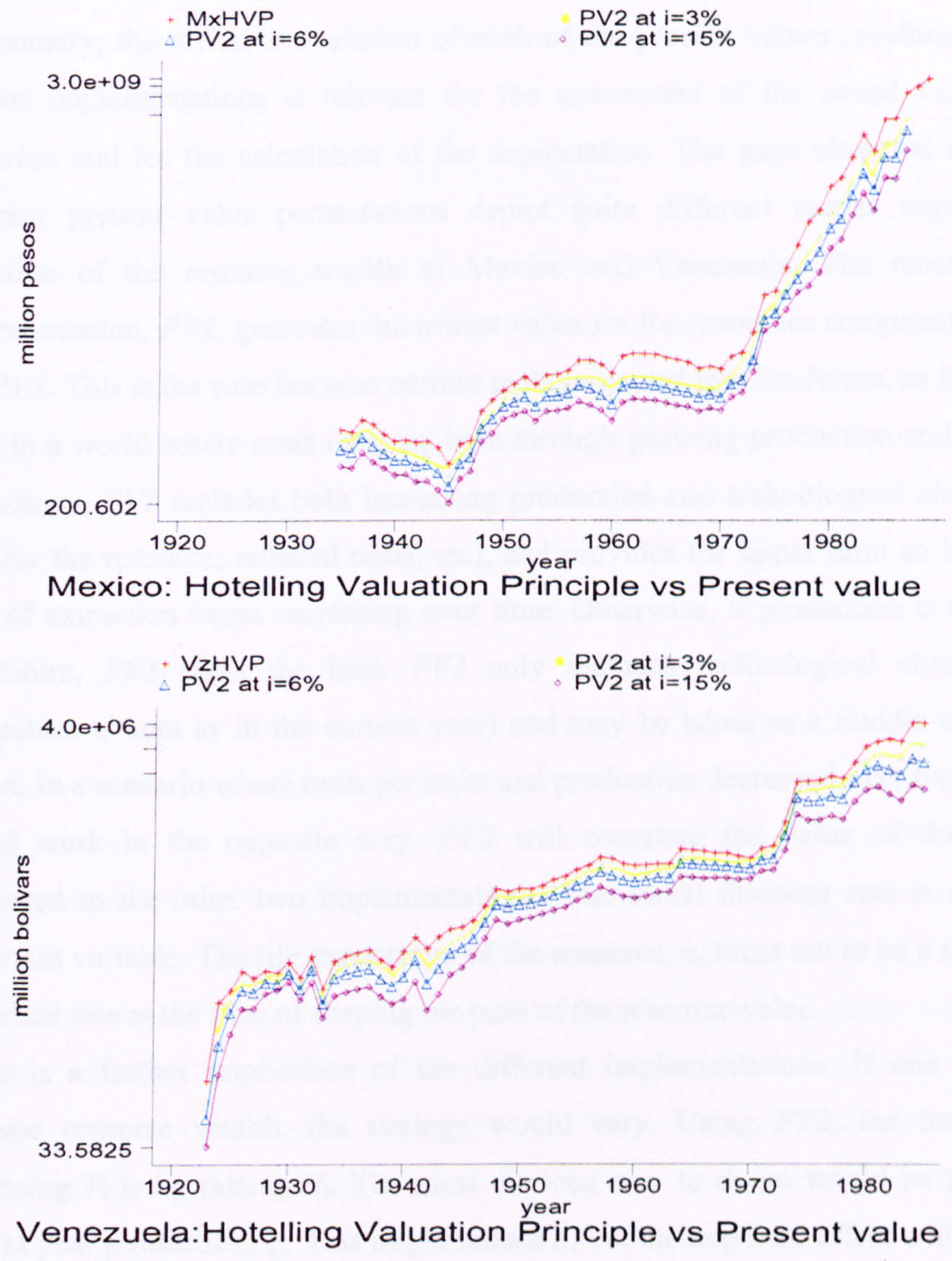
Figure 5.2-3: Comparative Value of Mexican and Venezuelan oil resources, 1920-1985 ($ per barrel and million $)



Sources and notes: Labels as defined in Table 4.4-1. Note that the present value per unit has been calculated as V_t/q_t. This produces a different result from substituting N_t by u_t in the formulae only in the case of *PV1*. If this latter approach is used, the present value of the per unit rent is identical for *PV1* and *PV3*. Elaborated from the present values in Tables 5.2-2 and 5.2-3.

Yet another point remains to be made in relation to the present value. That is the relationship between the values calculated here and the Hotelling Valuation Principle (HVP) that tries to approximate them by assuming the rent per unit follows Hotelling's rule (i.e. u_t increases at the rate of interest). The literature has put forward a number of theoretical exercises that demonstrate that the HVP overvalues the resource.[20] Figure 5.2-4 plots the s HVP versus the present value assuming constant rents, which is the comparison implied by the theoretical exercises.[21]

Figure 5.2-4 Mexico and Venezuela: Hotelling Valuation vs. Present Value



Sources: own elaboration from data in Chapter 4 and this section.

[20] See for instance G.A. Davis, and D.J. Moore, 'Valuing mineral stocks and depletion in green national income accounts', *Environment and Development Economics* 5 (2000).

[21] Note however that the theoretical definition given in Chapter 2 of the HVP was $Q_t(p_t\text{-}MC_t)$, that is available reserves times the difference between price minus marginal costs. We can only calculate it using average costs.

The message from Figure 5.2-4 is that the higher the rate of return used, the more the HVP overvalues the resource. However, we know from the exercises above, that *PV2* undervalues systematically the value of the resource at every rate of discount if rents are allowed to change over time. Consequently, it is safe to say that the HVP overvalues the resource if, and only if, the value assigned to the resource is that resulting from *PV2*. That is, if the resource is valued maintaining the assumption that the rents in the future remain as in the current year.

In summary, the different evolution of each of the present values resulting from the various implementations is relevant for the assessment of the actual value of the resources and for the calculation of the depreciation. The gaps observed among the different present value permutations depict quite different stories regarding the evolution of the resource wealth of Mexico and Venezuela. The most common implementation, *PV2*, generates the lowest value for the resources compared with *PV1* and *PV3*. This is the case because current rents projected into the future, as in *PV2*, fall short in a world where rents increase both through growing production and improved technology. *PV1* includes both increasing production and technological change (new uses for the resource, reduced costs, etc), and provides the upper limit so long as the pace of extraction keeps increasing over time. Otherwise, if production is reduced in the future, *PV3* takes the lead. *PV3* only includes technological change (since production is kept as in the current year) and may be taken as a middle of the road option. In a scenario where rents per units and production decreased over time, the bias would work in the opposite way. *PV2* will overstate the value of the resource compared to the other two implementations. The social discount rate is not a very important variable. The life expectancy of the resource, *n*, turns out to be a much more important one at the time of shaping the path of the resource value.

There is a further implication of the different implementations. If one wished to increase resource wealth, the strategy would vary. Using *PV2*, the best way of increasing V_t is by raising N_t. The most obvious way to do so would be to increase current year production, q_t. This might reduce *n*, but the expected effect will be still an overall increase of V_t, because:

$$\Delta \sum_{n=0}^{R_t/q_t} \frac{N_t}{(1+i)^n} \geq \frac{N_t}{(1+i)^n} \qquad [5.2\text{-}4]$$

If *PV2* is used, reducing the life expectancy of the resource is the strategy for increasing the value. Using the same argument, a cut in production thus increasing the value of *n*, would not lead to an increase in value. This is because, if the country is a price taker, the reduction in the rent for every year in the sum can never be compensated by the addition of an extra year of life.[22]

In contrast, if *PV1* or *PV3* are used, expanding the time horizon for the resource becomes an option. An increase in *n* can be achieved by: (1) increasing reserves or (2) reducing production enough to gain an extra year of life for the resource. It can be argued that the former depends on random factors, but the latter is just a straightforward management decision. In a setting with increasing rents over time it is quite likely that a reduction in q_t sufficient to ensure a further year of production would lead to higher V_t if:

$$\Delta N_t \leq \frac{N_{t+(n+1)}}{(1+i)^{(n+1)}} \qquad [5.2\text{-}5]$$

Given the magnitude of the rents by the end of the period under consideration, it is not heroic to assume that a cut in production and the consequent rent reduction in year *t* would be more than offset by the addition of an extra term with big rents at the end of the equation. Therefore, the use of different formulae is not a simple disagreement about the best way of implementing the algebra. It has strategic implications for the management of the resources.

The Depreciation of the Resource

This chapter seeks a measure of the cost of using natural capital. Depreciation is the change in value of assets (mineral assets in this case) as a consequence of their use over time. Since the value of the assets has now been estimated, the variation in value can be calculated as the difference among the present values of consecutive years, simply V_{t+1} - V_t. In general, negative values are expected from such a calculation. This expectation derives from the underlying assumptions regarding future behaviour of rents and constrain to the life expectancy of the resource, which is normally fixed at its value at time *t*. From simple observation of the series presented above, one can anticipate that a continuous depreciation is an unlikely outcome since the value of the assets shows an increasing trend over time.

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[22] The price taker assumption is needed as otherwise a cut in production could lead to an increase in prices keeping the rent at the same level or even increasing it. If prices are not affected by the production cut, the aggregated rent will be reduced. The unit rent can also be expected to get smaller in the presence of scale economies.

Table 5.2-4: Change in value of Venezuelan oil resources, 1920-1985 (V_{t+1}-V_t)

		$PV1_{t+1}$-$PV1_t$			$PV2_{t+1}$-$PV2_t$			$PV3_{t+1}$-$PV3_t$			Net price
t	*t+1*	*i=3* Mll. Blvs.	*i=6* Mll. Blvs	*I=15* Mll. Blvs	*i=3* Mll. Blvs	*i=6* Mll. Blvs	*i=15* Mll. Blvs	*i=3* Mll. Blvs	*i=6* Mll. Blvs	*i=15* Mll. Blvs	*Nt* Mll. Blvs
1920	1921	4,428	2,539	430	(25)	(14)	(4)	53	38	18	
1921	1922	15,625	6,935	656	15	15	10	92	56	26	
1922	1923	19,424	6,904	531	198	131	62	234	137	65	
1923	1924	58,439	14,759	620	757	462	208	1,002	414	147	4.4
1924	1925	(92,498)	(27,174)	(708)	895	799	490	(315)	203	282	31.5
1925	1926	(3,587)	(1,949)	(64)	1,392	1,171	751	441	427	343	98.4
1926	1927	(922)	(575)	12	(331)	(165)	13	564	522	401	206.0
1927	1928	(855)	(676)	(64)	750	797	762	871	854	758	218.4
1928	1929	(1,376)	(1,243)	(548)	(330)	(104)	274	(443)	(281)	14	375.2
1929	1930	375	325	89	1,152	971	607	218	150	21	581.7
1930	1931	79	72	(134)	(1,479)	(1,412)	(1,222)	(459)	(465)	(457)	608.2
1931	1932	423	386	133	2,170	1,819	1,177	140	82	(2)	332.1
1932	1933	1,028	779	112	(3,038)	(2,675)	(1,934)	111	(4)	(172)	496.3
1933	1934	7,335	5,309	1,524	2,251	1,748	979	2,218	1,531	615	176.2
1934	1935	3,854	2,738	756	609	452	233	1,108	744	267	303.6
1935	1936	2,232	1,706	571	442	354	214	538	372	125	332.7
1936	1937	2,692	2,035	680	322	258	156	1,668	1,206	518	362.7
1937	1938	3,127	2,392	809	(1,350)	(1,083)	(652)	548	386	122	384.5
1938	1939	4,090	3,134	1,142	(810)	(649)	(391)	1,451	1,082	512	293.0
1939	1940	33,396	13,635	2,955	1,464	843	238	2,555	1,351	233	238.1
1940	1941	(6,419)	(2,322)	686	2,677	2,123	1,237	1,734	1,668	1,130	257.5
1941	1942	209,658	60,636	6,123	(3,116)	(2,763)	(1,734)	16,684	5,065	(869)	426.7
1942	1943	(72,498)	(13,239)	1,342	2,198	1,589	811	(3,455)	188	1,116	188.2
1943	1944	(119,923)	(27,753)	(417)	2,479	2,354	1,570	(5,870)	(148)	2,189	295.0
1944	1945	(11,915)	(5,055)	954	1,078	1,122	886	2,338	2,697	2,261	513.8
1945	1946	(8,831)	(4,146)	844	2,536	2,310	1,676	1,816	2,357	2,388	648.2
1946	1947	(2,860)	(896)	1,382	6,608	5,699	3,905	1,643	1,975	2,079	905.6
1947	1948	(101)	736	1,496	12,001	10,229	6,906	2,670	2,600	2,232	1,502.3
1948	1949	13,363	9,675	3,270	(1,592)	(1,879)	(1,887)	3,485	2,092	335	2,556.7
1949	1950	(5,912)	(3,229)	357	1,645	1,923	1,916	678	1,302	1,734	2,200.9
1950	1951	(971)	(34)	1,047	554	771	910	2,947	2,845	2,360	2,561.0
1951	1952	(1,199)	(249)	982	2,165	2,170	1,921	454	827	1,219	2,754.2
1952	1953	15,765	11,928	4,878	6,181	4,512	2,037	5,915	3,986	1,313	3,123.1
1953	1954	4,635	4,009	2,522	3,797	3,179	2,076	4,074	3,329	2,068	3,284.9
1954	1955	4,240	3,773	2,499	8,883	7,437	4,858	7,483	6,169	3,894	3,593.7
1955	1956	3,903	3,396	2,103	7,876	6,594	4,307	8,662	7,095	4,369	4,316.1
1956	1957	4,880	3,818	2,006	16,235	13,593	8,879	10,466	8,356	4,829	4,956.6
1957	1958	43,002	27,829	7,748	(5,830)	(6,187)	(5,619)	30,827	18,680	3,434	6,277.0
1958	1959	(1,525)	(5)	1,509	(9,388)	(7,129)	(3,795)	4,227	4,208	2,896	5,261.6
1959	1960	22,562	15,994	6,806	(2,811)	(2,327)	(1,488)	30,303	21,159	8,086	4,789.4
1960	1961	(184)	1,673	3,550	1,182	1,539	1,690	2,690	3,930	3,958	4,572.1
1961	1962	(535)	1,460	3,697	4,727	4,579	3,816	12,778	11,937	8,608	4,907.0
1962	1963	24,218	18,619	9,544	(484)	(410)	(274)	37,250	28,001	13,039	5,592.0
1963	1964	(487)	2,066	4,943	30,211	26,516	19,021	9,150	10,257	9,357	5,550.4
1964	1965	25,524	19,890	9,903	(1,112)	(953)	(652)	46,668	35,887	17,227	8,653.4
1965	1966	23,589	19,283	10,758	(2,805)	(2,403)	(1,644)	32,558	26,013	13,647	8,551.9
1966	1967	(1,856)	1,699	5,627	(1,964)	(781)	793	14,026	15,864	14,672	8,295.8
1967	1968	(2,299)	1,435	6,038	(3,227)	(1,903)	55	6,071	10,098	13,036	8,671.7
1968	1969	43,689	36,484	21,986	(3,112)	(2,730)	(1,965)	68,653	56,837	34,159	8,990.5
1969	1970	(1,049)	3,695	10,251	(2,718)	(1,526)	308	14,070	19,094	23,462	8,663.9
1970	1971	62,624	53,758	35,091	20,186	17,924	13,260	90,356	76,379	49,396	9,088.4
1971	1972	121,000	100,661	57,463	6,162	4,331	1,355	157,171	125,428	69,562	11,385.9
1972	1973				105,026	83,690	48,445				11,143.4
1973	1974				408,327	330,534	202,196				17,178.3
1974	1975				(34,612)	(47,981)	(50,271)				45,686.0
1975	1976				9,024	7,087	4,126				36,840.9
1976	1977				89,930	65,296	33,091				37,409.2
1977	1978				(46,008)	(40,608)	(27,512)				41,662.7
1978	1979				351,876	286,166	175,383				37,662.5
1979	1980				470,096	336,018	166,681				62,337.5
1980	1981				203,230	131,561	54,957				83,690.1
1981	1982				(63,444)	(134,144)	(124,197)				90,320.7
1982	1983				(174,642)	(149,592)	(86,923)				72,278.0
1983	1984				855,253	546,196	251,041				60,657.9
1984	1985				(161,837)	(149,286)	(84,869)				93,405.6

Sources and notes: Numbers in parenthesis indicate depreciation (negative change in value), except for the net price, which presented in absolute value. Table 5.2-2 for V_t and Table 4.4-2 for Nt=(Vz[Na15]). The use of alternative permutations of Nt does not alter the substantive message of these results.

Table 5.2-5: Change in value of Mexican oil resources 1935-1987 (V_{t+1}-V_t)

		$PV1_{t+1}$-$PV1_t$			$PV2_{t+1}$-$PV2_t$			$PV3_{t+1}$-$PV3_t$			
t	*t+1*	*i=3* Mll. Pesos	*I=6* Mll. Pesos	*I=15* Mll. Pesos	*i=3* Mll. Pesos	*i=6* Mll. Pesos	*i=15* Mll. Pesos	*i=3* Mll. Pesos	*i=6* Mll. Pesos	*i=15* Mll. Pesos	**Net price** N_t
1935	1936	197	236	110	(237)	(157)	(73)	140	132	56	113
1936	1937	(1,043)	(311)	76	1,532	1,177	656	305	334	200	104
1937	1938	1,914	990	141	(1,010)	(783)	(442)	(430)	(359)	(226)	192
1938	1939	(2,411)	(995)	(24)	(755)	(487)	(207)	(344)	(28)	89	133
1939	1940	1,653	996	275	(415)	(327)	(190)	736	460	137	107
1940	1941	906	659	281	32	24	13	196	169	93	81
1941	1942	3,588	1,914	455	(250)	(230)	(154)	(216)	(239)	(133)	83.
1942	1943	3,228	1,708	475	61	36	14	765	447	163	61
1943	1944	200,405	76,870	5,436	(320)	(256)	(146)	20,161	8,076	804	63
1944	1945	(175,959)	(65,584)	(3,572)	(439)	(287)	(133)	(13,988)	(4,768)	147	43
1945	1946	(25,968)	(10,751)	(443)	734	567	318	(3,931)	(1,216)	430	26
1946	1947	(1,538)	(391)	488	289	262	180	721	852	753	69
1947	1948	(178)	269	626	3,125	2,505	1,506	331	484	567	95
1948	1949	2,799	1,836	811	2,287	1,651	828	1,431	1,027	567	306
1949	1950	(2,042)	(846)	301	3,893	3,342	2,221	968	1,135	1,071	412
1950	1951	979	711	373	2,227	1,677	900	1,022	812	503	737
1951	1952	16,862	9,175	1,741	3,277	2,217	962	6,362	3,423	611	854
1952	1953	42,425	22,482	3,779	(4,925)	(3,877)	(2,258)	9,373	4,691	411	967
1953	1954	113,063	58,701	9,523	5,727	4,245	2,263	28,020	15,260	3,295	656
1954	1955	4,694	5,201	2,267	219	290	259	4,667	3,410	1,259	957
1955	1956	365,662	188,203	29,068	2,001	1,387	661	52,219	27,350	4,552	997
1956	1957	4,382,035	2,095,044	260,410	7,574	5,177	2,446	397,345	190,565	23,935	1,081
1957	1958	3,815,101	1,831,745	232,691	(3,224)	(2,371)	(1,253)	402,569	194,489	25,362	1,395
1958	1959	261,440	252,126	80,621	(5,107)	(3,633)	(1,835)	54,877	40,212	10,718	1,228
1959	1960	27,500,000	12,700,000	1,433,833	(5,520)	(4,264)	(2,396)	3,000,548	1,386,120	157,843	987
1960	1961	1,094,700	1,028,992	308,439	12,823	9,512	5,085	437,584	267,093	55,366	664
1961	1962	1,126,844	1,090,014	353,924	3,286	2,608	1,513	346,036	234,846	57,635	1,342
1962	1963	20,400,000	10,300,000	1,502,009	(773)	(573)	(307)	2,680,384	1,350,188	198,185	1,548
1963	1964	(18,000,000)	(7,889,212)	(627,393)	(2,015)	(1,133)	(332)	(2,226,197)	(970,650)	(74,733)	1,507
1964	1965	1,231,184	1,298,060	538,053	(2,811)	(1,954)	(936)	265,233	224,120	80,046	1,474
1965	1966	22,300,000	12,200,000	2,284,611	(2,487)	(1,897)	(1,055)	3,089,599	1,696,392	318,131	1,354
1966	1967	(19,700,000)	(9,395,852)	(953,814)	(1,690)	(998)	(302)	(2,016,988)	(902,598)	(50,897)	1,212
1967	1968	23,600,000	13,700,000	3,021,618	(3,349)	(2,604)	(1,492)	4,125,857	2,398,115	528,987	1,185
1968	1969	2,054,872	2,371,116	1,272,191	1,702	1,462	967	898,077	714,071	282,477	981
1969	1970	(21,500,000)	(11,200,000)	(1,450,483)	(2,320)	(1,570)	(659)	(3,150,046)	(1,596,066)	(169,171)	1,121
1970	1971	25,800,000	16,400,000	4,595,710	10,267	8,231	4,960	4,347,820	2,757,430	778,957	1,050
1971	1972	2,244,616	2,823,212	1,933,924	4,121	3,558	2,419	841,286	779,589	423,933	1,745
1972	1973				36,749	29,774	18,281				2,109
1973	1974				244,260	203,425	131,391				4,703
1974	1975				84,102	73,302	51,475				24,029
1975	1976				512,593	354,973	160,155				32,123
1976	1977				749,754	603,039	362,133				50,602
1977	1978				1,916,026	824,542	201,216				100,964
1978	1979				2,444,917	1,488,491	669,206				122,561
1979	1980				8,986,486	5,306,320	2,357,414				209,874
1980	1981				6,595,082	3,865,925	1,712,939				517,399
1981	1982				30,300,000	19,100,000	8,741,090				740,845
1982	1983				72,000,000	43,500,000	19,500,000				1,881,754
1983	1984				(58,700,000)	(35,700,000)	(16,100,000)				4,429,150
1984	1985				164,000,000	99,400,000	44,600,000				2,331,022
1985	1986				(3,045,760)	(4,144,304)	(2,294,524)				8,148,324
1986	1987				432,000,000	262,000,000	118,000,000				7,847,933

Sources and notes: Numbers in parenthesis indicate depreciation (negative change in value), except for the net price that is presented in absolute value. Table 5.2-3 for V_t and Table 4.4-3 for *Nt* (Mx[Na6] is used). The use of alternative permutations of *Nt* does not alter the substantive message of these results, except if permutation *Nb* is used given (its negative sign).

Tables 5.2-4 and 5.2-5 report the differences between consecutive year's present values. That is the direct estimation of the right hand side of the fundamental equation of asset equilibrium presented in Chapter 2 (equation 2.3-2). Since the net price method is an attempt to approximate the change in value, the last column of each table provides the relevant net price for comparison.

As expected, negative changes in value (i.e. depreciation) are not the rule but the exception for the two countries regardless of the implementation used for calculating the present value. In addition, the higher the social discount used, the less frequent depreciation becomes. More crucially, the net price is not a good approximation to the change in value. Worse, contrary to a widespread view in the literature the bias is not systematically upwards.[23] The net price both overestimates and underestimates changes in value. The net price seems to have a tendency to underestimate during the first half of the century and to overestimate during the second half. Before analysing the reasons behind the poor performance of the net price, lets analyse the results for each country.

The differences across the columns are striking. Of the 53 years (1920-1972) for which *PV1* and *PV3* were calculated for, only a minority of years show depreciation - i.e., a diminished value of the resources. The sensitivity of *PV1* to the discount rate has already been mentioned. This translates here as the higher the social discount applied, the less the number of years for which a depreciation in value is obtained. For Venezuela, the range goes from 22 years (at 3 percent) to 6 years (at 15 percent). As it can be expected from the simple observation of the upward trend of the series, the implementation *PV3* results in depreciation for just 5 years clustered around 1930 plus one other in the early 1940s. For its part *PV2*, the most common implementation in the literature, records the highest number of years showing depreciation. This is regardless of the fact it covers a longer period (1920-1985). Just over one third of the years observed present a depreciation in value in the case of Venezuela. Unlike the other implementations, the social discount has a small impact on *PV2* depreciation findings.

[23] It has become widely accepted that the net price overestimates depletion. Most of the demonstrations (if not all) are theoretical, and therefore subject to the assumptions regarding the alternative scenarios.. See for example G.A. Davis and D.J. Moore, 'Valuing mineral stocks and depletion in green national income accounts', *Environment and Development Economics* 5 (2000). Nevertheless, this paper finds that under several assumptions the direction of the bias is unknown for the value of the reserves –thus for the depreciation too.

Identifying the periods over which Venezuelan oil resources lost value is also dependent on the formula used. While the variation that assumes perfect foresight (*PV1*) signals the 1920s and the 1940s as the decades with most depreciation, the variation that keeps variables constant (*PV2*) points to the late 1950s and the whole of the 1960s as the years in which more value was lost.

The results for Mexico present some similarities but also important differences when analysing the depreciation values obtained using the present value methodology. The main similarity, again, is that assuming perfect foresight (*PV1*) generates less years with depreciation than the traditional operational approach (*PV2*) suggests. The sensitivity to the rate of discount also remains. However, here the net price tends almost systematically to underestimate the depreciation obtained from the change in value.

All in all, the present value method obtains depreciation for periods in which one would expect Mexican oil assets to depreciate. These are:

- the 1920s , which were years of fast depletion;
- the 1940s, when Mexican oil fields lost value and productivity due to the nationalisation;
- the 1960s and the early 1970s, when resource rents decreased due to increasing labour costs.

Note that no depreciation is observed at the time of the massive discoveries of the early 1970s. This result is consistent with the fact that the resource base grew tremendously during those years, expanding the time horizon and thus the present value of the resource by virtue of the extra terms added at the tail of the formula. As a consequence, the value of the resource appreciates over time.

This last fact is directly connected with the issue of why the net price is not a good proxy for the change in value of the resources. As used in applied studies, the net price method estimates gross, not net changes in value. 'By making V_{t+1}-V_t= - $(p_t - AC_t)$=Nt the applied studies have ignored the capital gain (loss) associated with holding the resource (which is conveyed by the first term of equation 2.3-2, that is $Vt(i/(1+i))$. It appeared that the only problem with the net-price method was that it used average costs instead of marginal costs. Unfortunately, this advice was misguided. This is not to say it was incorrect: it was indeed correct, but only under the strong assumptions underlying it (see Section 2.3). Since the assumptions are violated, the capital gains term in the definition of the change in value becomes important.'[24]

The results demonstrate that the value given to the resource in any given year depend greatly on the assumptions regarding the behaviour of the rent over time. The most common assumption, that of keeping rents constant over time, tends seriously to underestimate the historical present values of the resources in both Mexico and Venezuela. In the absence of better tools for predicting future trends of prices, rates of extraction and costs, and the pace of new discoveries the calculation of depreciation is a hazardous undertaking. In addition, the expectation of obtaining a depreciation value to charge yearly for the use of the resource finds no satisfactory answer in the presence of capital gains.

With regard to methodology, one of the most important findings of the section is the confirmation that the net price is a poor approximation to the change in value of the resource. That should not be new to most experts in the field. What is new is that the results presented here demonstrate that the net price does not systematically overestimate the depreciation values, even under the most restrictive assumptions. The net price both underestimates and overestimates the change in the value of oil resources in Mexico and Venezuela, because it is indeed a measure of gross change in value.

The results also prove that the life expectancy of the resource has a role to play in the value of the resource, which is at least as relevant as the discount rate chosen. This is mostly ignored by the literature as a result of the assumptions regarding the value of *n* over time. This variable depends on both the rate of extraction and the variation of the stock of reserves. Typically, both extraction and stock are held constant which make *n* decrease one year at a time as exhaustion of the resource takes place. In the exercises carried out here, both the rate of extraction and the stock of resources vary constantly and as a consequence, the time horizon of consecutive years can be very different. Therefore, it should be kept in mind that an important part of the change in value over time observed is due to the variations in the time horizon from period to period.

Since the present value is at the core of all calculations regarding the value of natural resources, the results in this section have further implications for the other main method, the user cost.

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[24] J.R.Vincent, 'Green accounting: from theory to practice', *Environment and Development Economics* 5 (2000), p.21. Parenthesis added.

5.3 User Cost Method

The actual magnitude of the present value for a given year is also relevant to the calculations put forward by El Serafy. His user cost method proposes to match the present value of the finite income from the resources to the present value of a perpetual income generated by investing part of the rents generated in a given year.[25] His working assumptions lead him to use our *PV2* measure as the value of the finite income in his calculation.[26] Hartwick and Hageman have already pointed out that, in the case of changing yearly receipts, El Serafy's measure could be a poor approximation to the amounts that can be consumed (reinvested) from the yearly receipts. However, their result was based on the elaboration of a hypothetical case.[27]

The first part of this section presents the results under the constant rents assumption. Then rents (and thus prices and costs) are allowed to change using the results of *PV1* and *PV3* from the previous section for the calculation of the user costs. This simple exercise demonstrates the user cost reproduces exactly the net change in value (right hand side of equation 2.3-2) regardless of the assumptions made about the value of the resource, but that once the assumption of constant rents over time is removed, the amount that can be consumed keep no relation to the rent produced in the current period.

The algebra of the user cost method (see Chapter 2) demonstrates that, if receipts are kept constant, the amount that should be set aside and invested to create a perpetual stream of income is a proportion of the current year receipts. Under this assumption, the proportion is equal to $1/(1+i)^{n+1}$. It is possible to calculate the proportion of net receipts that correspond to the user cost using the historical data of Mexico and Venezuela. The two pieces of information needed are the life expectancy of the oil reserves in the two countries at the current rate of extraction *(n)* and the social discount

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[25] For El Serafy, setting part of the proceeds aside for reinvestment is only a metaphor. 'The owner may dispose of his receipts any way he chooses. But he should be made aware of the fact that his true income is only a fraction of his total receipts'. S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy and Lutz (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989), p.16.

[26] El Serafy argues that in his method 'it is not necessary to estimate the absolute value *(present value)* of the total mineral reserves or resort to what is known as 'wealth accounting' Ibid. p.16. However, 'an estimate of the value *(present value)* of total reserves is implied by his formula' as already pointed out by J. Hartwick and A. Hageman, 'Economic depreciation of mineral stocks and the contribution of El Serafy', in Lutz (ed.), *Toward Improved Accounting for the Environment: An UNSTAT-World Bank Symposium* (Washington, D.C., 1993), p.221. Parentheses added.

[27] Ibid, p.217.

rate *(i)*. We shall see that, given any rate of discount, the variations in the value resulting from the equation are solely due to variations in *n*.

The choice of the social discount rate is more difficult to ground historically. The US Tariff Commission in 1932 used 6 percent.[28] An identical figure was used in 1970 for the calculation of the present value of future production, in order to compensate Pauley Co for the cessation of the exploration contract this company had with Pemex.[29] El Serafy suggests 5 percent or thereabouts as an approximation to what classical economists used to call a natural rate of time preference.[30] This should not deter us from attempting the calculation using different values of *i*.

Figures 5.3-1 and 5.3-2 plot the proportion of receipts that should be accounted as user costs for both countries using the historical data on life expectancy of the resource and considering two values of *i;* 6 and 3 percent. The value of *n* has also been plotted to facilitate the understanding of its influence on the calculation.

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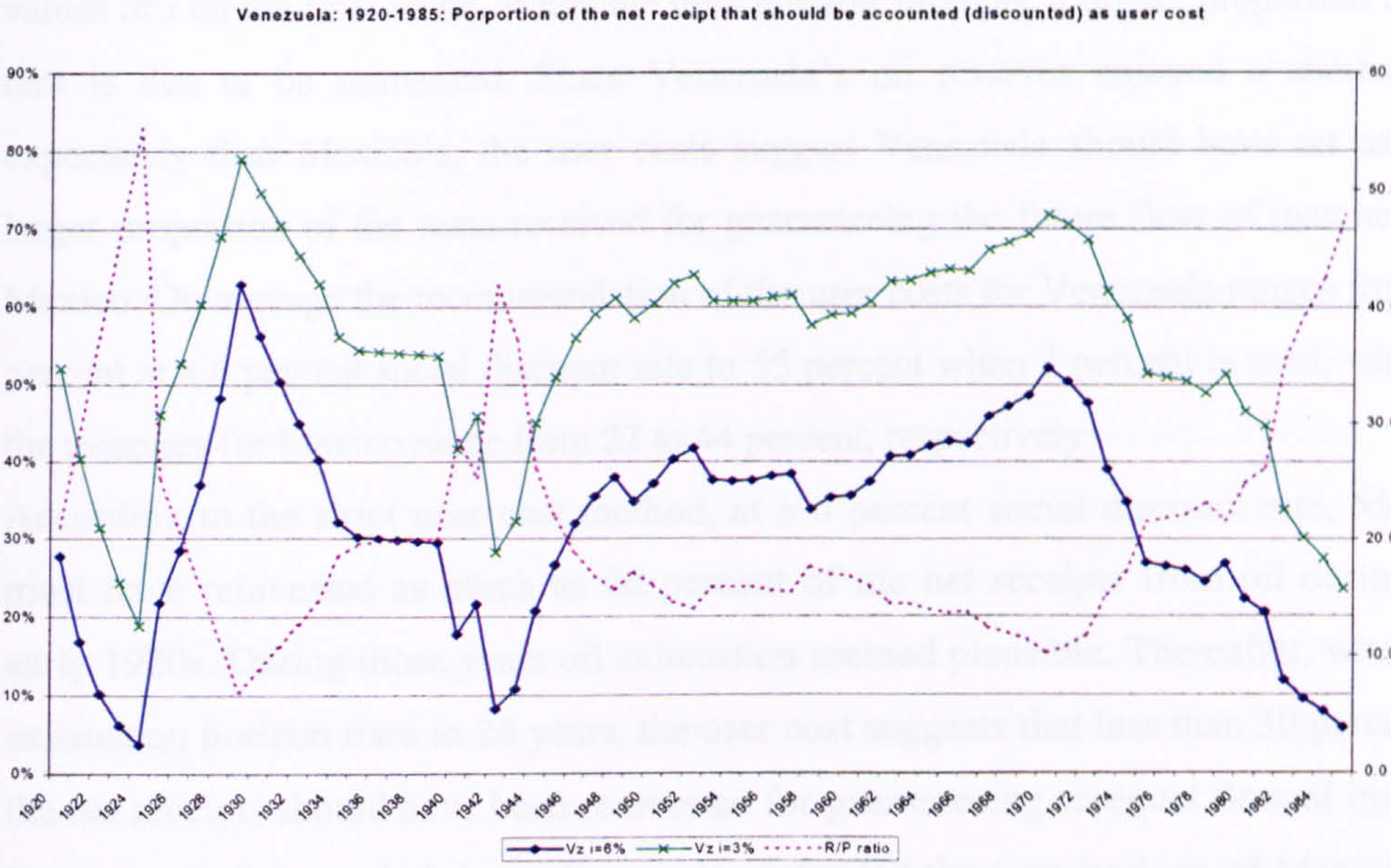
[28] US Tariff Commission, 'Production cost of petroleum products and of refined petroleum products'. (Washington, D.C., 1932), p.59.

[29] A. Echevarría, E. Loreto, W. Friedeberg, et al., *Dictamen sobre el valor que representa para Petróleos Mexicanos el compromiso contraido en el contrato Puley-Noreste celebrado originalmente con E.W. Pauley* (México D.F., 1970, 27 February), p.3.

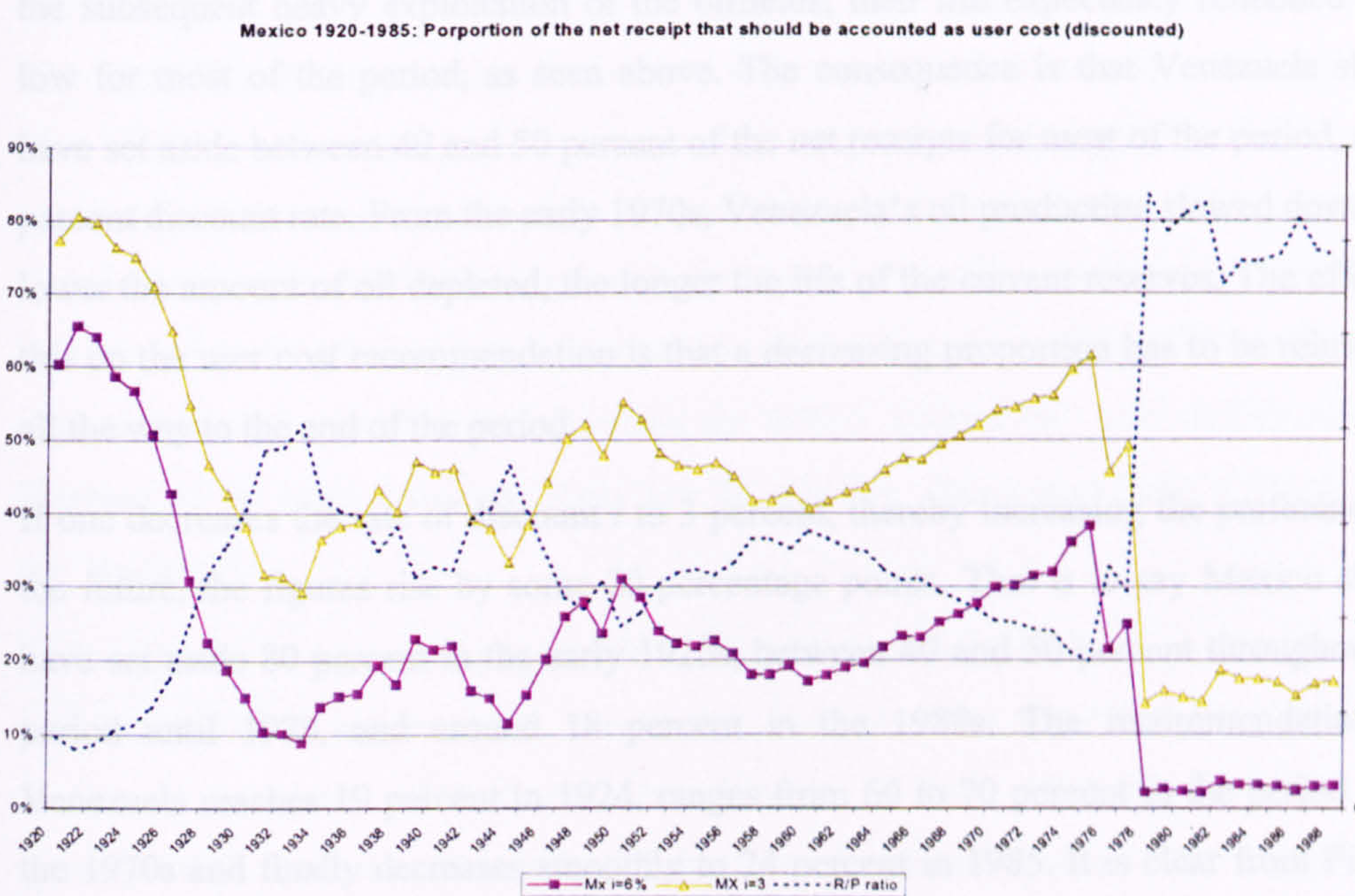
[30] S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy and Lutz (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989), p.16.

Figure 5.3-1: Venezuela 1920-1985. Proportion of the net receipts to be accounted as User Cost (assuming constant rents over time)



Sources: own calculation base on the reserves/production ratio in Appendix E, Table E.1.

Figure 5.3-2: Mexico 1920-1989. Proportion of the net receipts to be accounted as User Cost (assuming constant rents over time)



Sources: own calculation base on the reserves/production ratio in Appendix E, Table E.1.

Figures 5.3-1 and 5.3-2 reveal the direct effect of the fluctuations of *n* and of the different values of *i* on the final value. When the time horizon shortens, a higher proportion of the rent is due to be reinvested. Since Venezuela's oil reserves enjoyed a shorter life expectancy than Mexico's, the user costs suggest Venezuela should have set aside a larger proportion of the rents received for guaranteeing the future flow of income than Mexico. On average the recommendation of the user costs for Venezuela ranges from 32 percent at a 6 percent social discount rate to 55 percent when 3 percent is used, whereas the averages for Mexico range from 22 to 44 percent, respectively.
According to the strict user cost method, at a 6 percent social discount rate, Mexico must have reinvested as much as 60 percent of the net receipts from oil during the early 1920s. During those years oil exhaustion seemed plausible. Thereafter, when the exhaustion horizon rises to 20 years, the user cost suggests that less than 30 percent of the net receipts should have been reinvested for guaranteeing an equal flow of income. By the end of the period, huge discoveries extended the time horizon of Mexican oil and a mere 2 percent of the net receipts should have been set aside.

In the early days of Venezuela's booming oil industry, the user cost recommends a low proportion of reinvestment. It is as low as 4 percent in 1924 (*i* is set at 6 percent). Due to the subsequent heavy exploitation of the oilfields, their life expectancy remained quite low for most of the period, as seen above. The consequence is that Venezuela should have set aside between 40 and 50 percent of the net receipts for most of the period, at a 6 percent discount rate. From the early 1970s, Venezuela's oil production slowed down; the lower the amount of oil depleted, the longer the life of the current reserves. The effect of this on the user cost recommendation is that a decreasing proportion has to be reinvested all the way to the end of the period.

If one decreases the rate of discount *i* to 3 percent, thereby increasing the preference for the future, the figures rise by some 20-percentage points. That is to say Mexico should have set aside 80 percent in the early 1920s, between 40 and 50 percent throughout the period until 1970, and around 18 percent in the 1980s. The recommendation for Venezuela reaches 19 percent in 1924, ranges from 60 to 70 percent in the period up to the 1970s and finally decreases smoothly to 24 percent in 1985. It is clear from Figures 5.3-1 and 5.3-2 that the choice of *i* is also critical for the results. A mere three percentage points of difference in the social discount (from 3 to 6 percent) produces about 20-percentage points difference in the result. Therefore, time preference matters. The lower the discount rate, the bigger the proportion of the rents that should be set aside. Yet life expectancy matters also.

It is also interesting to see that the period in which the lowest proportion of net receipts should have been reinvested is the 1970s-1980s. It is the period of highest receipts for the oil industry and also the one in which concerns regarding sustainability came to the fore. Nevertheless, according to these results, it is the period with the least need to care about the future. The discrepancy generated by the two different social discounts is greater when longer time horizons are present. In presence of a short-lived resource, both social discount rates imply relatively similar high reinvestment policies. This is observable in the late 1920s and second half of the 1960s. However, when the life expectancy of the reserves increases, a smaller part of the rent needs to be reinvested and a bigger percentage of the rent can be consumed. The lower the preference for the future and the longer the life expectancy of the resources, the smaller the amount that should be reinvested. During the 1970s and particularly the early 1980s, Venezuela exemplifies the point. The life expectancy of Venezuelan oil fields grew consistently during those years. Starting from the same rents, the lower preference for the future of 6 percent generates a reinvestment path that decreases at a faster pace than the reinvestment recommendation at 3 percent.

Theoretically, new discoveries do not have to be accounted as income in this approach. Yet, if discoveries occur, and the same pace of extraction is kept, the time horizon automatically increases and so does the proportion of the rent that can be consumed in the current period –since the proportion that needs to be reinvested shrinks. Equally, if the owner decides to keep the reserves-to-extraction ratio unchanged by raising his annual extraction when new discoveries are added, income will also rise through the increase of the rents obtained. Therefore, in practice, discoveries have a direct effect on 'income'.[31]

So far, the user costs seem to provide a satisfactory answer to our quest for the value that should not be accounted as income (i.e., the value that should be subtracted from traditional measures of income). The problem is that, when the constant rents assumption is removed, the algebra of the sum of geometric series is no longer valid. Therefore, the hypothetical amount that should be reinvested for continuing to yield the same level of income in perpetuity does not correspond to a proportion of the rent.

[31] Reckoning that the market share of the producer is small, thus neither discoveries nor increasing production will alter prices.

To demonstrate this point, it is necessary to recall the algebra supporting the user cost method, yet in a more simplified fashion than in Chapter 2.

User cost is derived from setting equal the present value of the finite series produced by the resource, *N*, to the value of a perpetual income *X*:

$$\sum_{n=0}^{R_t/q_t} \frac{N_t}{(1+i)^n} = \sum_{n=0}^{\infty} \frac{X}{(1+i)^n} \qquad [5.3\text{-}1]$$

In the previous section, the left hand side of equation 5.3-1 has been calculated as *PV1*,*PV2* and *PV3* depending on the assumptions regarding the evolution of N_t, that is the value of the resource V_t. The right hand side is the sum of a perpetual geometric series whose simplified result can be found in any maths book. Therefore the equations can be rewritten as:

$$V_t = \frac{X}{1-\frac{1}{1+i}} \qquad [5.3\text{-}2]$$

for whatever implementation of the present value, V_t. The value of *X* is therefore:

$$X = V_t \cdot \left(1-\frac{1}{1+i}\right) \qquad [5.3\text{-}3]$$

The user cost is meant to be the difference between this true income and the rents obtained every year. Thus user cost is *X-N*, which replacing *X* by the expression in [5.3-3] and simplifying becomes:

$$UC = V_t \frac{i}{1+i} - N_t \qquad [5.3\text{-}4]$$

which is also the expression for V_{t+1}-V_t derived in equation 2.3-2.[32] The user cost is therefore equivalent to the net change in value. Now, if *PV2* replaces *Vt* in the equations above, *N-X* becomes the proportion of *N* that Figure 5.3-2 and 5.3-2 have above, that is $1/(1+i)^{n+1}$. But if we remove the basic underlying constant rents assumption and we plug *PV1* or *PV3* into the equations above, the results are quite different. Tables 5.3-1 and 5.3-2 report the results of applying equation 5.3-4 to the different values generated for *Vt*.

[32] Hartwick and Hageman, 'Economic depreciation of mineral stocks and the contribution of El Serafy', p.215.

Table 5.3-1: El Serafy's user costs (net change in value $V_t(i/1+i) - N_t$) for Venezuelan oil resources, 1935-1987

Year	UC(1)			UC(2) El Serafy's user cost			UC(3)		
	i=3 mll.blvs	*i=6* mll.blvs	*i=15* mll.blvs	*i=3* mll.blvs	*i=6* mll.blvs	*i=15* mll.blvs	*i=3* mll.blvs	*i=6* Mll.blvs	*i=15* mll.blvs
1920	107.2	148.5	140.1				0.4	0.4	0.1
1921	236.1	274.7	196.2				1.9	2.6	2.4
1922	691.2	630.0	281.8				4.6	5.8	5.8
1923	1,252.6	987.0	346.6	(1.1)	(0.3)	(0.0)	7.0	9.1	9.8
1924	2,927.6	1,774.8	400.4	(6.2)	(1.3)	0.0	9.1	5.4	1.9
1925	166.6	246.8	241.1	(47.0)	(22.9)	(3.0)	(67.0)	(50.0)	(28.2)
1926	(45.5)	40.3	125.1	(114.1)	(64.2)	(12.6)	(161.7)	(133.4)	(91.1)
1927	(84.7)	0.1	114.3	(136.1)	(86.0)	(23.3)	(157.7)	(116.3)	(51.3)
1928	(266.4)	(187.1)	(50.8)	(271.1)	(197.7)	(80.7)	(289.1)	(224.8)	(109.1)
1929	(513.0)	(455.2)	(328.7)	(487.2)	(410.1)	(251.5)	(508.5)	(447.2)	(313.8)
1930	(528.6)	(466.0)	(343.6)	(480.1)	(381.6)	(198.8)	(528.7)	(465.2)	(337.6)
1931	(250.2)	(189.8)	(85.0)	(247.1)	(185.4)	(82.1)	(266.0)	(215.4)	(121.1)
1932	(402.1)	(336.3)	(231.8)	(348.1)	(246.7)	(92.8)	(426.1)	(375.0)	(285.5)
1933	(52.0)	21.2	103.0	(116.5)	(78.0)	(24.9)	(102.8)	(55.1)	12.2
1934	34.2	165.9	174.3	(178.4)	(106.4)	(24.6)	(165.6)	(95.8)	(35.0)
1935	117.4	277.5	243.9	(189.7)	(109.9)	(23.3)	(162.4)	(82.8)	(29.2)
1936	152.4	335.4	288.3	(206.8)	(119.9)	(25.5)	(176.7)	(91.7)	(42.9)
1937	209.0	419.4	355.3	(219.3)	(127.1)	(27.0)	(149.9)	(45.2)	2.9
1938	391.5	634.3	552.3	(167.1)	(96.8)	(20.6)	(42.5)	68.1	110.3
1939	565.6	851.7	756.2	(135.8)	(78.7)	(16.7)	54.7	184.2	231.9
1940	1,518.9	1,530.8	1,122.2	(112.5)	(50.4)	(5.1)	109.7	241.3	242.9
1941	1,162.7	1,238.1	1,042.6	(203.8)	(99.4)	(12.9)	(9.0)	166.5	221.0
1942	7,507.8	4,813.6	2,079.8	(56.0)	(17.3)	(0.6)	715.5	691.7	346.1
1943	5,289.4	3,959.9	2,148.0	(98.8)	(34.2)	(1.7)	508.0	595.6	384.9
1944	1,577.7	2,194.0	1,874.9	(245.4)	(119.7)	(15.6)	118.3	368.4	451.7
1945	1,096.2	1,783.7	1,864.9	(348.4)	(190.6)	(34.4)	51.9	386.7	612.2
1946	581.6	1,301.7	1,717.6	(531.9)	(317.3)	(73.2)	(152.6)	262.8	666.3
1947	(98.4)	659.4	1,301.2	(936.2)	(591.4)	(160.6)	(701.4)	(222.1)	340.8
1948	(1,155.8)	(355.4)	442.0	(1,641.0)	(1,066.8)	(314.2)	(1,678.1)	(1,129.4)	(422.5)
1949	(410.7)	513.0	1,224.3	(1,331.6)	(817.4)	(204.6)	(1,220.8)	(655.1)	(23.0)
1950	(943.0)	(18.3)	910.8	(1,643.8)	(1,068.6)	(314.7)	(1,561.1)	(941.6)	(156.9)
1951	(1,164.5)	(212.6)	854.2	(1,820.8)	(1,218.2)	(389.2)	(1,668.5)	(973.7)	(42.3)
1952	(1,568.4)	(594.3)	613.5	(2,126.7)	(1,464.2)	(507.6)	(2,024.2)	(1,295.8)	(252.2)
1953	(1,271.0)	(113.9)	1,087.9	(2,108.4)	(1,370.7)	(403.7)	(2,013.7)	(1,232.0)	(242.8)
1954	(1,444.8)	(204.5)	1,108.0	(2,306.7)	(1,499.5)	(441.7)	(2,203.8)	(1,352.4)	(281.8)
1955	(2,043.7)	(722.2)	711.5	(2,770.3)	(1,801.0)	(530.4)	(2,708.3)	(1,725.6)	(496.4)
1956	(2,570.5)	(1,178.5)	345.3	(3,181.4)	(2,068.2)	(609.1)	(3,096.5)	(1,964.5)	(567.0)
1957	(3,748.8)	(2,284.6)	(713.4)	(4,029.0)	(2,619.2)	(771.4)	(4,112.0)	(2,811.9)	(1,257.5)
1958	(1,480.9)	296.4	1,312.5	(3,183.4)	(1,954.0)	(489.0)	(2,198.8)	(739.2)	205.9
1959	(1,053.2)	786.4	1,981.6	(2,984.6)	(1,885.3)	(511.8)	(1,603.5)	(28.8)	1,055.9
1960	(178.7)	1,921.0	3,086.7	(2,849.2)	(1,799.8)	(488.6)	(503.6)	1,386.2	2,327.9
1961	(519.0)	1,701.4	3,214.8	(3,149.6)	(2,047.5)	(603.1)	(760.1)	1,273.7	2,509.3
1962	(1,219.5)	1,118.5	3,012.0	(3,697.0)	(2,473.3)	(790.3)	(1,072.9)	1,264.4	2,947.1
1963	(472.6)	2,219.9	4,298.5	(3,669.5)	(2,454.9)	(784.4)	53.6	2,891.0	4,689.3
1964	(3,589.7)	(749.9)	1,840.3	(5,892.5)	(4,057.0)	(1,406.4)	(2,782.9)	368.6	2,806.9
1965	(2,744.8)	478.6	3,233.5	(5,823.4)	(4,009.5)	(1,389.9)	(1,322.1)	2,501.4	5,155.4
1966	(1,801.7)	1,822.9	4,892.8	(5,649.0)	(3,889.4)	(1,348.3)	(117.7)	4,230.0	7,191.5
1967	(2,231.6)	1,556.4	5,250.8	(6,082.1)	(4,309.5)	(1,620.8)	(85.1)	4,752.0	8,729.4
1968	(2,617.4)	1,330.9	5,719.7	(6,494.9)	(4,736.1)	(1,932.4)	(227.1)	5,004.8	10,111.0
1969	(1,018.3)	3,707.7	8,914.1	(6,259.0)	(4,564.0)	(1,862.2)	2,099.1	8,548.6	14,893.1
1970	(1,473.3)	3,505.7	9,826.7	(6,762.6)	(5,074.9)	(2,246.5)	2,084.4	9,204.9	17,528.8
1971	(1,946.8)	4,222.4	12,106.2	(8,472.2)	(6,357.8)	(2,814.4)	2,418.7	11,230.7	21,674.3
1972	1,819.9	10,028.9	19,843.9	(8,050.2)	(5,870.2)	(2,395.2)	7,239.0	18,572.9	30,990.0
1973				(11,026.1)	(7,167.9)	(2,111.2)			
1974				(27,640.8)	(16,966.2)	(4,245.4)			
1975				(19,803.8)	(10,837.0)	(1,957.4)			
1976				(20,109.3)	(11,004.1)	(1,987.5)			
1977				(21,743.4)	(11,561.6)	(1,924.8)			
1978				(19,083.3)	(9,859.9)	(1,513.1)			
1979				(33,509.5)	(18,336.9)	(3,312.0)			
1980				(41,170.0)	(20,669.6)	(2,923.6)			
1981				(41,881.2)	(19,853.4)	(2,385.9)			
1982				(25,686.4)	(9,403.8)	(542.8)			
1983				(19,153.0)	(6,251.2)	(260.4)			
1984				(26,990.4)	(8,082.1)	(263.6)			
1985				(20,485.9)	(5,314.1)	(115.3)			

Sources: own elaboration from the present values in Section 5.2. Negative numbers shown in parenthesis. *UC(1)*, *UC(2)* and *UC(3)* correspond to the user costs generated by *PV1*,*PV2* and *PV3* respectively.

Table 5.3-2: El Serafy's user costs (net change in value $V_t(i/1+i)-N_t$) for Mexican oil resources, 1935-1987

Year	UC(1)			UC(2) El Serafy's user cost			UC(3)		
	i=3 Mll. Pesos	*i=6* Mll. Pesos	*I=15* Mll. Pesos	*i=3* Mll. Pesos	*i=6* Mll. Pesos	*i=15* Mll. Pesos	*i=3* Mll. Pesos	*I=6* Mll. Pesos	*i=15* Mll. Pesos
1935	59	222	96	(65)	(19)	(2)	(22)	65	30
1936	75	245	119	(60)	(18)	(2)	(9)	82	47
1937	(22)	139	41	(114)	(40)	(4)	(87)	12	(16)
1938	66	255	119	(77)	(25)	(2)	(38)	52	14
1939	63	224	141	(66)	(27)	(4)	(13)	76	52
1940	118	306	203	(49)	(19)	(3)	26	128	95
1941	136	342	238	(50)	(19)	(3)	29	136	106
1942	213	472	319	(35)	(11)	(1)	44	144	110
1943	261	567	380	(36)	(10)	(1)	55	168	130
1944	2,519	4,938	1,108	(24)	(5)	(0)	310	644	254
1945	627	1,243	660	(15)	(4)	(0)	189	392	291
1946	270	591	559	(42)	(15)	(2)	110	280	304
1947	233	543	596	(60)	(27)	(4)	109	302	376
1948	30	347	467	(198)	(96)	(19)	(88)	119	239
1949	(22)	345	467	(256)	(108)	(17)	(164)	71	207
1950	(372)	(27)	182	(483)	(244)	(52)	(455)	(190)	22
1951	(469)	(105)	112	(552)	(267)	(52)	(550)	(262)	(30)
1952	(314)	302	227	(600)	(253)	(39)	(562)	(180)	(62)
1953	651	1,885	1,031	(402)	(162)	(23)	(115)	396	302
1954	2,060	4,907	1,972	(580)	(223)	(29)	28	958	430
1955	2,172	5,162	2,228	(611)	(246)	(35)	88	1,112	555
1956	7,569	15,730	5,935	(655)	(252)	(33)	800	2,576	1,064
1957	68,276	134,004	39,587	(818)	(273)	(28)	6,037	13,048	3,872
1958	121,794	237,854	70,105	(720)	(240)	(25)	11,868	24,224	7,347
1959	129,379	252,367	80,862	(585)	(205)	(23)	13,281	26,741	8,986
1960	499,189	970,749	268,208	(385)	(123)	(11)	53,977	105,525	29,898
1961	528,481	1,028,315	307,760	(787)	(263)	(27)	61,078	119,965	36,441
1962	560,023	1,089,808	353,718	(917)	(321)	(36)	67,712	133,052	43,753
1963	859,160	1,671,111	549,673	(893)	(313)	(35)	107,079	209,518	69,644
1964	629,410	1,224,585	467,873	(893)	(344)	(45)	78,840	154,609	59,929
1965	667,337	1,298,179	538,173	(830)	(335)	(47)	85,488	167,415	70,490
1966	1,023,714	1,990,626	836,308	(743)	(299)	(42)	135,040	263,580	112,128
1967	750,076	1,458,812	711,925	(745)	(329)	(55)	108,777	212,516	105,516
1968	1,150,550	2,236,900	1,106,253	(617)	(272)	(45)	178,829	348,462	174,718
1969	1,219,471	2,370,974	1,272,050	(714)	(330)	(60)	199,487	388,741	211,423
1970	893,606	1,737,621	1,082,929	(688)	(347)	(74)	153,072	298,470	189,429
1971	1,369,643	2,663,406	1,681,673	(1,144)	(577)	(123)	232,689	453,855	290,336
1972	1,451,509	2,822,847	1,933,561	(1,404)	(739)	(170)	255,032	497,619	345,268
1973				(3,131)	(1,648)	(380)			
1974				(16,532)	(9,459)	(2,568)			
1975				(22,491)	(13,404)	(3,948)			
1976				(30,631)	(11,790)	(1,537)			
1977				(63,429)	(28,018)	(4,665)			
1978				(61,010)	(2,943)	(16)			
1979				(104,969)	(6,002)	(42)			
1980				(257,941)	(13,169)	(78)			
1981				(368,787)	(17,789)	(97)			
1982				(952,754)	(76,338)	(863)			
1983				(2,232,358)	(159,914)	(1,536)			
1984				(1,174,870)	(84,161)	(809)			
1985				(4,098,310)	(277,542)	(2,458)			
1986				(3,918,627)	(211,734)	(1,354)			
1987				(11,663,431)	(746,622)	(6,095)			

Sources: own elaboration from the present values in Section 5.2. Negative numbers shown in parenthesis. *UC(1), UC(2)* and *UC(3)* correspond to the user costs generated by *PV1*,*PV2* and *PV3* respectively.

Comparing Table 5.3-1 and 5.3-2 with Table 5.2-4 and 5.2-5 in the previous section it turns out that 'change of the value' calculated here $(V_t(i/(1+i)-N_t)$ does not replicate the 'change in value' calculated there $(V_{t+1}-V_t)$.[33] If the approximation is only rough, it is because our historical scenario does not fit some of the theoretical abstractions supporting the equality. Nevertheless, the contrast of the results for each country remains, since it reveals that outside the El Serafy assumptions, the value of Venezuelan oil resources depreciated to a greater extent and more often than Mexican ones.

According to the numbers in Table 5.3-1 and 5.3-2, current generations could have consumed far more than the rent they were currently obtaining from the resource. The results show that once the constant rents assumption is removed, the true income, *X*, that represents the amount that can be consumed without jeopardising future generation's ability to consume according to El Serafy, is greater than the rent for a number of years. This is shown by the positive figures in the table. This is a result quite on line with the history of oil producer countries. They could, for instance, borrow against the resources they hold.[34]

Still, the figures generated do not represent a value that can be charged as depreciation for the use of the natural resource in the national income accounts. Although El Serafy himself is not in favour of depreciation methods, he would take away his user cost from the GDP itself, 'for it does constitute neither an economic rent nor a value added to the economy. Thus, it is wrong to describe as current production that which is not, applauding as good economic performance what comes from the liquidation of subsoil assets rather than from labour, capital formation, technological progress and efficient organisation'.[35] But, removing one of El Serafy's assumptions, produces an outcome that increases rather than decreases the GDP of resource producers. This hardly seems satisfactory.

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[33] J.R. Vincent, 'Green accounting: from theory to practice', *Environment and Development Economics* 5 (2000), p. 21, defines in this manner the two sides of the equation.
[34] Both Mexico and Venezuela used oil as collateral for borrowing in international markets during the late 1970s and the early 1980s. In words of P. Lucke, 'oil sales were used to catalyse external borrowing and bring forward high levels of future income', see Luke, P., 'Debt and Oil-led Development: The Economy Under Lopez Portillo', in Philip, G. (ed.), *The Mexican Economy* (London, 1988), p.70
[35] El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources',, p.12-13.

5.4 Imputed Income Method

Finally we turn to the adjustment proposed by Sefton and Weale.[36] We must remember that their departing concept of income and their interpretation of the adjustment are different from the methods implemented above. Sefton and Weale's adjustment to conventional net income seeks the calculation of welfare income rather than a better proxy for sustainable-Hicksian-income. They construct the adjustment term as the adjustment corresponding to the extraction of exhaustible resources ($-N_t$) plus an income imputed to the stock of the resource due for exports (i.e. the gains from trade, $V_t(i/(1+i))$. In this framework, V_t is calculated as the present value of the expected gains from the stock of the resource targeted for exports assuming Hotelling's rule holds. Under these assumptions, as shown in Section 2.4 above, V_t can be 'constructed from an estimate of the total remaining stock of the resource and the estimate of the present ratio of the domestic to foreign final consumption of this resource' times the price net of extraction costs.[37] In our notation it translates as $V_t = u_t Q_E$. Observe that, as it was noted in Chapter 2, in practical terms the adjustment proposed by Sefton and Weale responds to the formulation described for all the other methods ($-N_t + (V_t(i/(1+i))$) with the difference that the value of the resource is a function only of the resources made available for exports rather than the total stock.

For Venezuela the imputed income adjustment resulting of this method is almost identical to the adjustment produced by El Serafy's method at low interest rates (UC(2) in Table 5.3-1 above). This is the case because the values of V_t assigned by the two methods are very similar at low interest rates. For Venezuela there is almost no difference between using the whole of the stock or just the stock dedicated to exports for the calculation of V_t, since the country exported most of the oil it produced (see Figure 1.1-1). Note that if instead of using the stock targeted for exports we use the whole of the stock then the value assigned to the resource corresponds precisely to the Hotelling Valuation Principle shown in Figure 5.2-4, that is $V_t = u_t Q_E \approx u_t Q = HVP$. From Figure 5.2-4 we also know that $HVP \approx PV(2)$ at low interest rates. As a consequence, the adjustments of El Serafy and Sefton and Weale are very similar for Venezuela.

[36] J.A. Sefton and M.R. Weale, 'The net national product and exhaustible resources: The effects of foreign trade', *Journal of Public Economics* 61 (1996)
[37] Ibid, p.46.

Table 5.4-1: Sefton and Weale adjustment, imputed value to the stock targeted for exports. Venezuela 1921-1985,

Year	$V_t = u_t Q_E$	$-N_t + V_t(i/1+i)$		
		i=3%	i=6%	i=15%
1921	(149.08)	0.77	(3.33)	(14.34)
1922	(140.54)	(0.37)	(4.23)	(14.60)
1923	202.65	1.51	7.08	22.05
1924	1,724.67	18.71	66.10	193.43
1925	2,446.21	(27.15)	40.07	220.67
1926	4,194.66	(83.80)	31.46	341.15
1927	3,464.23	(117.50)	(22.31)	233.45
1928	4,246.87	(251.46)	(134.76)	178.79
1929	3,990.64	(465.45)	(355.79)	(61.16)
1930	5,328.35	(452.97)	(306.56)	86.84
1931	3,540.41	(228.97)	(131.69)	129.70
1932	6,233.77	(314.70)	(143.41)	316.84
1933	2,547.60	(101.96)	(31.96)	156.13
1934	5,543.86	(142.09)	10.25	419.56
1935	6,429.00	(145.49)	31.16	505.82
1936	7,050.14	(157.37)	36.35	556.87
1937	7,519.11	(165.54)	41.07	596.21
1938	5,761.94	(125.19)	33.14	458.55
1939	4,709.35	(100.96)	28.44	376.14
1940	7,263.64	(45.95)	153.63	689.92
1941	10,644.62	(116.71)	175.78	961.68
1942	7,928.94	42.75	260.62	846.02
1943	10,791.19	19.30	315.82	1,112.54
1944	13,136.11	(131.17)	229.78	1,199.63
1945	13,911.06	(243.06)	139.18	1,166.25
1946	16,569.10	(423.00)	32.28	1,255.59
1947	24,675.17	(783.58)	(105.56)	1,716.23
1948	39,011.97	(1,420.46)	(348.51)	2,531.79
1949	36,461.71	(1,138.86)	(136.98)	2,555.02
1950	39,511.32	(1,410.22)	(324.55)	2,592.61
1951	38,786.71	(1,624.50)	(558.74)	2,304.93
1952	42,138.92	(1,895.72)	(737.84)	2,373.31
1953	49,563.93	(1,841.30)	(479.40)	3,179.95
1954	54,155.41	(2,016.35)	(528.29)	3,470.06
1955	64,802.85	(2,428.62)	(648.00)	4,136.46
1956	73,072.17	(2,828.30)	(820.46)	4,574.54
1957	91,598.38	(3,609.07)	(1,092.18)	5,670.63
1958	87,861.97	(2,702.49)	(288.26)	6,198.68
1959	76,644.19	(2,557.04)	(451.05)	5,207.67
1960	73,001.87	(2,445.86)	(439.95)	4,949.85
1961	74,373.97	(2,740.73)	(697.11)	4,793.99
1962	76,710.32	(3,357.75)	(1,249.94)	4,413.67
1963	75,832.04	(3,341.74)	(1,258.06)	4,340.69
1964	114,054.70	(5,331.45)	(2,197.51)	6,223.26
1965	110,532.69	(5,332.48)	(2,295.31)	5,865.43
1966	107,730.95	(5,157.97)	(2,197.78)	5,756.10
1967	101,568.39	(5,713.44)	(2,922.59)	4,576.31
1968	101,106.42	(6,045.65)	(3,267.49)	4,197.30
1969	93,133.68	(5,951.31)	(3,392.23)	3,483.93
1970	87,447.84	(6,541.37)	(4,138.52)	2,317.85
1971	115,111.21	(8,033.12)	(4,870.14)	3,628.64
1972	121,395.17	(7,607.67)	(4,272.03)	4,690.70
1973	239,467.92	(10,203.47)	(3,623.47)	14,056.68
1974	713,399.88	(24,907.35)	(5,304.86)	47,366.18
1975	708,383.56	(16,208.35)	3,256.30	55,556.97
1976	717,854.94	(16,500.85)	3,224.05	56,224.00
1977	802,217.38	(18,297.18)	3,745.80	62,974.32
1978	742,623.13	(16,032.70)	4,372.77	59,201.38
1979	1,144,123.63	(29,013.55)	2,424.18	86,895.98
1980	1,709,050.38	(33,911.98)	13,048.55	139,229.47
1981	1,906,609.75	(34,788.37)	17,600.62	158,367.53
1982	2,014,999.75	(13,588.65)	41,778.63	190,548.09
1983	1,859,640.38	(6,493.59)	44,604.80	181,903.91
1984	3,153,399.75	(1,559.03)	85,088.70	317,907.38
1985	3,065,309.50	7,093.42	91,320.66	317,635.53

$u_t = u(a15)$ and $N_t = N(a15) = u(a15)*q_t$ as in Table 4.4-1

Q_E is the stock targeted for exports 'assuming the ratio of the domestic utilisation of the resource to foreign utilisation remains constant'. Data derived from the data in Appendix A.

Table 5.4-2: Sefton and Weale adjustment, imputed value to the stock targeted for exports. Mexico 1935-1985

Year	$V_t=u_tQ_E$	$-N_t+V_t(i/1+i)$		
		i=3%	i=6%	i=15%
1935	1,997.75	(55.78)	(0.89)	146.61
1936	1,657.15	(56.27)	(10.73)	111.62
1937	2,045.39	(133.37)	(77.17)	73.84
1938	945.37	(105.67)	(79.69)	(9.89)
1939	911.49	(81.09)	(56.04)	11.26
1940	689.32	(61.47)	(42.53)	8.36
1941	402.57	(71.60)	(60.54)	(30.81)
1942	170.28	(56.68)	(52.00)	(39.43)
1943	52.46	(61.83)	(60.38)	(56.51)
1944	27.18	(43.02)	(42.27)	(40.26)
1945	29.18	(25.66)	(24.86)	(22.71)
1946	101.56	(66.57)	(63.78)	(56.29)
1947	114.33	(92.27)	(89.13)	(80.69)
1948	1,198.39	(271.46)	(238.53)	(150.05)
1949	975.66	(383.80)	(356.99)	(284.96)
1950	2,319.55	(669.53)	(605.79)	(434.53)
1951	1,686.54	(805.86)	(759.51)	(635.00)
1952	3,766.17	(857.34)	(753.86)	(475.80)
1953	876.51	(631.08)	(607.00)	(542.28)
1954	1,372.45	(917.93)	(880.22)	(778.89)
1955	1,547.23	(952.41)	(909.90)	(795.67)
1956	1,943.57	(1,025.08)	(971.67)	(828.18)
1957	1,419.20	(1,354.38)	(1,315.38)	(1,210.60)
1958	110.97	(1,225.67)	(1,222.62)	(1,214.43)
1959	33.28	(986.72)	(985.80)	(983.34)
1960	228.80	(657.39)	(651.10)	(634.21)
1961	2,608.93	(1,266.56)	(1,194.87)	(1,002.25)
1962	2,930.71	(1,463.29)	(1,382.77)	(1,166.39)
1963	2,646.11	(1,430.65)	(1,357.94)	(1,162.57)
1964	2,607.30	(1,398.58)	(1,326.94)	(1,134.44)
1965	2,071.58	(1,294.64)	(1,237.72)	(1,084.77)
1966	2,566.76	(1,137.62)	(1,067.09)	(877.59)
1967	2,081.27	(1,124.80)	(1,067.61)	(913.95)
1968	1,516.93	(937.23)	(895.55)	(783.56)
1969	1,574.04	(1,076.00)	(1,032.75)	(916.53)
1970	2,375.19	(980.85)	(915.58)	(740.22)
1971	1,696.81	(1,696.50)	(1,649.88)	(1,524.60)
1972	1,244.49	(2,072.96)	(2,038.77)	(1,946.89)
1973	2,554.10	(4,628.96)	(4,558.78)	(4,370.20)
1974	10,945.76	(23,710.37)	(23,409.60)	(22,601.46)
1975	65,245.06	(30,222.89)	(28,430.12)	(23,613.01)
1976	151,312.21	(46,195.30)	(42,037.61)	(30,866.07)
1977	475,758.31	(87,107.55)	(74,034.88)	(38,909.16)
1978	2,395,112.37	(52,800.94)	13,010.91	189,844.47
1979	4,648,334.08	(74,486.48)	53,238.39	396,429.56
1980	13,943,776.20	(111,270.19)	271,870.78	1,301,353.75
1981	22,541,948.51	(84,283.81)	535,113.94	2,199,408.50
1982	56,838,225.94	(226,271.88)	1,335,503.75	5,531,927.00
1983	147,849,366.55	(122,857.50)	3,939,682.00	14,855,550.00
1984	76,856,905.87	(92,471.75)	2,019,368.50	7,693,791.50
1985	260,638,189.67	(556,921.00)	6,604,780.50	25,847,960.00
1986	259,935,103.18	(277,008.50)	6,865,374.00	26,056,646.00
1987	726,356,555.59	(2,079,234.00)	17,879,274.00	71,506,912.00
1988	918,474,382.47	(3,278,902.00)	21,958,532.00	89,770,424.00
1989	822,735,404.02	(17,498,832.00)	5,107,928.00	65,851,312.00

$u_t=u(a6)$ and $N_t=N(a6)=u(a6)*q_t$ as in Table 4.4-2

Q_E is the stock targeted for exports 'assuming the ratio of the domestic utilisation of the resource to foreign utilisation remains constant'. Data derived from the data in Appendix A.

Mexico exported negligible amounts of oil until the mid-1970s consequently the expected gains from trade are very small and do not compensate the loss of the exhaustible resource until well into the 1970s as reported in Table 5.4-2. Accordingly, for the years in which Mexico restricted its oil exports, the adjustment to its conventional income in this model is negative and very similar to the adjustment produced by the net income price (which imputes no income at all to the reserves).

It must be noticed that the value of the adjustment depends highly on the rate of interest used in its computation, particularly in the case of Venezuela where the rate of return also affects the sign of the adjustment. The sensitivity analysis assumed three alternative rates of interest 3, 6 and 15 per cent. At low interest rates Venezuelan expected gains from trade do not suffice to compensate for the loss of exhaustible resources, thus the adjustment is negative. At high interest rates the expected gains from trade exceed the loss of natural capital and the resulting adjustment is positive. If we believe that 6 per cent is a reasonable interest rate over the twentieth century then, as predicted by Sefton and Weale, the adjustment takes positive and negative values at different points in time.

Sefton and Weale do not explain what are the implications for the resource exporter of having a positive or a negative adjustment, except that their adjustment to the NNP of the resource exporter is far less severe than the net price adjustment.[38] However, since their definition of income (welfare income) is expressed entirely in terms of future consumption, a negative adjustment to conventional income could be interpreted as indicating that the future consumption prospects of the economy are worse than the conventional net income indicates. Per contrary, a positive adjustment would indicate that the weighted average of future consumption (that is welfare income) is larger than the conventional national accounts suggests. Sefton and Weale do not specify whether a negative adjustment (conventional income > welfare income) implies that the country is actually consuming above the trajectory chosen by a rational utility-maximising consumer (above what would be optimal) and whether this indicates that actual consumption would decline in the future. What is clear is that welfare income can be both greater and smaller than conventional national income depending on the rate of discount used.

The results of this model seem to indicate a preference of methodology depending on the actual use given to the resource. For a pure resource exporter, such as Venezuela,

[38] J.A. Sefton and M.R. Weale, 'The net national product and exhaustible resources' (1996) p.43.

the user costs as proposed by El Serafy would be preferred over the net price. For an oil producer that uses the resource entirely for domestic production, such as Mexico during the period 1938-1970s, the net price will be preferred over the user costs method. A direct implication of Sefton and Weale's approach is that an oil producer receives no benefit from owning a vast reserve of an exhaustible resource unless the country plans to export the resource. While the net price adjustment imputes an income to none of the stock, the user costs imputes an income to the whole of the stock and Sefton and Weale impute an income only to the exportable part of the stock.

Finally, Sefton and Weale rely on the optimal behaviour of rents over time. The sensitivity of the adjustment to the rate of return is a consequence of the fact that the expected gains from trade in this model arise from the application of Hotelling's rule. It has been noted earlier in the thesis that Hotelling's rule does not represent accurately the historical evolution of prices (and rents). Dropping this assumption and taking the historical data on exports (rather than keeping the proportion of exports to production fixed) and the historical rents produces very different results as it happened with El Serafy's method in the previous section.

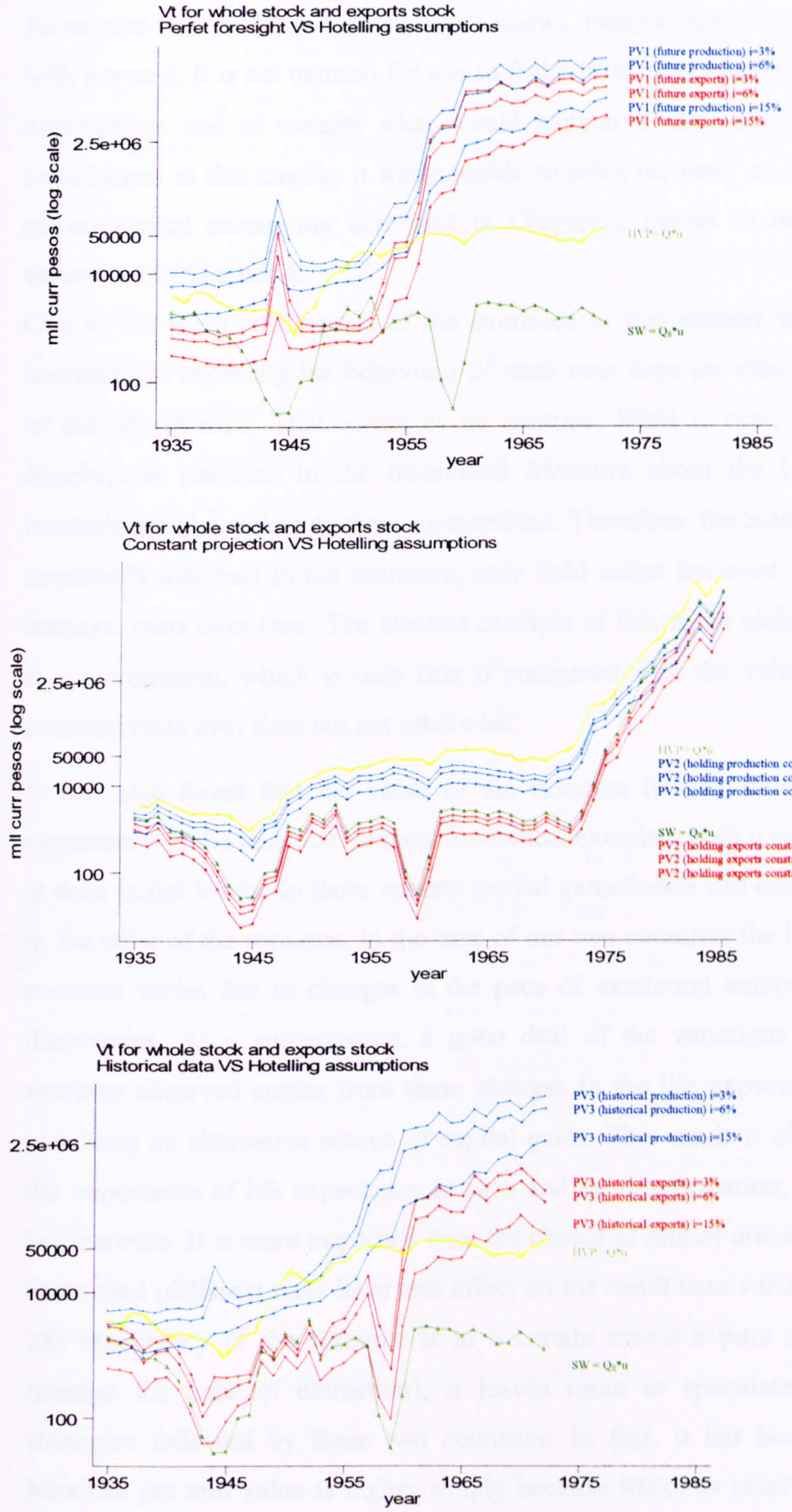
Figures 5.4-1 and 5.4-2 demonstrates that the value of the resource assumed in the theoretical models (the middle panel showing HVP, Sefton and Weale and the constant rents assumptions used by El Serafy) differ substantially from the perfect foresight and historical paths (shown in the upper and lower panels). This comparison gives an idea of the deviation between the optimal depletion path assuming no technological change and the historical path that we can assume is technologically determined. In the case of Sefton and Weale's model this fact induces to question the empirical influence of the gains from trade in our historical cases. Chapter 6 returns to these issues.

[39] Ibid, p.31.
[40] Ibid, p.34.

Figure 5.4-1: The value of the resource: Total stock versus export stock valued at optimal versus technologically determined paths. Venezuela 1920-1989

Sources: PV1, PV2 and PV3 defined in Table 5.2-1, values for the total stocks as in Table 5.2-2, values of the export stock calculated from Appendix A data.

Figure 5.4-2: The value of the resource: Total stock versus export stock valued at optimal versus technologically determined paths. Mexico 1935-1985



Sources: PV1, PV2 and PV3 defined in Table 5.2-1, values for the total stocks as in Table 5.2-3, values of the export stock calculated from Appendix A data. 'SW' refers to Sefton and Weale results.

5.5 Concluding remarks

As anyone who performs applied works knows, many assumptions are made in coming with answers. It is not unusual for one to feel a little uncomfortable with some of these assumptions and to wonder what would happen if they could be relaxed. In the calculations in this chapter it was possible to relax the most common assumptions of environmental accounting described in Chapter 2 thanks to the historical data set assembled in Chapter 4.

One of the main conclusions of the exercises in this chapter is that the underlying assumptions regarding the behaviour of rents over time are crucial to the actual level of the adjustments. That comes as no surprise. What is new, however, is that the conclusions obtained in the theoretical literature about the bias of the different methods are also linked to these assumptions. Therefore, the biases of the methods, as commonly assumed in the literature, only hold under the most restricted scenario of constant rents over time. The clearest example of this is the claim that the HVP leads to overvaluation, which is only true if compared with the valuation obtained using constant rents over time but not otherwise.

It was also found that the value of the resource is very much related to the life expectancy of the resource. In most theoretical exercises both n and q are held constant at their initial levels. In those models capital gains/losses can only arise from changes in the price of the resource. In the case of our two countries the life expectancy of the resource varies due to changes in the pace of extraction and/or the finding of new discoveries. As a consequence, a great deal of the variations in the value of the resource observed comes from these changes in the life expectancy of the resource, providing an alternative source of capital gains. This result is clearly exemplified by the importance of life expectancy in each and every calculation; n turns out to be the key variable. It is more important than the choice of rate of discount or the underlying costs used (different rents have less effect on the result than variations in n). Since the life expectancy of the resource is to a certain extent a pure management variable (change the pace of extraction), it leaves room to speculate about the different strategies followed by these two countries. In fact, it has been demonstrated that Mexican per unit value is higher simply because Mexican reserves were expected to last longer, not because they were of better quality nor even more abundant.

The chapter started by stating that the complication in ex post analysis is to distinguish the effects of our inability to anticipate the future accurately from the analytical failure of the models. Through the findings of this chapter it can be argued that the difference between what is expected to happen and what actually did happen is for the most part due to a missing variable, namely technological change, and a misleading assumption, that is increasing scarcity which is at the root of Hotelling's principle. These should serve as a caveat to the recommendations resulting from adjustments based on these models.

The chapter's purpose was to compare the results of the alternative methods thus filling the gap between the considerable progress made towards resolving basic theoretical issues and the lack of agreement on the empirical side about the most appropriate methods for making specific adjustments. Even the most recent attempts of applying environmental accounting do not settle for either the net price or the user cost method.[41] Nevertheless, as a result of adopting the theoretical arguments spelt out by Sefton and Weale, it is possible to establish that the net price and the user cost are not competing methods as such, but alternative adjustments to different scenarios. While the net price is the correct adjustment for closed economies, open economies need to impute an income to the stock targeted for exports; in the case of a pure resource exporter the user costs approximates this result quite reasonably as the results for Venezuela in Section 5.4 have shown. This suggests a different type of adjustment for each of our two case studies. Since Mexico resembles the closed economy for the period 1938-1970s and Venezuela the pure resource exporter during the 20th century, the net price should be the method used to the adjustment of Mexican national accounts for the aforementioned period, whereas the user costs should be used for Venezuela. In fact, implementing the methodology proposed by Sefton and Weale avoids having to switch from one method to another when Mexico changed its policy in the 1970s, since their method is able to capture the change in policy.

These results are carried forward to Chapter 6 in order to see how the adjustments calculated here change the estimates of income of the cases studied. The caveats introduced by the discrepancies between the assumptions of the model and the actual evolution of rents, production, exports and the terms of trade shall not be forgotten there.

[41] See for instance, E. Newmayer, , 'Measuring Genuine Savings: Are Most Resource-extracting Countries Really Unsustainable?', in Munasinghe, M., O. Sunkel and C.d. Miguel (eds.), *The Sustainability of Long-term Growth. Socioeconomic and Ecological Perspectives* (Cheltenham, UK, 2001), pp.422-443; A.C.Hansen, 'Estimating Non-renewable Resource Capital Consumption', in Munasinghe, M., O. Sunkel and C.de Miguel (eds.), *The Sustainability of Long-term Growth* (Cheltenham, UK, 2001), pp.397-421, or the recommendations made in W.D. Nordhaus, and E.C. Kokkenlenber (eds.), *Nature's Numbers: Expanding the U.S. National Economic Accounts to Include Environment* (Washington D.C., 1999).

'As will be clear for the reader of this report, the indicator arena is full of interesting and challenging issues. It is also obvious that much of the work is in its infancy. Many of the results presented here are initial efforts at estimating indicators and are offered in the spirit of transparent exchange of research results and thinking. We hope to provoke dialogue and to advance both the methodologies used and the policy applications of indicators for sustainable development'[1]

Chapter 6

Measuring the Illusion of Oil Wealth: Venezuela and Mexico 1920s-1980s

Inasmuch as Chapter 5 can be considered as the contribution of economic history to environmental accounting, this last chapter can be considered as the contribution of environmental accounting to economic history. The chapter achieves this in three ways. Firstly, by looking at the effects of correcting gross measures by the use of oil resources, and the implications of such adjustment for economic performance and growth. Secondly, by asking whether Venezuela and Mexico were living beyond their means and examining the variables that supported consumption through out the twentieth century. Thirdly, by re-evaluating the arguments proposed by the historiography presented in Chapter 3, using the quantitative evidence produced in the thesis.

This chapter answers the main question set in the introduction of the thesis: to what extent do environmental historical national accounts diverge from traditional national accounts? Chapter 2 discussed the three main approaches to the inclusion of natural resources in national accounts. It concluded that only inclusions in the System of National Accounts (SNA) or a restricted use of the System of Integrated

[1] World Bank, *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development*, Vol. 17 (Washington, D.C., 1997), p.3.

Environmental and Economic Accounting (SEEA) are feasible. As it was pointed out in Section 2.2, the adjustment could be done at the GDP or at the net income level within the traditional SNA. Very briefly, the reasoning is as follows. In the view of the United Nations and the World Bank all natural resources are regarded as equivalent to man-made capital. Since net income is GDP minus an allowance made for the deterioration (depreciation) of man-made capital, including estimates of depreciation of natural capital will result in an adjusted net income measure. Nevertheless, in the traditional national accounts, reductions in stock are conventionally subtracted from GDP. Then, if one characterises exhaustible resources as 'stock' rather than 'capital', the adjustment should be done at the GDP level.[2] In this last case, the whole of the rent should be discounted from the GDP. The first section of the chapter implements this adjustment to traditional GDP. It also establishes what effects such adjustment has on the historical performances of Mexico and Venezuela.

Nevertheless, the core of environmental accounting literature opts for the correction of net income. In the second section of this chapter the results of the previous chapters are used to elucidate the main claims of environmental accounting regarding this adjustment. Did traditional indicators exaggerate income? Did traditional indicators encourage unsustainable levels of consumption? The answer to these questions is produced in a sequence of three exercises that connect the findings of the previous chapters:

1. The first exercise computes the genuine savings indicator that was introduced in Chapter 2 as a test for weak sustainability. In the way it was originally formulated, the genuine savings indicator implies the use of the net price method for adjusting the traditional net income. By emphasising the level of genuine savings, we are in effect asking the question: how much of the adjusted income was actually consumed? Or in other words, were Mexico and Venezuela living beyond their means? In this first exercise Venezuela appears to have been living beyond its means for a very long period of time, yet the expected decline in well-being cannot be observed. Hence, the prediction of unsustainability implied by negative genuine savings comes into question.
2. The second exercise considers whether this is explained by the terms of trade effects in open economies. Two alternative analysis are carried out:

[2] Section 2.1 elaborated on the different arguments in favour and against characterising non-renewable resources as either 'capital' or 'stock'.

a) The methodology used is that of Sefton and Weale that takes into account the expected gains in the terms of trade of an oil exporter. This second indicator reverses the view of the previous exercise, showing that Venezuela and Mexico were never consuming beyond their means if the expected gains from the terms of trade are taken into account.

b) The methodology used is that proposed by Nicholson in 1960 for assessing the effect of the actual changes in the terms of trade on national income.[3] This method belongs to the national income literature that adjusts for the terms of trade impact on the measurement of national income.[4] The additions to welfare income due to the historical changes in the terms of trade differ substantially from the expected terms of trade effects derived from Sefton and Weale model resulting in the return of the paradox of negative genuine savings without observable declines in well-being.

3. The third exercise examines the implications of technological change for the genuine savings indicator. From the results in Chapters 4 and 5 we know that technological change, in the form of lower costs and further oil discoveries, has a role to play in the value of the resources. These two factors are explored in the last exercise.

This chapter demonstrates that technological change plays a crucial role in helping Venezuela to enjoy non-declining consumption levels despite consuming most of the rents generated by oil extraction. This is an important finding because while gains from trade have now been included in some environmental accounting models (for instance, Sefton and Weale), technological change has been left out.

The third section of the chapter is dedicated to the re-evaluation of some of the arguments proposed in the historiography using the quantitative evidence produced in the thesis. Chapter 3 demonstrated that Mexican and Venezuelans of different epochs used arguments that can be linked to the literature of environmental accounting, such as 'due to the nature of oil revenues an increasing gap opened between the real production capacity and its earning and expenditure possibilities' or 'after decades of consuming more than they produced, to restore balance, Venezuelans' real incomes

[3] J.L.Nicholson, 'The Effects of International Trade on the Measurement of National Income', *Economic Journal* 70 (1960) 279, pp.608-612.

[4] A summary of the many attempts can be found in P. Gutman, 'The Measurement of Terms of Trade Effects', *Review of Income and Wealth* 27 (1981) December, pp.433-453. The work of Gutman does not include the later attempt by K. Hamada and K. Iwata, 'National Income, Terms of Trade and Economic Welfare', *The Economic Journal* 94 (1984) 376.

and consumption would have to decline'.[5] The claims of the contemporaries were mostly supported by qualitative rather than quantitative evidence. The calculations of this chapter help to fill this quantitative gap. Also, the Mexican claims regarding the internal use of the resource such as, 'our effort should lead towards consuming in the country all the oil we produce; wasting not a single drop; we can be certain that when we have achieved this ideal, Mexico will be prosperous, important and respected', are qualified in the last section of the chapter.[6]

6.1 Environmental Adjustment to Production

> 'If the marginal cost of extraction is the only cost, then any surplus accruing to the sellers is pure rent but represents value added in the conventional GDP. This certainly corresponds to the accounting practices currently being used under the SNA. Based on these practices, the expansion of economic activity as a consequence of accelerating the liquidation of subsoil assets appears to be good economic performance and is confused with the growth that comes from labour force expansion, capital formation, technological progress, and more efficient organisation. In the case of non-renewable resources the rent should not qualify as value added or national income.'[7]

According to El Serafy, if an income correction is to be made, it should apply to GDP itself; it is not enough to effect the adjustment at NDP level since the whole apparatus of GDP with its structure, input-output relations and changes over time would be incorrectly calculated if revenues from depletable resources are counted as value added in GDP. Adjustment of GDP to exclude oil rents has also been advocated from other parts of the literature not strictly connected to the environmental issues.[8]

Table 6.1-1 carries out an adjustment to the traditional GDP following these arguments. Adjusted GDPs are calculated by deducting from traditional GDP the resource rents. The adjusted measures are compared with the traditional non-oil-GDP that results from deducting the oil sector GDP from the total GDP, which was typically used to confront the bias introduced by oil cash into the national statistics of oil produced countries as explained in Chapter 3.

[5] The first quote belongs to A. Uslar Pietri, 'Los males del petroleo', *El Nacional* (1985) 28th April. The increasing disparity between consumption and production in a country such as Venezuela is also referred by B. Mommer and A. Baptista, 'El Petróleo En Las Cuentas Nacionales: Una Proposicón', *Working Paper IESA* 10 (1983), p.3. The second quotation was taken from M. Naim and A. Pinango (eds.), *El caso Venezuela: una ilusión de armonía* (Caracas, 1974)

[6] J.D. Báez, 'Influencia de la guerra en el petróleo mexicano', *Revista de Industria* 5 (1939 November) 35.

[7] 'In the perception of the classical economist the rent that qualifies as value added derived from the indestructible powers of nature. Such revenue is clearly sustainable where the powers of nature to reproduce it are not impaired, and it can therefore legitimately be counted as income. In the case of non-renewable resources, since they are not reproducible, the rent should not qualify as value added or national income'. S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy, et al. (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989), pp.12-13. Most of this section relies on this same source.

[8] See the references in Chapter 2 to the works of Stauffer, Mommer and Baptista.

The first result of this exercise is that the environmentally adjusted GDPs are larger than the traditional non-oil GDP until the 1970s. GDP minus rents leaves Venezuela with less than 90 percent of traditional GDP from the late 1920s to 1945, and with around 80 percent from that date until the 1970s. There is some 5-percentage points difference compared with the traditional exclusion of the oil sector GDP. In the case of Mexico, the environmental adjustments leave GDP almost intact until the 1970s and are above 99 percent of the traditional GDP excluding the three years before the nationalisation for which data are available and the period 1949-1957. Even in those periods adjusted GDP is never less than 97 percent of traditional GDP.

After the 1970s, when rents increased massively, GDP adjusted by rents becomes smaller than non-oil-GDP. For once, the effect is more dramatic in the Mexican case. Mexico's GDP adjusted by rents is between 90 to 85 percent of the traditional GDP by the late 1970s/early 1980s compared with non-oil-GDP which is still about 96 percent of the traditional GDP at the same date. For Venezuela the correction produced by the rents pushes the adjusted GDP well below 80 percent of the traditional GDP, reaching 62 percent in 1974. At the end of the period, in both countries GDP adjusted by rents is approximately 85 percent of traditional GDP.

All in all, the resource rent adjustments to GDP produce considerable corrections to the level of traditional GDP and the results differ from non-oil-GDP. While non-oil-GDP is an attempt to identify the economic activity that is independent from the oil sector, the environmentally adjusted GDP describes current production including the productive contribution of the oil sector (payments to production factors) but excluding the resource rents.

Table 6.1-1: Environmentally adjusted GDP as percentage of traditional GDP: Venezuela 1920-1985 and Mexico 1935-1985

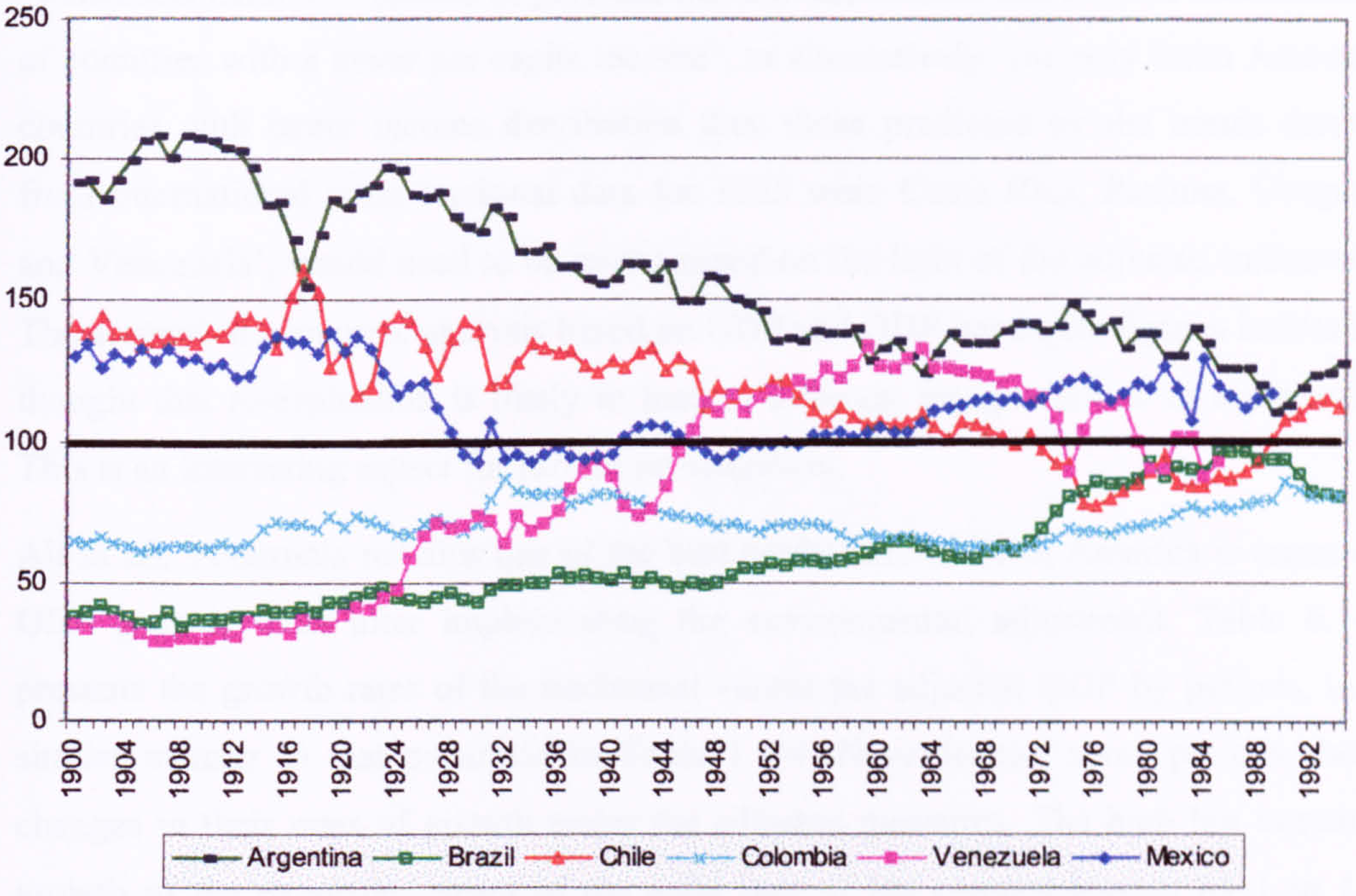
	Venezuela		Mexico	
Year	GDP_{NP}/GDP_{TRAD} %	$NoilGDP/GDP_{TRAD}$ %	GDP_{NP}/GDP_{TRAD} %	$NoilGDP/GDP_{TRAD}$ %
1920	100.4	99.8		
1921	100.5	99.5		
1922	100.4	99.2		
1923	99.6	98.6		
1924	97.8	97.1		
1925	94.9	94.3		
1926	92.6	95.9		
1927	91.6	88.7		
1928	87.0	84.3		
1929	82.0	80.2		
1930	80.8	80.2		
1931	85.4	82.7		
1932	77.6	78.8		
1933	91.1	84.8		
1934	85.2	84.0		
1935	84.5	82.8	97.5	97.4
1936	85.5	82.7	98.0	97.8
1937	87.5	83.4	97.2	97.7
1938	90.9	85.4	98.2	98.2
1939	93.0	86.7	98.6	98.7
1940	92.0	85.7	99.0	98.7
1941	86.9	81.6	99.1	98.7
1942	93.7	86.4	99.4	98.7
1943	91.3	85.1	99.5	98.7
1944	88.4	82.5	99.8	98.9
1945	89.0	83.2	99.9	98.8
1946	88.0	81.2	99.8	98.9
1947	85.9	79.6	99.7	98.8
1948	80.1	74.2	99.1	98.6
1949	83.9	77.7	98.9	98.6
1950	81.4	77.8	98.3	96.9
1951	81.3	77.5	98.4	97.2
1952	80.5	76.5	98.4	97.3
1953	80.4	76.6	98.9	97.3
1954	81.8	78.5	98.7	97.4
1955	80.0	77.4	98.9	97.4
1956	79.4	76.8	98.9	97.5
1957	74.4	71.5	98.8	97.5
1958	82.0	78.7	99.1	97.4
1959	82.7	78.5	99.3	96.8
1960	83.6	78.8	99.6	96.8
1961	84.1	80.3	99.3	96.8
1962	83.0	80.1	99.3	96.9
1963	84.0	81.3	99.3	96.5
1964	77.9	78.0	99.4	96.7
1965	79.7	82.1	99.5	96.8
1966	80.9	80.9	99.6	97.0
1967	81.3	81.3	99.6	96.9
1968	82.0	82.2	99.7	97.0
1969	83.4	83.1	99.7	97.2
1970	84.0	84.8	99.8	97.3
1971	81.8	84.2	99.6	97.5
1972	83.5	85.4	99.6	97.6
1973	78.3	81.5	99.3	98.0
1974	62.2	70.6	97.3	97.5
1975	71.5	77.3	97.1	97.5
1976	75.1	80.0	96.3	97.5
1977	76.4	82.0	94.5	96.8
1978	80.4	84.7	94.8	96.7
1979	73.1	80.9	93.2	97.2
1980	70.4	78.4	87.9	98.1
1981	71.6	79.4	87.4	96.2
1982	78.1	83.8	80.0	96.8
1983	81.4	85.9	74.2	94.5
1984	76.2	82.6	91.9	95.6
1985	81.0	86.8	82.8	96.5

Sources and notes: elaborated from data in Appendix D for traditional indicators (GDP_{trad} and NoilGDP). GDP_{NP}: GDPtrad minus the resource rents. Rents are from Section 4.4. The GDP_{NP} presented here corresponds to the traditional GDP minus *N(a)15* for Venezuela and *N(a)* for Mexico.

Effects on Performance and Growth

This section looks at the effects of the adjustment to GDP on the positions of Mexico and Venezuela relative to other economies (especially to non-oil producers) and to the growth rates of each economy. Figure 6.1-1 shows the index of GDP per capita of six Latin American countries after implementing the environmental adjustment to the GDP of Mexico and Venezuela.

Figure 6.1-1: Index GDP per capita of six Latin American countries after environmental adjustments were carried on for Mexico and Venezuela, 1900-1994



Sources and notes: as Figure 1.2-1 for Argentina, Brazil, Chile and Colombia. For Venezuela and Mexico, the traditional GDP was substituted by environmentally adjusted GDP (net price method) as in Table 6.1-1. The series were converted to 1980 international dollars using the implicit deflator and PPP obtainable in A.A., Hofman, *The Economic Development of Latin America in the Twentieth Century* (Cheltenham, UK, 2000).

The adjustments applied to traditional GDP in Mexico and Venezuela affect the average GDP per capita of the region only slightly, and only for a few years in the 1980s is the adjusted average smaller than the traditional average by more than 5 percentage points. It was shown in Chapter 1 that Venezuela started the century with the lowest traditional GDP per capita of the six largest Latin American countries but by the 1950s it had surpassed them (see Figure 1.2-1). Venezuelan GDP per capita is much more similar to that of its neighbours after the implementation of the environmental adjustment. In fact, the gap with the average Latin American GDP per capita per capita halves from 50 percent higher to 25 percent higher in the years between 1950 and the late 1960s. As would be expected, the effects on the relative position of Mexico are only appreciable from the 1970s and particularly from 1980. In the traditional view (see Figure 1.2-1), Mexico had the highest GDP per capita of the six countries by a good margin in the 1980s. After the environmental adjustment is implemented Mexico falls to second place.

If these adjustments to GDP were taken into account, many statements based on the comparative levels of GDP would need to be re-examined. Statements such as 'Venezuela exhibits a pattern of personal income distribution that is more characteristic of countries with a lower per capita income', or alternatively 'the only Latin American countries with better income distribution than those predicted by the trends derived from international cross-sectional data for 1965 were Costa Rica, Panama, Uruguay, and Venezuela', would need to be re-examined on the light of the adjusted indicators.[9] The amount of economic analysis based on GDP and GDP per capita figures invites the thought that re-evaluation is likely to lead to different interpretations in some areas. This is an interesting aspect for further investigation.

All in all, Venezuela remains one of the best performers of Latin America in terms of GDP growth, even after implementing the environmental adjustment. Table 6.1-2 presents the growth rates of the traditional versus the adjusted GDP by periods, in a similar manner to that presented in Table 1.1-4. Nevertheless, some periods show changes in their rates of growth under the adjusted measures. The high but unstable growth of the export-led years of the early part of the century lessens by 1 to 1.5 percentage points when adjusted. Similar results would be expected for Mexico, but there is insufficient data to calculate the rents. These are the years in which the divergence between traditional and environmental indicators commences. For Venezuela, the levels of the traditional and environmentally adjusted GDP run mostly parallel to each other until the oil boom when the gap widen considerably. As a consequence, the growth rates of both series are very similar. For Mexico, since the adjustment needed from the nationalisation of the oil industry onwards is very small, the effects on the growth rates are negligible too.

[9] The first statement belongs to P.P. Kuczynski, 'The Economic Development of Venezuela: a Summary view as of 1975-1976', in Bond (ed.), *Contemporary Venezuela and its role in international affairs* (New York, 1977), p.49, the second one to H. Chenery, and M. Syrquin, *Patterns of Development 1950-1970* (London, 1975) as quoted by M. Urrutia, 'Twenty-Five Years of Economic Growth, 1960-1985', in Urrutia (ed.), *Long-Term Trends in Latin American Economic Development* (Inter-American Development Bank, Washington D.C., 1991), who in addition argues that 'the Venezuelan data show increasing equality from the late 1950s until 1983 and better income distribution than that found in the other large Latin American countries', p.57.

Table 6.1-2: Rate of growth of six Latin American countries. GDP vs. environmentally adjusted GDP. (Average annual compound rate)

	1913-1929		1929-1950		1950-1973		1973-1980		1980-1985		1900-1985	
	GDP_{trad}	GDP_{NP}	GDP_{trad}	GDP_{NP}	GDP_{trad}	GDP_{NP}	GDP_{trad}	GDP_{NP}	GDP_{trad}	GDP_{NP}	GDP_{trad}	GDP_{NP}
Argentina	3.5		2.5		4.0		3.0		-2.0		3.5	
Brazil	4.7		5.0		6.9		7.2		1.3		5.3	
Chile	2.9		2.2		3.6		2.8		-0.4		2.8	
Colombia	4.7		3.6		5.1		5.0		2.2		4.4	
Mexico	**0.8**	**n.a**	**4.0**	**3.9**	**6.5**	**6.6**	**6.4**	**4.6**	**1.9**	**0.8**	**3.9**	**3.7**
Venezuela	**8.2**	**6.8**	**5.9**	**5.9**	**6.4**	**6.3**	**4.1**	**2.5**	**-1.3**	**1.5**	**5.5**	**5.2**

Notes and sources:

GDP_{trad} - Calculated from A.A. Hofman, *The Economic Development of Latin America in the Twentieth Century* (Cheltenham, UK, 2000), pp. 156-157.

GDP_{NP} - Growth rates of the GDP adjusted by rents.

Growth rates are comparable since the adjusted measures were transformed to the units used by Hofman (Ibid.), i.e. 1980 international dollars using his implicit deflator and PPPs.

The real changes for both countries appear after the oil shock. During the period 1973-1980, Venezuela's GDP growth rate almost halves from 4.1 to 2.5 percent, while Mexico's experiences the biggest reduction of all the sub-periods considered, from 6.4 to 4.6 percent. This result is expected. In general, environmentally adjusted GDP showed slower growth than conventional GDP during the 1970s.

It was said in Chapter 1 that both countries experienced substantial declines in GDP during the first half of the 1980s. Nevertheless, the growth of environmentally adjusted GDP for Venezuela is positive for those years. How can this result arise? The scale of the rents generated in 1974 and 1979 affect the adjusted measures, making the series much more erratic than the traditional indicators. This does not imply that the adjusted indicators erase the crisis of the early 1980s but they indicate a different timing. The adjusted indicators begin declining in real terms already in the late 1970s and 1980 is the trough from which indicators start to grow again. For the period 1978-1985, the growth rate resulting from the adjusted indicators ranges between –0.9 and –0.5 percent, compared to –1.0 percent as traditionally measured. Therefore, according to the environmentally adjusted GDP, the 1980s crisis had already started in the late 1970s. The notion that 'the Venezuelan economic model was exhausted even before the oil boom' can be found in the literature of the 1990s. In that sense, this result confirms this view that oil wealth obscured an underlying economy in crisis.[10]

The results of Figure 6.1-1 and Table 6.1-2 need some qualification. It is likely that environmental accounting will also be relevant to other countries portrayed in the comparison. Examples include the Brazilian rainforest and mining or the Argentinean pampas and petroleum production. The relative positions sketched in Figure 6.1-1 and the growth rates of Table 6.1-2 are likely to vary if the environmental adjustment is applied to the rest of countries.

Considering that environmental accounting claims that traditional national accounting generated an illusion of rapid growth, the environmental adjustment yields surprisingly small modifications to the traditional growth rates, particularly to those of Venezuela. The explanation lies, as noted above, in the fact that the environmental adjustment represents about 20 percent of the traditional GDP for most of the century, only reaching higher proportions from the 1970s onwards. As a consequence, the traditional and the environmentally adjusted GDP series run parallel to each other and their

[10] See, for example, M. Naim, *Paper, Tigers and Minotaurs. The politics of Venezuela's Economic Reforms* (Washington, D.C., 1993); O.A. Echevarría, *La economía venezolana, 1944-1994* (Caracas, 1995) and F. Coronil, *The magical state: Nature, money, and modernity in Venezuela* (Chicago and London, 1997).

growth rates are very similar. For Mexico, since the adjustment needed from the nationalisation of the oil industry onwards is very small, the effects on the growth rates are also very small for the period 1938-1974.

This section has explored one of the two proposed adjustments to national accounts for taking into account environmental depletion, namely, the adjustment of the GDP. Interpreting these results in the light of the opening quote of this section, the level adjustment of Table 6.1-1 provides a measure of the amounts by which the expansion of economic activity in Mexico, and especially in Venezuela, has been a consequence of accelerating the extraction of subsoil assets. It showed that, as expected, the levels of GDP of Venezuela experience a significant reduction once oil depletion is taken into account, while those of Mexico remain almost untouched until after the 1970s. This has effects on the positions of the two countries relative to other economies. In relation to the growth rates, it seems that the growth that comes from labour force expansion, capital formation, technological progress, and more efficient organisation have also been significant in Venezuela and Mexico. The growth rates do not change substantially when the resource rent is excluded from the product measures. Venezuela remains the best performer in Latin America, although its rates of growth for the periods 1913-1929 and 1973-1980 are slightly reduced. Only the timing of the 1980s crisis seems to be brought forward under the adjusted indicators. Nevertheless, these results are only tentative since the application of the environmental adjustment to other nations portrayed in the comparison will surely be relevant.

In any case, it was mentioned in Chapter 2 that gross measures do not indicate whether the nation is either building up or living off its capital. As a consequence, the environmentally adjusted GDP does not do any better than the traditionally computed GDP at the time of identifying whether the economy is on a path towards prosperity or extinction, whether it is sustainable or not. For that purpose, the analysis of net income is needed.

6.2 Living Beyond Their Means?

From the discussion in the previous chapters it is clear that the core of environmental accounting relates to the correction of net income measures. In this section the results of the previous chapters are used to elucidate the main claims of environmental accounting regarding this adjustment. Did traditional indicators exaggerate income? Did traditional indicators encourage unsustainable levels of consumption? The answer to these questions is produced in a sequence of three exercises that connect the findings of the previous chapters:

1. The first exercise computes the genuine savings indicator that was introduced in Chapter 2 as a test for weak sustainability. In the way it was originally formulated, the genuine savings indicator implies the use of the net price method for adjusting the traditional net income. By emphasising the level of genuine savings, we are in effect asking the question: how much of the adjusted income was actually consumed? Or in other words, were the countries living beyond their means?
2. The second exercise examines in two alternative ways the role of the terms of trade in modifying the standard sustainability indicator in open economies:
    a) Using the methodology of Sefton and Weale (imputed income method) that takes into account the expected capital gains from trade for the adjustment of net income.
    b) Using one of the methodologies proposed in the national income literature for assessing the effect of the actual changes in the terms of trade on national income.
3. The third exercise examines the implications of technological change for the standard genuine savings indicator through cost reduction and through new discoveries.

This section demonstrates that technological change has a crucial role in helping Venezuela to continue to enjoy non-declining consumption levels despite consuming most of the rents generated by oil extraction. This is an important finding because while gains from trade have now been included in some environmental accounting models, technological change is left out.

The exercises of this section are restricted by the availability of traditional macro-economic data. In particular, the short series on national income (NNP) bring forward the starting year of the analysis to 1936 for Venezuela and to 1950 for Mexico. This does not affect the main thrust of the argument.

The Standard Sustainability Indicator: Genuine Savings

The traditional measure of a nation's rate of accumulation of wealth is gross saving. This is calculated as a residual: GNP minus public and private consumption. Gross saving represents the total amount of produced output that is set aside for the future. Gross savings rates can say little about the sustainability of development, however, because productive assets depreciate through time: if this depreciation is greater than gross saving, then aggregate wealth is in decline. Net saving, total gross saving less the value of depreciation of produced assets, is one step closer to a sustainability indicator, but focuses narrowly on produced assets. It has been already mentioned that if the equivalence between man made capital and natural capital stands, a country's consumption may be mainly supported by draining natural resources, i.e. from the depreciation of natural capital. By also subtracting the depreciation of natural capital we arrive to the concept of 'genuine savings'.[11] From this concept derives the sustainability indicator already presented in Chapter 2 that can be expressed in the form[12]

$$Z = \frac{S}{Y} - \frac{\delta_M K_M}{Y} - \frac{\delta_N K_N}{Y} \qquad [6.2\text{-}1]$$

where S is gross savings, $\delta_M K_M$ and $\delta_N K_N$ are man-made capital and natural capital depreciation respectively and Y is total output in the economy. According to its authors, Z 'is an intuitive zero-order rule for determining whether a country is on or off a sustainable development path at any one point in time. The value of Z must be either zero or positive to ensure sustainability.'[13]

By emphasising the level of genuine savings, we are in effect asking the question: how much of the adjusted income was actually consumed? The Z indicator can actually be re-expressed in the following terms: [14]

$$Z = \frac{NNP_{adj} - C}{Y} \qquad [6.2\text{-}2]$$

where NNP_{adj} is the environmentally adjusted net income and C is the sum of public

[12] It is worth emphasising that Z is an indicator of 'weak' sustainability. It assumes substitution possibilities between the component parts of capital. It is therefore possible to run down the stock of natural capital provided that the proceeds are reinvested.

[13] D.W. Pearce and G. Atkinson, 'Measuring Sustainable Development', in Bromley (ed.), *Handbook of environmental economics* (Cambridge, MA, 1995).

[14] Gross savings are GNP minus consumption. Net savings are gross savings minus depreciation of physical capital, which can also be expressed as $(GNP - \delta_M K_M) - C = NNP - C$. Subtracting natural capital depreciation from these net savings we arrive to genuine savings, $NNP - \delta_N K_N - C = NNP_{adj} - C$.

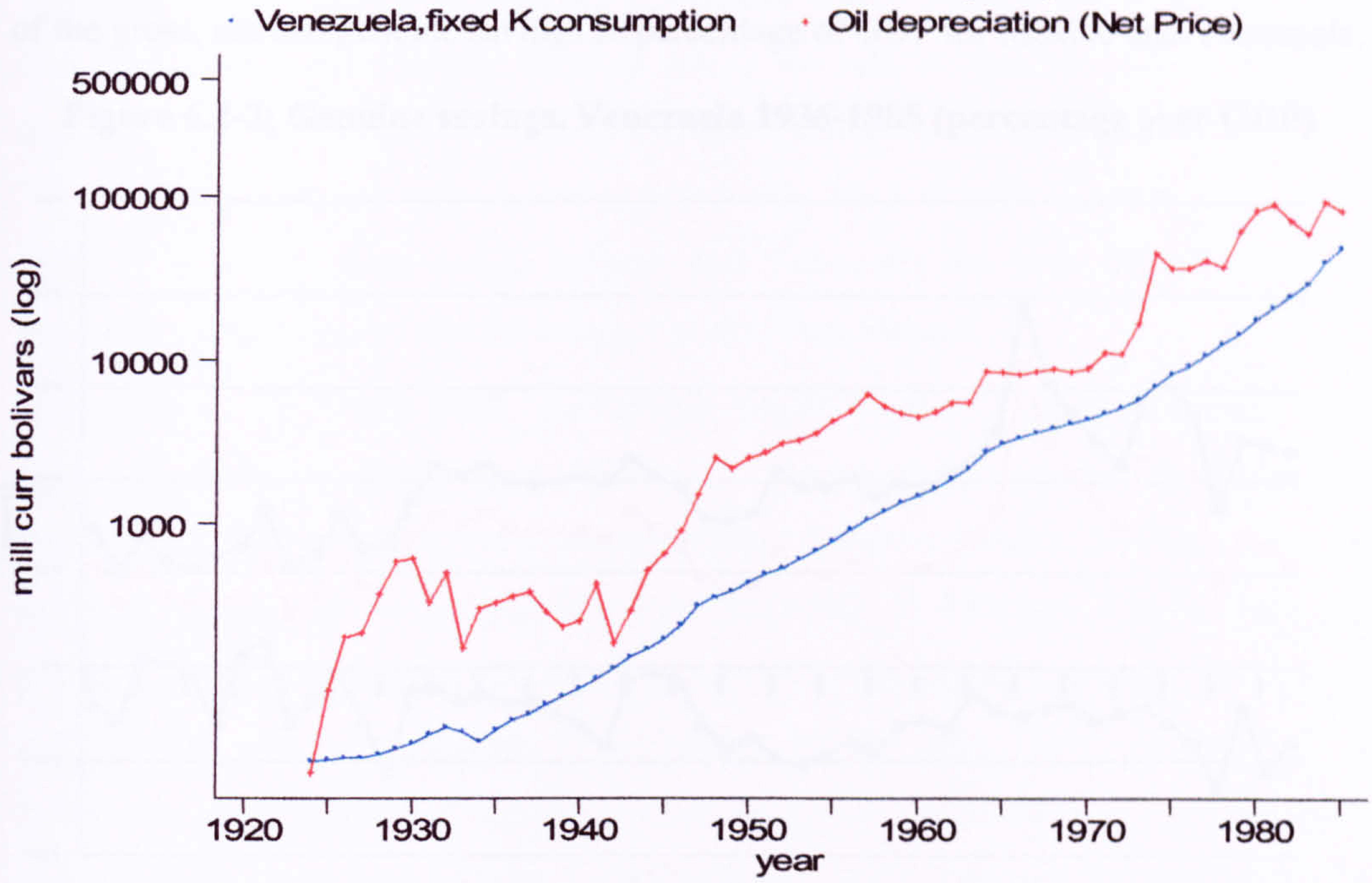
and private consumption. Observe that, in the way it was originally formulated, the genuine savings indicator implies the use of the net price method for adjusting the traditional NNP.

It should be noted that $\delta_M K_M$ is quite large compared with most of the net balancing items in the national accounts. It is, on average, the largest adjustment to conventional national accounting measures. Its mean is more than 10 percent of mean GNP and nearly 60 percent of mean gross savings.[15] Figures 6.2-1 and 6.2-1 compare the sizes of the man-made capital depreciation ($\delta_M K_M$) as recorded in the traditional accounts, with the measure of natural capital depreciation ($\delta_N K_N$) implied by the genuine savings indicator, that is N_t.

Natural resource depreciation –approximated by the depreciation of oil resources- is larger than physical capital depreciation throughout the period studied in the case of Venezuela. For Mexico the scale of the natural depreciation cannot be dismissed from the 1970s onwards. Prior to that date the level of natural capital depreciation for Mexico was of the order of 1.5 percent of traditional GDP. At least two caveats are required in relation to this comparison. First, it is worth bearing in mind that the natural capital depreciation estimates calculated here are only considering a single natural resource, i.e. oil. It is the resource that generated the greatest rents and therefore the greatest depreciation during the century, but the depreciation of other natural resources should ideally be also accounted for (consider, for instance, natural gas). Therefore, the figures shown here underestimate natural depreciation. In the second place, the comparison should be regarded with caution since the historical estimates of consumption of fixed capital are feeble as noted in Appendix D, especially in the case of Mexico. All in all, however the message from Figures 6.2-1 and 6.2-2 is clear: natural depreciation is by no means negligible.

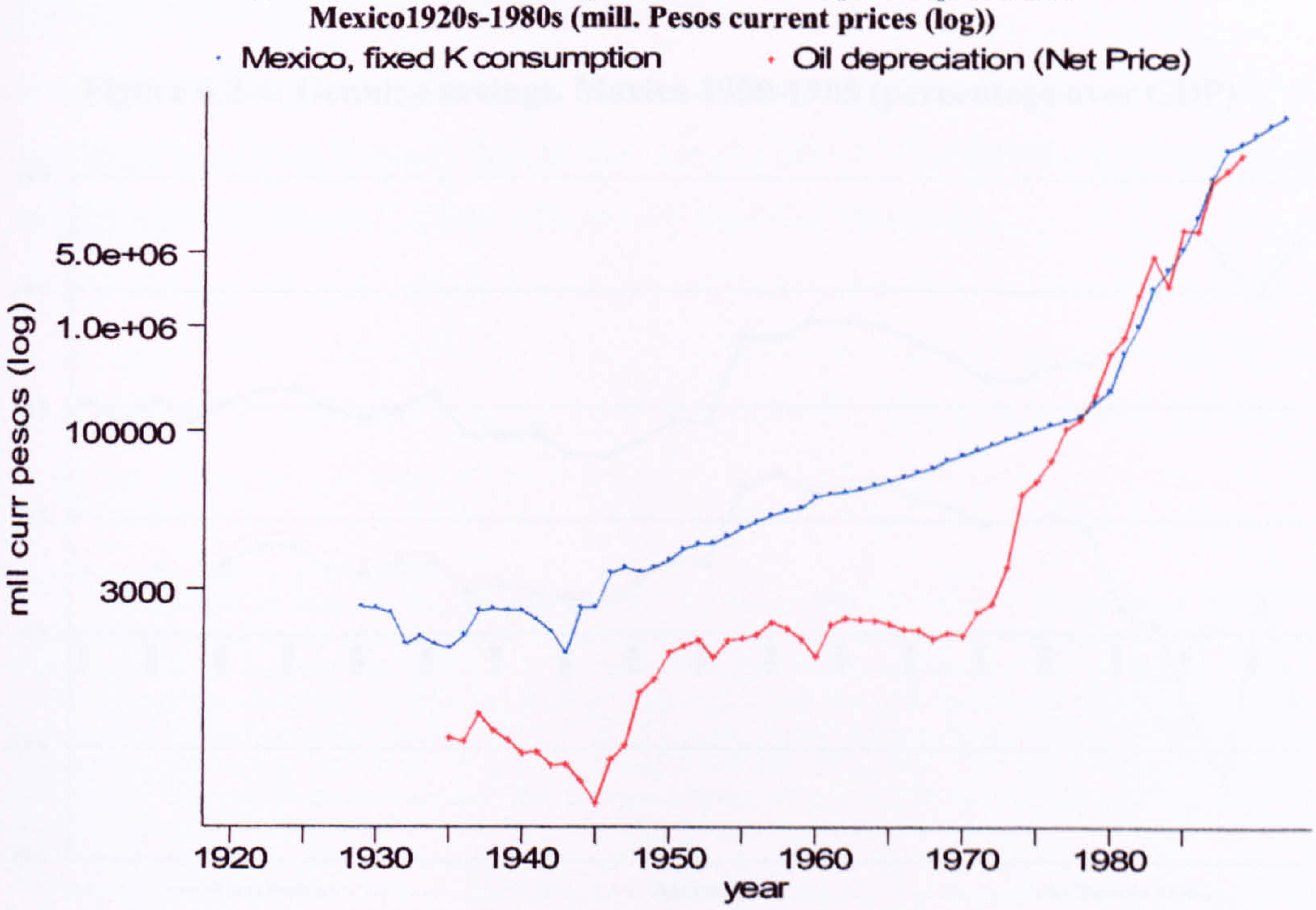
[15] United Nations, *System of National Accounts 1993* (New York, 1993), paragraph 6.201. Precisely for that reason it has been considered sufficient to carry on the adjustments on this section over NDP rather than to the NNP. Historical data for the reconstruction of the NDP (simply GDP less the depreciation allowance) are available, whereas for the complete recreation of the historical NNP the rest of data needed (net remittances from labour and capital to other nations, indirect taxes and subsidies) are not.

Figure 6.2- 1: Man-made capital VS natural capital depreciation.
Venezuela 1920s-1980s (mill. Bolivars current prices)



Notes and sources: Own elaboration from the fixed capital consumption ($\delta_M K_M$) data sources in Appendix D and natural capital depreciation $\delta_N K_N = N(a)15$ as calculated in section 5.1.

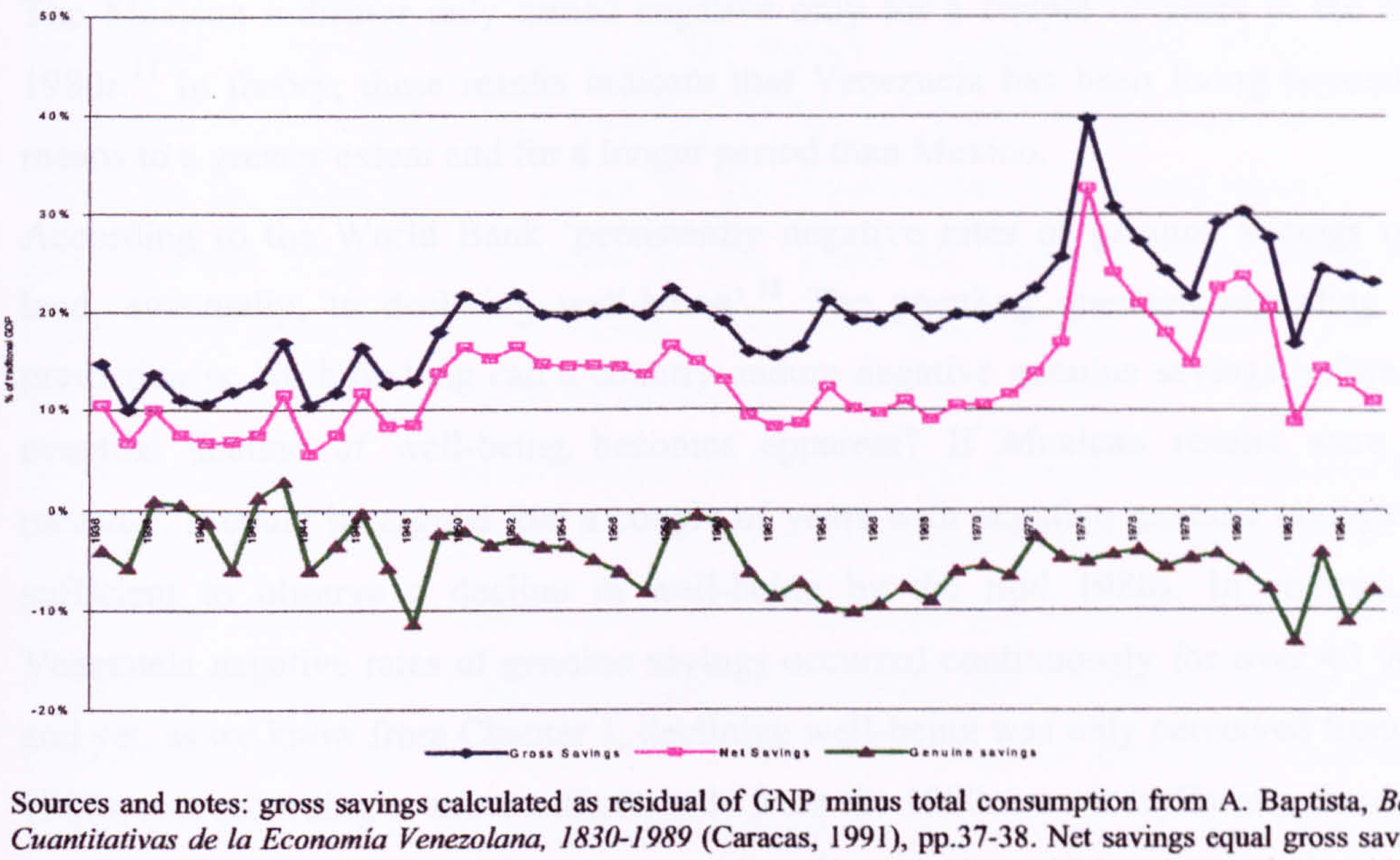
Figure 6.2-2: Man-made capital VS natural capital depreciation.
Mexico1920s-1980s (mill. Pesos current prices (log))



Notes and sources: Own elaboration from the fixed capital consumption ($\delta_M K_M$) data sources in Appendix D and natural capital depreciation $\delta_N K_N = N(a6)$ calculated in Section 5.1

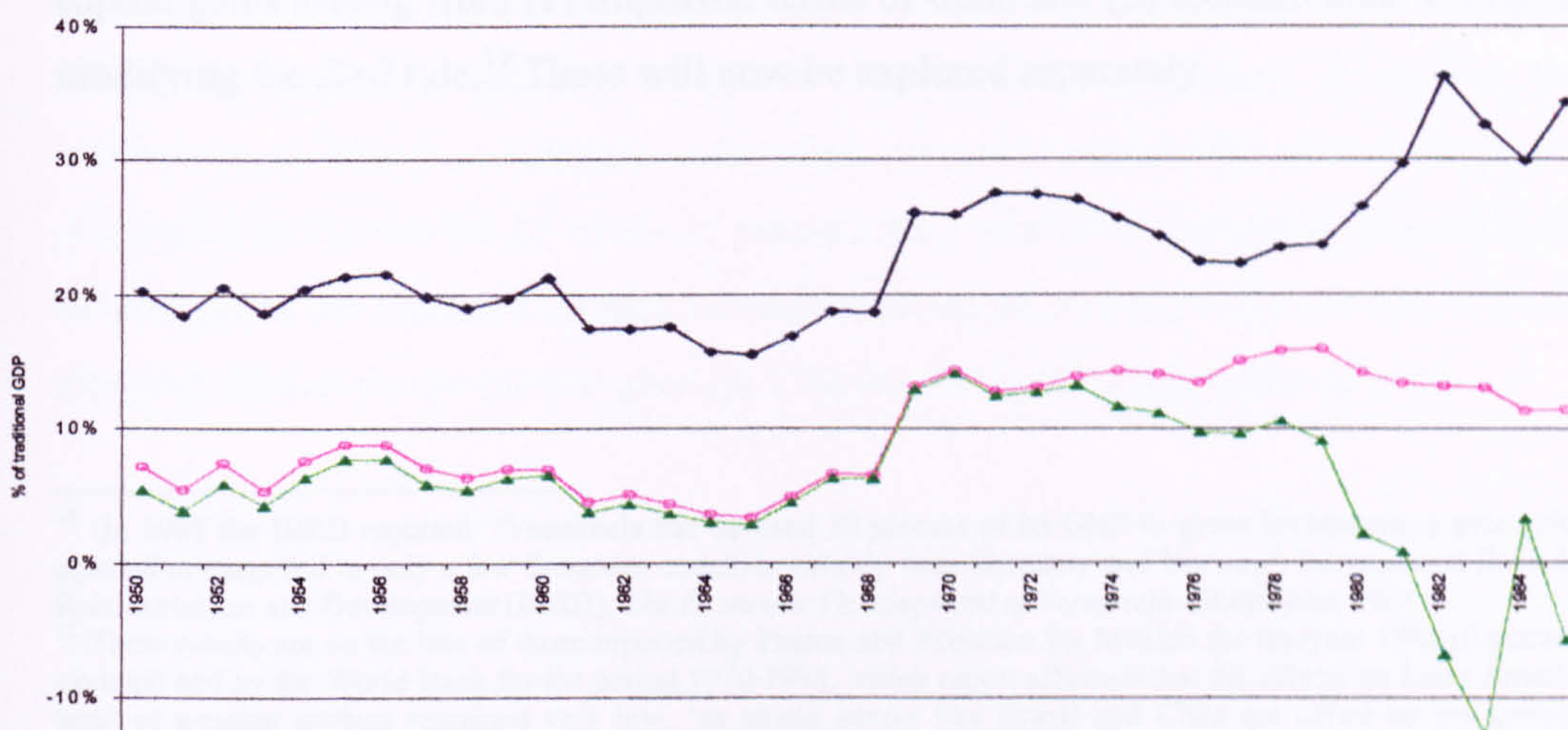
These estimates of natural depreciation are used for the computation of the Z indicator described in equation [6.2-1]. Figures 6.2-3 and 6.2-4 offer the graphical representation of the gross, net and genuine savings as percentage of GDP for Mexico and Venezuela.

Figure 6.2-3: Genuine savings. Venezuela 1936-1985 (percentage over GDP)



Sources and notes: gross savings calculated as residual of GNP minus total consumption from A. Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991), pp.37-38. Net savings equal gross savings minus the consumption of fixed capital listed in Appendix D. The net saving series here are consistent with the calculated by Baptista as shown in Appendix D. For the calculation of the genuine savings the corresponding natural capital depreciation was deducted, its value is $N= N(a15)$as listed in Table 4.4-2.

Figure 6.2-4: Genuine savings. Mexico 1950-1985 (percentage over GDP)



Sources and notes: Net savings sources as listed in Figure D.1-2 in Appendix D. Gross savings calculated adding to net savings the consumption of fixed capital also listed in Appendix D. Natural capital depreciation corresponds to $N= N(a\ 6)$ as listed in Table 4.4-3.

This first exercise shows Venezuela's *Z* indicator taking negative values by the 1930s and from 1944 it permanently failed to satisfy the rule in equation [6.2-1]. This is a striking result for an economy historically portrayed as an exceptionally high saver.[16] The Mexican indicator only turned negative only for a couple of years in the early 1980s.[17] In theory, these results indicate that Venezuela has been living beyond its means to a greater extent and for a longer period than Mexico.

According to the World Bank 'persistently negative rates of genuine savings must lead, eventually, to declining well-being'.[18] The puzzling question regarding this prediction is: for how long can a country endure negative genuine savings before the eventual decline of well-being becomes apparent? If Mexican results were the measure, it could be argued that a couple of years with negative genuine savings are sufficient to observe a decline in well-being by the mid 1980s. In contrast, in Venezuela negative rates of genuine savings occurred continuously for over 40 years and yet, as we know from Chapter 1, declining well-being was only perceived from the 1980s, and according to some authors, only from the 1990s onwards. By any standards the negative rents of Venezuela were persistent enough, yet the expected decline in well-being was greatly delayed. Hence, the predicted unsustainability of negative genuine savings comes into question.

It was mentioned in Chapter 2 that several authors have theorised about the role of capital gains arising from (1) improved terms of trade and (2) technological change in modifying the $Z>0$ rule.[19] These will now be explored separately.

[16] In 1961 the IBRD reported 'Venezuela has devoted 30 percent of its GNP to gross investment, a proportion equaled or exceeded in only a few European countries notably west Germany and Norway', International Bank for Reconstruction and Development (IBRD), *The Economic Development of Venezuela* (Baltimore, 1961).

[17] These results are on the line of those reported by Pearce and Atkinson for Mexico for the year 1985 (0 genuine savings) and by the World Bank for the period 1970-1993, which report affirmed that the effects on Latin America level of genuine savings remained very low, 'as strong savers like Brazil and Chile are offset by the genuine dissaving of Venezuela and Ecuador and the near-zero genuine savings of Mexico'. See Pearce and Atkinson, 'Measuring Sustainable Development', in, , p.173 and World Bank, *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development*, p.12.

[18] World Bank, *Expanding the Measure of Wealth.*, p.8. This report used the net price method for evaluating natural capital depreciation.

[19] G.B. Asheim, 'Hartwick's rule in open economics', *Canadian Journal of Economics* 86 (1986); G.B. Asheim, 'Capital gains and net national product in open economies', *Journal of Public Economics* 59 (1996) 3 ; J.M. Hartwick, 'Sustainability and constant consumption paths in open economies with exhaustible resources', *Review of International Economics* 3 (1996) 3; R.M.,Solow, 'Intergenerational Equity and Exhaustible Resources', *Review of Economic Studies* (1974). For additional references in Section 2.3.

The Effects of the Terms of Trade

The national income literature has long noted the problem that traditional indicators 'may not be a good indicator of national welfare in an open economy experiencing substantial change in its terms of trade.'[20] This occurs because traditional measures of output and income fail to account for the impact of changing terms of trade on the consumption possibilities of the economy. In this literature there are many attempts to adjust for the terms of trade impact on the measurement of national income.[21] The general result from those attempts is that 'when the terms of trade deteriorated, measures of economic growth tended to overstate gains in real income; when they improved, those measures understated such gains.'[22]

In earlier chapters it was found that the net price method is inappropriate for adjusting the net income for the depletion of oil reserves in open economies precisely because it ignores the effects on welfare income of the expected improvement of the terms of trade of an oil exporter. Accordingly, the sustainability rule *Z* presented in the section above would differ for open and closed economies. From the analysis in Chapters 2 and 5 we know that the imputed income adjustment proposed by Sefton and Weale is able to identify this difference between open and closed economies.[23] In this second exercise, the *Z* indicator is re-estimated using equation [6.2-2], but rather than adjusting the traditional income by the net price method, the net income is adjusted by the imputed income method that was calculated in Chapter 5. Figures 6.2-5 and 6.2-6 illustrate the effects of the expected gains from trade in modifying the *Z* indicator. When net income is adjusted using the imputed income method, it appears that Venezuela and Mexico consumed within their means throughout the period analysed.[24] According to the results the levels of consumption were not necessarily unsustainable ex-post given the expected continuous improvement on the terms of trade of a resource exporter. However, the caveats given in Chapter 5 should be taken into account.

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[20] K. Hamada and K. Iwata, 'National Income, Terms of Trade and Economic Welfare', *The Economic Journal* 94 (1984) 376, pp.752.

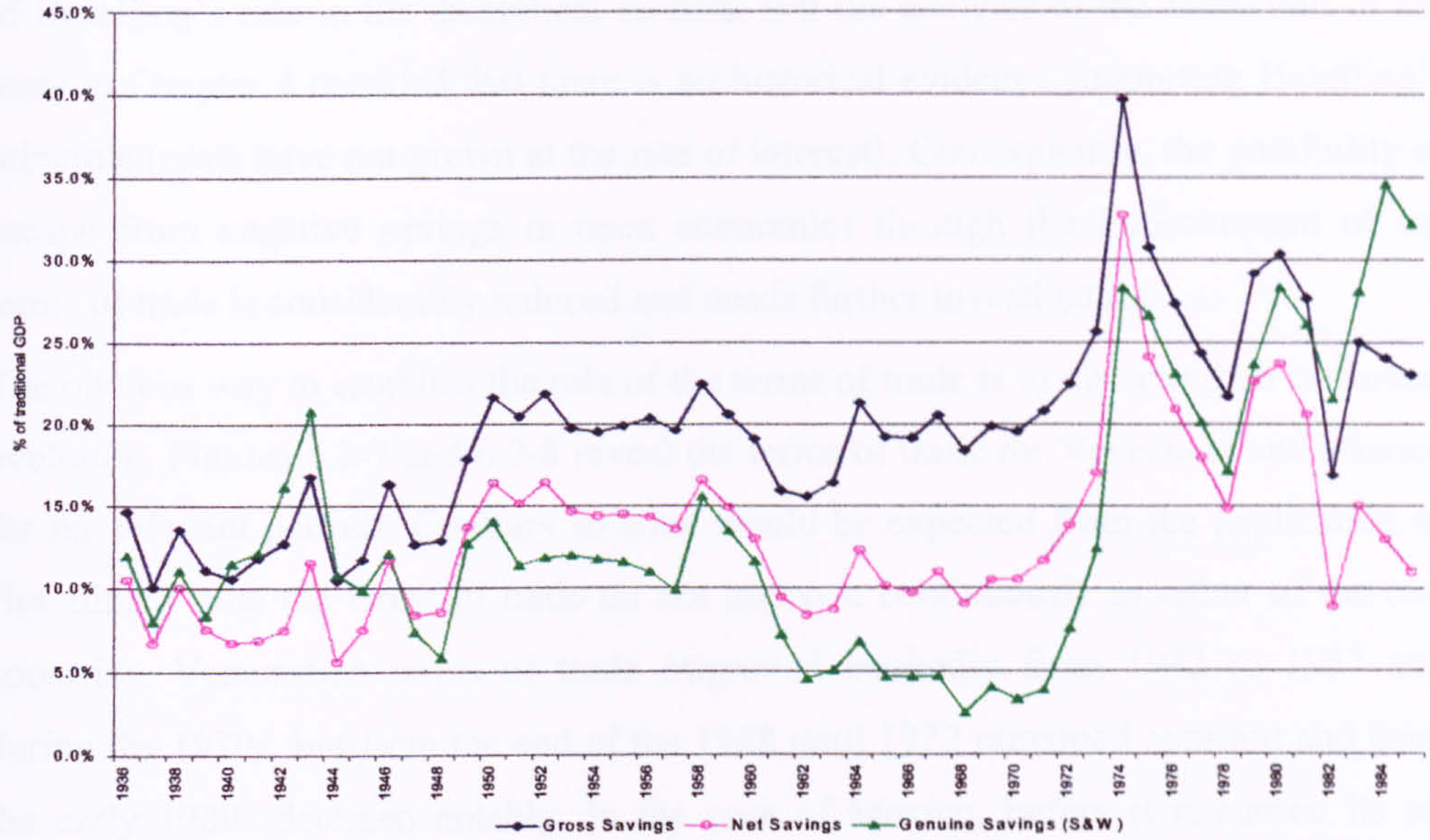
[21] A summary of the many attempts can be found in P. Gutman, 'The Measurement of Terms of Trade Effects', *Review of Income and Wealth* 27 (1981) December, pp.433-453. The work of Gutman does not include the later attempt by K. Hamada and K. Iwata, 'National Income, Terms of Trade and Economic Welfare', *The Economic Journal* 94 (1984) 376.

[22] D. Irwin, 'Terms of Trade and Economic Growth in Nineteenth Century Britain', *Bulletin of Economic Research* 43 (1991) 1, p.100.

[23] J.A. Sefton and M.R. Weale, 'The net national product and exhaustible resources: The effects of foreign trade', *Journal of Public Economics* 61 (1996). The method was dissused in Chapters 2 and implemented in Chapter 5.

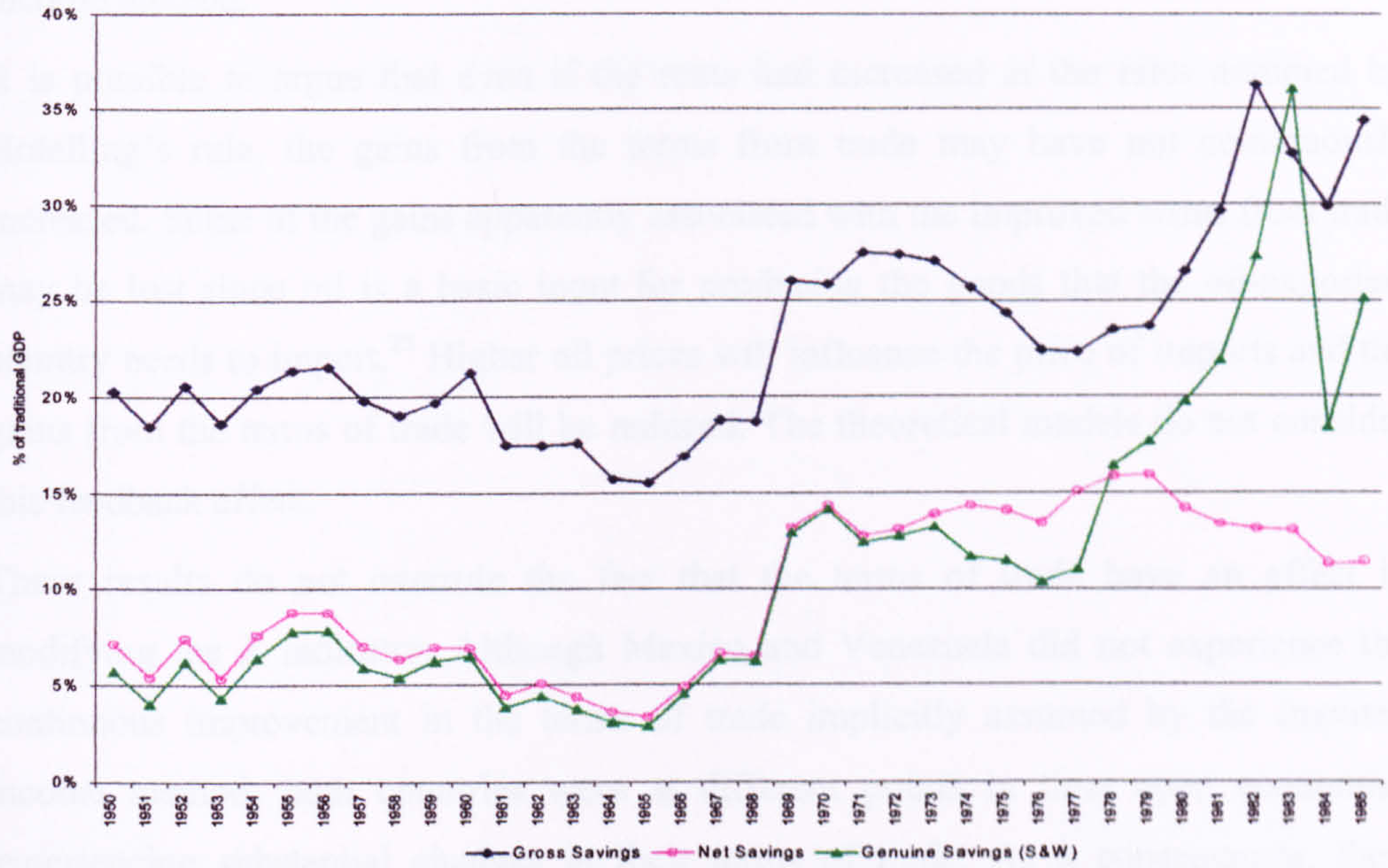
[24] This fact has been already pointed out by E. Newmayer, 'Measuring Genuine Savings: Are Most Resource-extracting Countries Really Unsustainable?', in Munasinghe, Sunkel, et al. (eds.), *The Sustainability of Long-term Growth. Socioeconomic and Ecological Perspectives* (Cheltenham, UK, 2001). Newmayer uses the user costs method to refute the conclusions based on the net price method of the report by World Bank, *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development.* Environmentally sustainable Development studies and monographs series, Vol. 17 (Washington, D.C., 1997).

Figure 6.2-5:Genuine Savings Taking into Account the Expected Gains from Trade. Venezuela 1936-1985 (percentage over traditional GDP)



Sources: Gross and net savings as in Figure 6.2-1. Genuine savings correspond to the NNP as listed in Appendix D minus the imputed income adjustment in Table 5.4-1 for a rate of interest of 6 percent.

Figure 6.2-6:Genuine Savings Taking into Account the Expected Gains from Trade. Mexico 1950-1985 (percentage over traditional GDP)



Sources: Gross and net savings as in Figure 6.2-2. Genuine savings correspond to the NNP as listed in Appendix D minus the imputed income adjustment in Table 5.4-2 for a rate of interest of 6 percent.

It was shown in Chapter 5 that the expected gains from trade arise from the application of Hotelling's rule in the theoretical models. But the analysis of the behaviour of the rents in Chapter 4 revealed that there is no historical evidence supporting Hotelling's principle (rents have not grown at the rate of interest). Consequently, the possibility of escape from negative savings in open economies through the improvement of the terms of trade is considerably reduced and needs further investigation.

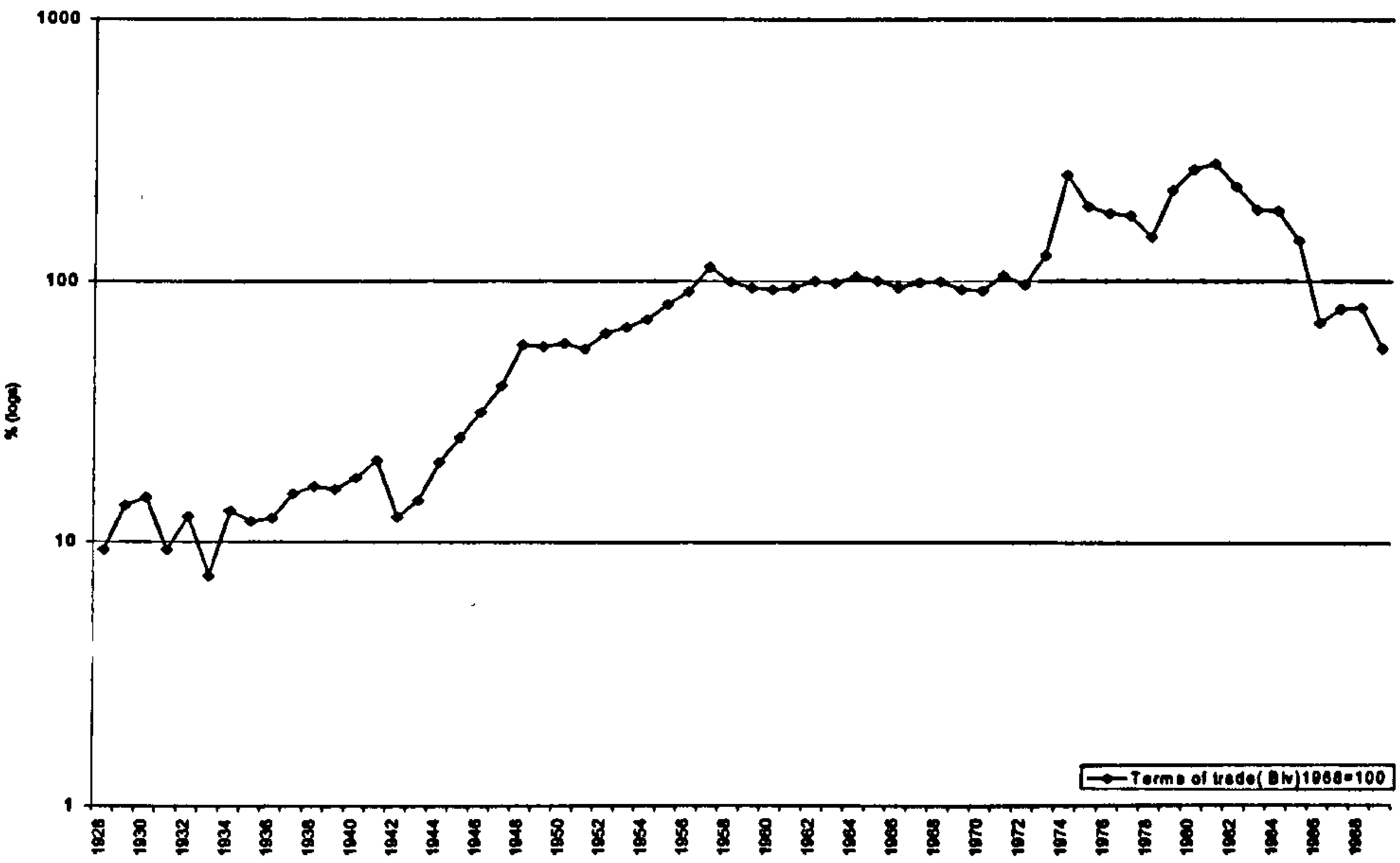
The obvious way to establish the role of the terms of trade is to observe their historical evolution. Figures 6.2-7 and 6.2-8 reveal the terms of trade for Venezuela and Mexico for the relevant periods. Contrary to what would be expected from the application of Hotelling's rule, the terms of trade do not improve continuously in either of the two countries. Venezuelan terms of trade improved markedly from 1942 to 1957 and during the 1970s, but from the end of the 1958 until 1972 remained constant and from the early 1980s declined notably. In the case of Mexico, before it re-started its oil exports, the terms of trade exhibit a modest upward trend; when oil regained a significant position in Mexican exports from 1974, the terms of trade improved briefly but started to decline from the 1980s and finally arrived at a constant level. The historical terms of trade do not satisfy the theoretical predications of the imputed income method.

It is possible to argue that even if the rents had increased at the rates assumed by Hotelling's rule, the gains from the terms from trade may have not continuously increased. Some of the gains apparently associated with the improved terms from trade may be lost since oil is a basic input for producing the goods that the oil-exporter-country needs to import.[25] Higher oil prices will influence the price of imports and the gains from the terms of trade will be reduced. The theoretical models do not consider this feedback effect.

These results do not overrule the fact that the terms of trade have an effect in modifying the Z indicator. Although Mexico and Venezuela did not experience the continuous improvement in the terms of trade implicitly assumed by the imputed income method, both countries were at different points in time open economies experiencing substantial changes in their terms of trade. As a consequence, their welfare incomes (their consumption possibilities) will differ from the standard income measures and this will have an effect on whether they were living beyond their means.

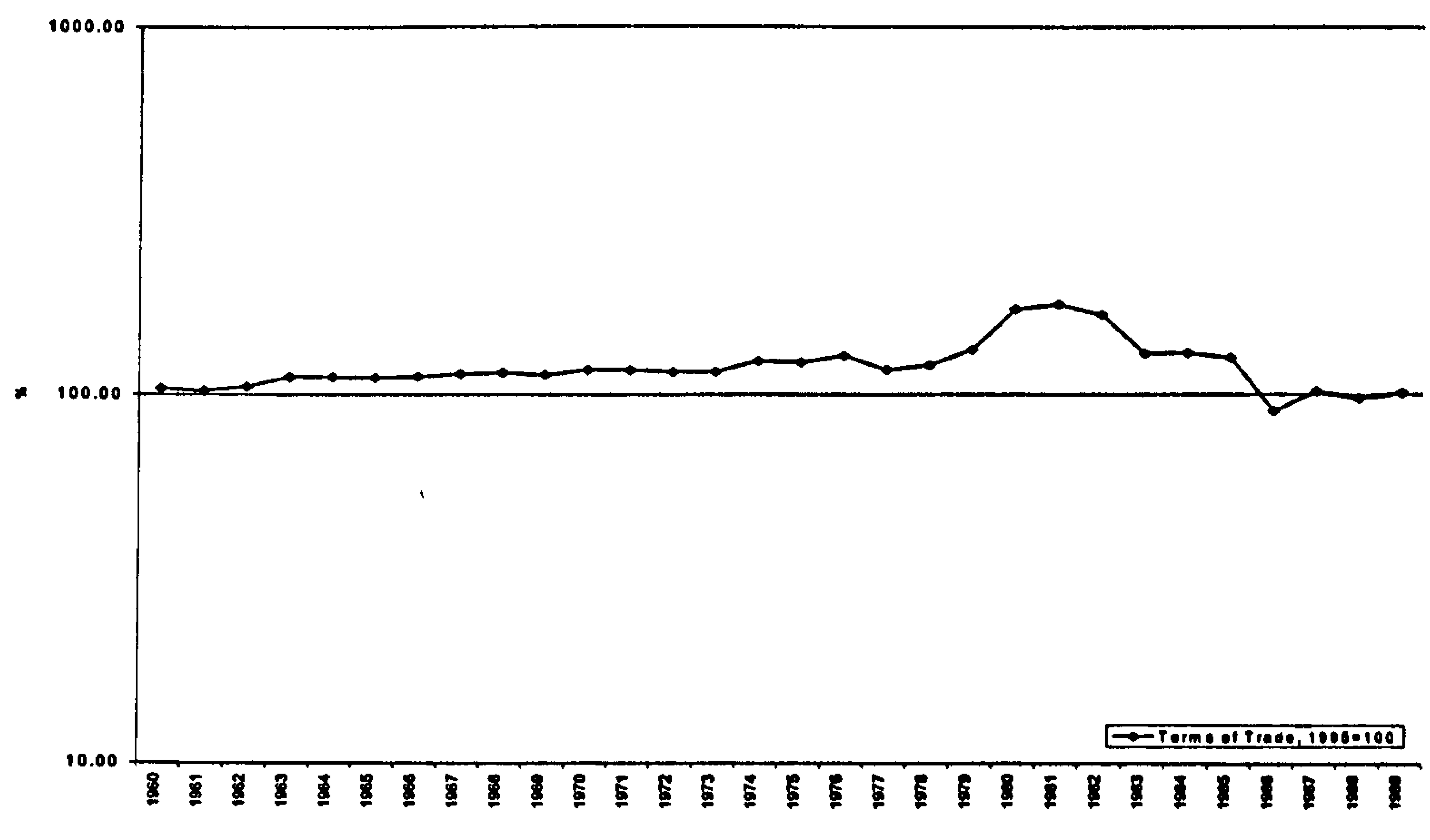
[25] '[...] the resource is essential for production' in Sefton and Weale model too. J.A. Sefton, and M.R. Weale, 'The net national product and exhaustible resources: The effects of foreign trade', *Journal of Public Economics* 61 (1996), p.36.

Figure 6.2-7: Venezuelan Terms of Trade, 1928-1989 (1968=100)



Sources: Terms of trade calculated as the ratio between exports and imports price indexes. Export price index was elaborated using the exports and prices series of oil from Appendixes A and B. It is worth recalling that oil exports represent the vast majority of Venezuelan exports (see Figure 1.1-2) for the dates shown. Imports price index from A. Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1995* (Caracas, 1997).

Figure 6.2-8: Mexican Terms of Trade, 1960-1989 (1995=100)



Source : W. Easterly, and M. Sewadeh, *Global Development Network Growth Database*, (2002), Available on line from: http://www.worldbank.org/research/growth/pdfiles/GDN/ macro_time_series_6_2001.xls.

A re-estimation of the Z indicator is needed taking into account the effect on income of the actual changes in the terms of trade instead of the expected gains from the terms of trade. 'Since the mid-1950 many authors have discussed the measurement of the effect of changes in the terms of trade on real income.'[26] In 1960 Nicholson proposed an adjustment procedure for assessing the effected of changes in the terms of trade on national income and product.[27] His adjustment formula for income gains/loss is given by:[28]

$$E^t\left(\frac{P_E^t}{P_M^t}-\frac{P_E^{t-1}}{P_M^{t-1}}\right) \qquad [6.2\text{-}3]$$

where E^t are exports in the current year t and, P_E and P_M denote exports and imports deflator respectively, thus the ratio P_E/P_M corresponds to the terms of trade.

Employing this equation, Tables 6.2-1 and 6.2-2 present evidence on how much the terms of trade fluctuations actually affect estimates of national income and contrast these results with the expected gains from the terms of trade assumed by the imputed income method. The results are shown as the percentage adjustment in income (NNP). Within each table, Panel a examines the relevant periods by decade averages, while Panel b divides the years into periods based on broad trends (such as peak-to-trough movements) in the terms of trade. This second Panel magnifies the possible effects of the terms of trade on measured income in the case of the actual effect figures. The first line of each table describes the importance of trade in the economy. It is evident from this line that the share of exports in Venezuela's income is much important than that of Mexico. This is relevant because the effects of the changes in the terms of trade on income are more important the higher the proportion of income that is derived from exports.[29]

By decades, the adjustment is most significant in the 1970s and the 1980s but with opposite signs. The figures for the terms of trade adjustment may be interpreted as follows: if the increase in the terms of trade from 1970 to 1979 is taken into account,

[26] K. Hamada and K. Iwata, 'National Income, Terms of Trade and Economic Welfare', *The Economic Journal* 94 (1984) 376, pp.761.
[27] J.L.Nicholson, 'The Effects of International Trade on the Measurement of National Income', *Economic Journal* 70 (1960) 279, pp.608-612. His adjustment has the advantage of being specifically designed for the adjustment of net income (rather than production that other methods attempt to adjust) and it does not include quantity changes which facilitate the comparison with the expected gains. These reasons justify the choice of this method among the available in the literature. For a discussion of the alternatives see K. Hamada and K. Iwata, 'National Income, Terms of Trade and Economic Welfare', *The Economic Journal* 94 (1984) 376.
[28] Nicholson's formula is taken from K. Hamada and K. Iwata, 'National Income, Terms of Trade and Economic Welfare', *The Economic Journal* 94 (1984) 376, p.769. It ignores net property income from abroad.
[29] The relationship between the share of exports on income and the effects of the terms of trade on income has been explored by J.Spraos, *Inequalising Trade? A Study of Traditional North/South Specialisation in the Context of Terms of Trade Concepts* (New York, 1983).

then the recorded national income in 1979 understates the level of Venezuela's income by about 7.2 percent. Similarly, the decline in the terms of trade of the 1980s means that the national income in 1989 overstates the level of Mexico's income by about 1 percent.

Table 6.2-1: Terms of Trade Effects on Venezuela's National Income
(all figures as percentage of NNP)

Panel a

	1936-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1985
Share of exports	32.4%	28.0%	32.2%	29.7%	31.2%	27.4%
Expected effect	13.5%	17.2%	18.3%	15.4%	23.3%	41.4%
Actual effect	0.3%	1.1%	1.3%	0.0%	7.2%	-2.5%

Panel b

	1936-1942	1943-1957	1958-1972	1973-1981	1982-1985	1936-1985
Share of exports	32.8%	29.4%	29.2%	32.6%	26.1%	30.1%
Expected effect	15.2%	17.9%	14.9%	30.3%	43.7%	20.9%
Actual effect	0.1%	2.0%	-0.3%	9.9%	-8.3%	1.7%

Sources: The expected effect on income from expected improvements in the terms of trade corresponds to the second term (Vt(i/(1+i)) of Sefton and Weale's adjustment as calculated in Section 5.4. The actual effect on income from changes in terms of trade calculated using Nicholson's method defined in equation [6.2-3] with data on exports as in Appendix B and terms of trade as in Figure 6.2-3. The sources of the NNP are listed in Appendix D.

Figures 6.2-2: Terms of Trade Effects on Mexico's National Income
(all figures as percentage of NNP)

Panel a

	1960-1969	1970-1979	1980-1989	1960-1989
Share of exports	6%	5%	14%	8%
Expected effect	0.1%	1.8%	26.9%	9.6%
Actual effect	0.1%	0.1%	-1.0%	-0.3%

Panel b

	1960-1973	1974-1981	1982-1986	1987-1989
Share of exports	5%	6%	16%	15%
Expected effect	0.0%	7.8%	34.6%	17.3%
Actual effect	0.0%	0.6%	-2.6%	0.6%

Sources: The expected effect corresponds to the second term (Vt(i/(1+i)) of Sefton and Weale's adjustment as calculated in Section 5.4. The actual effect on income from changes in terms of trade calculated using Nicholson's method defined in equation [6.2-3] with data on exports as in Appendix B and terms of trade as in Figure 6.2-4. The sources of the NNP are listed in Appendix D.

In looking at broad trends in the terms of trade (Panel b), the adjustment is also important (about 2 percent) for the period 1943-1957 for Venezuela, and the effects of the changes in the terms of trade of the oil boom and oil crisis are considerably magnified for both countries. These findings may lead economic historians to revise, at the margin, their interpretation of parts of the century. As a consequence of the terms of trade improvements, it appears that income increased much more than suggested by conventional estimates of national income during the 1970s. Likewise, the 1980s saw stronger losses in income than national accounts data suggested because of the sharp deterioration of the terms of trade during the 'lost decade'.

All in all, the actual effect on income from the terms of trade is much smaller than the imputed income for each and every period. This is also true for the whole period: an actual gain of 1.7 percent contrasts with the expected gain of 20.9 percent for the period 1936-1985 for Venezuela, and for Mexico an expected gain of 9.6 per cent contrasts with an actual loss of –0.3 percent for the period 1960-1989. The terms of trade do not appear to have helped oil producers over the long run as much as some theoretical models predict. We can now re-calculate the Z indicator taking into account the effects on income from the actual changes in the terms of trade. Figures 6.2-9 and 6.2-10 display the results.

Contrary to the results obtained using the expected gains from trade, the additions to welfare income due to the historical changes in the terms of trade do not suffice to compensate for the depletion of oil reserves, resulting in the return of the paradox of negative genuine savings for over 30 years in the case of Venezuela and yet no observable decline in well-being. The Mexican indicator also improves slightly as a consequence of the effects of the terms of trade, but it still remains negative for the early 1980s.

At least two caveats should be noted to this section.[30] First, the analysis presented here presumes that an increase in the relative price of exportables, an improvement in the terms of trade, is also an improvement from some welfare standpoint. Although Krueger and Sonnenchein established this presumption, simple connections between the terms of trade and national income or economic welfare cannot necessarily be drawn.[31] 'A tariff that improves the terms of trade, for example, may no increase national income if it reduces the volume of trade excessively.'[32] Second, the figures for NNP and savings are estimates and their precision should not be overstated. Thus, the figures presented here should be considered merely illustrative of the impacts of the terms of trade and depreciation of natural capital on national income.

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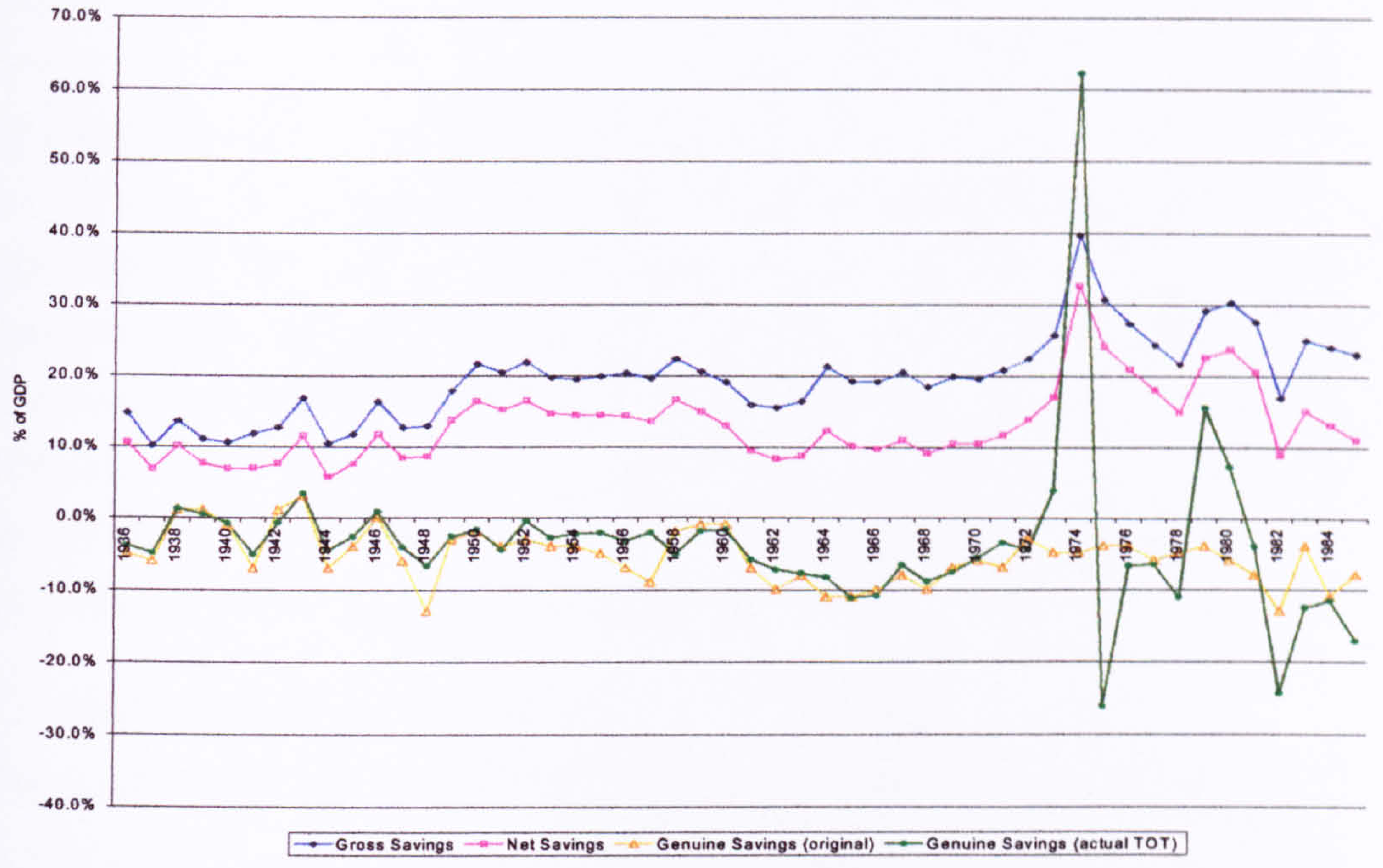
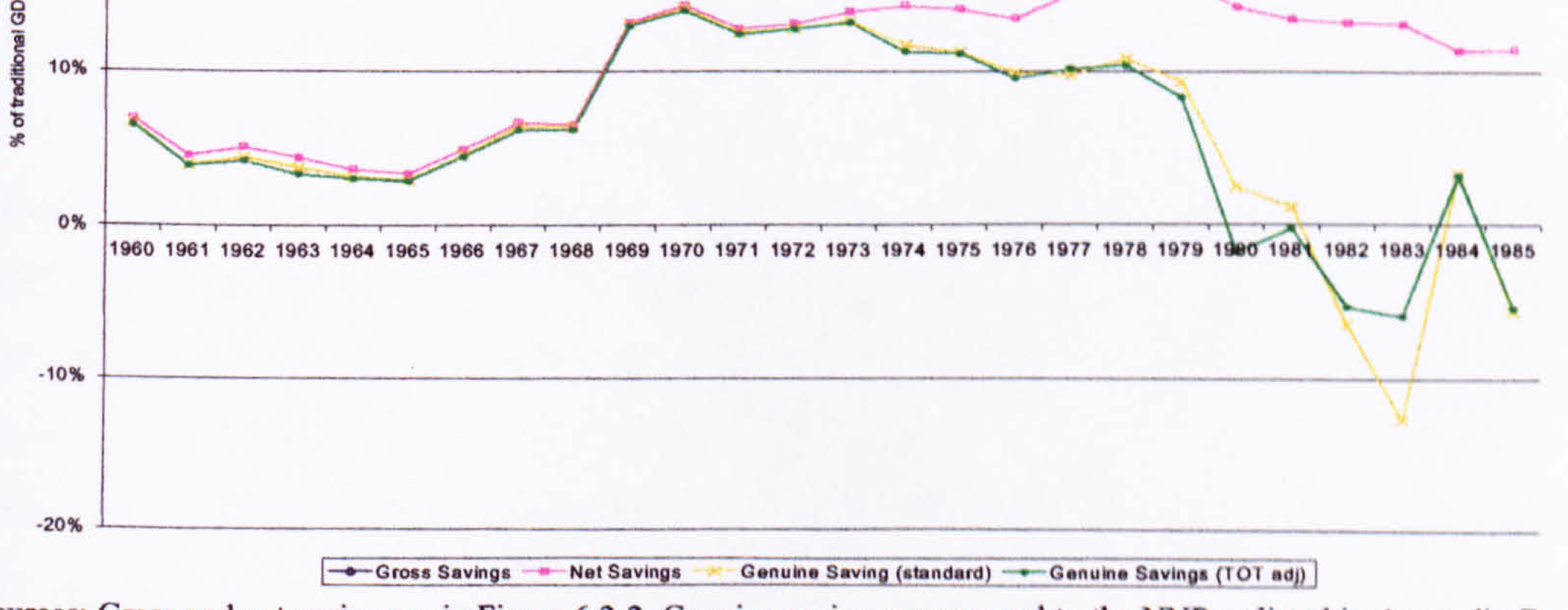
[30] The caveats to this section are the similar to the ones noted by D. Irwin, 'Terms of Trade and Economic Growth in Nineteenth Century Britain', *Bulletin of Economic Research* 43 (1991) 1, p.97.
[31] A.O.Krueger, and Sonnenschein, H., 'The Terms of Trade, the Gains from Trade, and Price Divergence', *International Economic Review*, Vol. 8, February, pp.121-127.
[32] D. Irwin, 'Terms of Trade and Economic Growth in Nineteenth Century Britain', *Bulletin of Economic Research* 43 (1991) 1, p.97.

Figure 6.2-9: Genuine Savings Taking into Account the Actual Gains from Trade. Venezuela 1936-1985 (percentage over traditional GDP)



Sources: Gross and net savings as in Figure 6.2-1. Genuine savings correspond to the NNP as listed in Appendix D twice adjusted: firstly by the effects of the changes in the terms of trade calculated in Table 6.2-1 and secondly the corresponding natural capital depreciation was deducted, its value is *N= N(a15)*as listed in Table 4.4-2.

Figure 6.2-10: Genuine Savings Taking into Account the Actual Gains from Trade. Mexico 1950-1985 (percentage over traditional GDP)



Sources: Gross and net savings as in Figure 6.2-2. Genuine savings correspond to the NNP as listed in Appendix D twice adjusted: firstly by the effects of the changes in the terms of trade calculated in Table 6.2-2 and secondly the corresponding natural capital depreciation was deducted, its value is *N= N(a6)*as listed in Table 4.4-3.

This section has explored the first of two theoretical objections to the *Z>0* rule: the role of capital gains arising from improved terms of trade. It has been shown that although theoretically it can be expected that the gains from improved terms of trade more than compensate for the cost of depleting oil resources in guaranteeing the future consumption of an oil exporter country, the historical changes in the terms of trade do not corespond to the theoretical expectations. The historical evolution of the terms of trade do not suffice to explain why Mexico and in particular Venezuela have enjoyed non-declining consumption levels despite consuming most of the rents generated by oil extraction. The next section analyses the second theoretical objection to the sustainability indicator: the effects of technological change.

The Effects of Technological Change

The second route of escape from negative savings offered by the theoreticians is technological change. The existing literature does not define the working mechanism of this alternative. Nevertheless, it is possible to think of several ways by which technological change can help to sustain consumption. The more general argument relates to total factor productivity growth by which the whole of the economy becomes more efficient, but this argument lies beyond the ambition of this dissertation. An alternative that can be explored is to consider the very argument used in the case of the expected capital gains from trade: the resource exporter 'can enjoy a level of positive consumption, because even though the country depletes its resource stock, the value of the remaining stock increased in value.'[33] The only difference is that the value of the remaining stock increases not because Hotelling's rule applies, but as a consequence of the progress in technology that added reserves and allowed increasing oil extraction for a growing demand of exports at lower costs.

The valuations of the stock calculated in Chapter 5 demonstrated that the remaining stock increased in value. It proved that current rents projected into the future, as in *PV2*, fall short in a world where rents increase both through growing extraction and improved technology. *PV1* included both future discoveries and technological change, providing the upper limit on the value of the remaining stock as long as the pace of extraction keeps increasing over time. *PV3* included technological change (new uses for the resource, reduced costs, etc.) but not future additions to the stock since it kept

[33] J.A. Sefton, and M.R. Weale, 'The net national product and exhaustible resources: The effects of foreign trade', *Journal of Public Economics* 61 (1996), pp.41-42.

extraction constant and limited to the reserves available in the current year. New discoveries indirectly affect the value of *PV3* since it can be argued that part of the reduction of the costs of production is due to the economies of scale allowed by greater oil fields. Furthermore, the life expectancy of the resource depends on the level of the current year reserves, which includes last year's stock plus this year's new discoveries net of extraction. However, future additions to the stock are not allowed in *PV3* as they are in *PV1*. In a scenario where rents per unit and extraction (and demand for exports) decreased over time, the bias would work differently: *PV2* would overstate the value of the resource compared to the other two implementations and *PV3* would provide the upper limit to the value of the resource.

If undertaking environmental accounting is for better policy management then predictive power is essential. The misfit between the different values associated with the stock is significant to both the environmental adjustment and also to the policymaker. Chapter 3 shows that erroneous forecasts, the confidence in continuing high oil prices, was blamed for the events of the 'lost decade'. The results of the previous and this chapter show how the assumptions underlying the various methods of environmental accounting can result in very differing policy advice.

The question is which one of the alternative values calculated is most appropriate to use for generating an alternative adjustment to income. Chapter 5 showed that using *PV2* to generate the adjustment is equivalent to applying the user cost method and that this adjustment is about the same as the one produced by the imputed income method in the case of open economies, such as Venezuela, that export almost all of its resource. In addition, in Chapter 5 it was also found that the user costs (thus *PV2*) should not be used for Mexico for it only applies to open economies. These reasons should suffice to show why *PV2* should not be used for generating the income adjustment. For *PV1*, it was argued in Section 5.1, there are serious objections to the attempt to include additional stock in the adjustments carried by environmental accountants. There is general agreement that including future additions to the stock of natural resources would make environmental accounts less useful for policy-making than traditional macro-economic indicators. Therefore if we want to take into account technological change, in the form of reduced costs but excluding future discoveries, then *PV3* is most appropriate to calculate the value of the resource, the capital gains associated with its extraction and the adjustment to income.

Spraos establishes the relationship between the terms of trade and the costs of extraction in order to achieve welfare neutrality for a resource-owing country. He affirms that 'with positive but constant marginal cost of extraction, the rate of terms of trade improvement needed to compensate for resource depletion will be slower the higher the initial share of marginal costs in price. If marginal cost of extraction rises, the needed rate of improvement of the terms of trade is faster the steeper the rise in the marginal cost because otherwise the royalty [rent] component will be eroded.'[34] By implication if the cost of extraction decreases, the necessary rate of improvement in the terms of trade is slower the steeper the decrease in the marginal cost. Decreasing marginal costs of extraction are rarely considered in theoretical models for technological change is generally left out. From the previous section we know that the rate of improvement in the terms of trade in Mexico and Venezuela is slow and fails to compensate for the depletion of the resource. Was this compensated by a fall in the marginal costs of extraction? As explained in Chapter 4, marginal costs of extraction are not available to the researcher. Only average costs of extraction are available and even these are compiled with difficulty. Nevertheless, Table 4.4-2 provided evidence on the increasing share of the rent in the price of oil. The implication, given the relatively stable price of oil for most of the twentieth century, is that the cost of extraction declined systematically relative to the price of oil. This suggests that reduced costs (technological change loosely) may play an important role in modifying the standard sustainability indicator.

One point remains to be made. In Chapter 2 it was indicated that only in open economies does the possibility of capital gains apply. If that is the case, and following the suggestion of Sefton and Weale in this context too, capital gains associated with technological change must only apply to that part of the resource that was exported but not to the amounts used in domestic consumption.[35] The results provided in Tables 6.2-3 and 6.2-3 (column (3a)) consider this distinction and calculate the value of the resource as a function of the quantities exported rather than extracted. The final result is that when the effects of technological change are accounted for, the levels of consumption are not unsustainable ex-post. For illustrative purposes only, the results of considering both reduced costs and future discoveries are also displayed (column

[34] J.Spraos, *Inequalising Trade? A Study of Traditional North/South Specialisation in the Context of Terms of Trade Concepts* (New York, 1983), p.80, footnote 6. Square brackets added.

[35] The fact that the resource is not exported does not necessarily imply a fully closed economy. Trade in other sectors may occur, as in the USA case. Then, it is possible to argue that it is the whole of the stock that should be taken into account. Sefton and Weale specify that the price the resources dedicated to internal consumption is identical to the price of the resource dedicated to exports. Thus domestic sales and export prices (and rents) increase exactly at the same rate. It is expected that if trade occurs in other sectors the owner of the resource would be able to spend the rents received from internal sales in buying imports and investing abroad. It follows that domestic sales of the resource contribute to welfare income (expected future consumption) not only through domestic production of goods but also generating rents that could be used similarly as the rent generated by the exports of the resource.

(3b)). It can be seen how distorted a view is obtained if future additions to stock were allowed to enter the calculation, particularly in the Mexican case.

These final calculations do not cover the period beyond 1972, because the life expectancy of the resource goes beyond the present day and data is required for stabilising the value of the resource. Yet it can be envisaged that some of the key factors that saved Venezuela previously from declining consumption were not present in the 1980s. These include the lower than expected prices, lower production, slower growth in demand for oil, and perhaps a slower pace of technological change than earlier in the century. The interesting events of 1980s and 1990s cannot yet be quantified.

The results of Tables 6.2-3 and 6.2-4 confirm the hypothesis put forward in the introductory chapter: environmentally adjusted income of Venezuela diverge further from traditional income estimates than those of Mexico. As expected, income does indeed differ when natural resources are included in national accounts. But traditional income estimates do not always exaggerate income as standard environmental accounting predicts. The adjustments in these tables show that adjusted income can result in greater or smaller incomes than those traditionally estimated once the effects of the terms of trade and of technological change are also considered. This should not discourage environmental accountants for it implies that the misfit between traditional and environmentally adjusted income is even greater than simple theoretical models predicted. Traditional measures of income can no longer be considered either a reliable indicator of sustainable income or the future consumption possibilities of the economy.

Paradoxically, the levels of consumption were not necessarily unsustainable ex-post given the existence of capital gains from trade and particularly from technological change. Lower costs of extraction, allowed by technological change, enabled oil producers to consume the rents without jeopardising future consumption. The terms of trade also influenced income, but much less than expected, being even negative in some instances. The results show that the role of technological change in sustaining the historical levels of consumption is substantial since the terms of trade did not improve in the continuous way needed to rescue the two economies from declining levels of consumption. This is an important finding because while gains from trade have now been included in some environmental accounting models (for instance, Sefton and Weale), technological change is left out.

Table 6.2-3: Living beyond its means? Summary of Venezuelan results 1936-1985

Year	Genuine Savings Standard Index				Terms of Trade Effects				Technological Change Effects			
					Expected		Actual		Tech Change (only)		Tech Change and Discoveries	
	(1) NNDadj	Gross savings	Net savings	(1) Z	(2a) NNDadj	(2a) Z	(2b) NNDadj	(2b) Z	(3a) NNDadj	(3a) Z	(3b) NNDadj	(3b) Z
	% of NNPtrad	% of GDPtrad	% of GDPtrad	% of GDPtrad	% of NNPtrad	% of GDPtrad	% of NNPtrad	% of GDPtrad	% of NNPtrad	% of GDPtrad	% of NNPtrad	% of GDPtrad
1936	83.3	14.7	10.5	-5.0	101.7	11.9	83.4	-3.9	95.8	6.7	115.4	23.9
1937	85.7	10.1	6.7	-6.0	101.5	8.0	86.7	-5.0	98.3	5.1	115.6	20.3
1938	89.9	13.6	10.0	1.0	101.1	11.0	90.2	1.2	102.3	12.0	121.9	29.6
1939	92.2	11.0	7.5	1.0	100.9	8.3	92.1	0.4	106.0	12.8	127.8	32.4
1940	91.2	10.6	6.7	-1.0	105.3	11.5	91.7	-0.8	108.3	15.3	152.4	54.0
1941	84.7	11.8	6.8	-7.0	106.3	12.1	85.9	-5.1	106.0	13.4	144.3	44.1
1942	93.0	12.7	7.5	1.0	109.7	16.2	90.9	-0.7	125.7	40.2	278.5	167.6
1943	90.5	16.8	11.5	3.0	110.2	20.8	91.0	3.3	119.2	35.1	227.8	127.9
1944	86.7	10.4	5.6	-7.0	105.9	10.7	88.4	-4.5	109.5	13.6	156.7	55.1
1945	87.8	11.7	7.5	-4.0	102.6	9.8	88.8	-2.6	107.3	13.8	133.7	37.7
1946	86.4	16.3	11.6	0.0	100.5	12.1	87.7	0.8	104.0	14.9	119.6	28.9
1947	83.7	12.6	8.3	-6.0	98.9	7.4	85.7	-4.1	97.6	6.0	107.2	14.6
1948	76.6	12.8	8.5	-13.0	96.8	5.8	82.1	-6.7	89.7	-0.5	96.7	5.7
1949	82.1	17.9	13.7	-3.0	98.9	12.7	81.8	-2.6	94.7	8.6	104.2	17.4
1950	78.7	21.6	16.4	-2.0	97.3	14.0	79.3	-1.7	92.2	9.2	99.8	16.3
1951	78.5	20.5	15.1	-4.0	95.6	11.4	77.5	-4.4	92.4	8.1	98.3	13.7
1952	77.7	21.9	16.5	-3.0	94.7	11.9	80.5	-0.5	90.7	8.0	95.8	12.8
1953	79.1	19.7	14.7	-4.0	97.0	12.0	80.2	-2.8	92.2	7.3	99.3	14.0
1954	79.5	19.5	14.4	-4.0	97.0	11.8	81.1	-2.3	92.3	7.1	98.8	13.4
1955	77.7	19.9	14.5	-5.0	96.7	11.6	81.0	-2.2	91.1	6.1	96.3	11.2
1956	76.1	20.3	14.3	-7.0	96.0	10.9	79.4	-3.3	90.5	5.6	94.3	9.5
1957	74.2	19.6	13.6	-9.0	95.5	9.8	81.4	-2.1	88.5	3.2	90.6	5.7
1958	79.6	22.4	16.6	-2.0	98.9	15.6	75.5	-5.1	97.1	13.3	101.1	17.6
1959	82.7	20.6	15.0	-1.0	98.4	13.5	81.3	-1.9	99.9	14.1	102.8	17.5
1960	83.7	19.1	13.0	-1.0	98.4	11.6	83.3	-1.7	104.9	16.5	106.8	19.1
1961	82.1	15.9	9.4	-7.0	97.5	7.1	82.5	-5.8	104.7	12.6	106.2	14.8
1962	80.1	15.6	8.3	-10.0	95.5	4.5	81.9	-7.2	104.5	11.2	104.0	11.7
1963	81.2	16.4	8.7	-8.0	95.7	5.0	80.8	-7.7	109.8	15.8	107.5	15.1
1964	73.8	21.3	12.3	-11.0	93.4	6.7	75.6	-8.3	101.1	12.1	97.7	10.4
1965	75.8	19.2	10.1	-11.0	93.5	4.6	74.7	-11.1	107.1	14.7	101.4	11.2
1966	77.3	19.1	9.7	-10.0	94.0	4.6	75.6	-10.8	111.6	17.9	105.0	13.9
1967	77.9	20.5	11.0	-8.0	92.5	4.7	79.2	-6.6	112.1	19.7	104.0	14.3
1968	78.6	18.4	9.0	-10.0	92.2	2.5	78.8	-8.9	111.9	17.6	103.2	11.7
1969	80.5	19.9	10.5	-7.0	92.4	4.0	78.8	-7.7	119.2	25.1	108.3	17.6
1970	81.5	19.6	10.5	-6.0	91.6	3.2	81.3	-5.7	118.7	25.0	107.1	16.7
1971	78.8	20.8	11.6	-7.0	90.9	3.8	82.3	-3.5	120.9	27.4	107.9	18.4
1972	81.4	22.5	13.8	-3.0	92.9	7.5	79.3	-4.5	131.0	38.1	116.7	28.6
1973	75.3	25.6	17.0	-5.0	94.8	12.4	85.1	3.8	n.a.	n.a.	n.a.	n.a.
1974	58.6	39.7	32.7	-5.0	95.2	28.3	132.4	62.3	n.a.	n.a.	n.a.	n.a.
1975	69.4	30.7	24.1	-4.0	102.7	26.6	46.1	-26.1	n.a.	n.a.	n.a.	n.a.
1976	73.4	27.3	20.9	-4.0	102.3	23.0	70.4	-6.7	n.a.	n.a.	n.a.	n.a.
1977	74.7	24.3	18.0	-6.0	102.3	20.1	73.7	-6.6	n.a.	n.a.	n.a.	n.a.
1978	78.9	21.7	14.8	-5.0	102.5	17.1	72.1	-11.0	n.a.	n.a.	n.a.	n.a.
1979	71.1	29.2	22.6	-4.0	101.1	23.6	92.4	15.5	n.a.	n.a.	n.a.	n.a.
1980	68.1	30.3	23.7	-6.0	105.0	28.3	82.3	7.2	n.a.	n.a.	n.a.	n.a.
1981	69.2	27.6	20.6	-8.0	106.0	26.1	73.3	-4.1	n.a.	n.a.	n.a.	n.a.
1982	75.6	16.9	8.8	-13.0	114.1	21.5	63.1	-24.3	n.a.	n.a.	n.a.	n.a.
1983	78.6	25.0	15.0	-4.0	115.7	28.0	69.1	-12.5	n.a.	n.a.	n.a.	n.a.
1984	72.6	24.0	13.0	-11.0	125.0	34.5	72.0	-11.6	n.a.	n.a.	n.a.	n.a.
1985	77.9	23.0	11.0	-8.0	124.6	32.1	67.2	-17.1	n.a.	n.a.	n.a.	n.a.

Sources and notes: traditional indicators as in Appendix D. Insufficient data for the calculation marked n.a.
(1) $NNP_{adj} = NNP_{trad} - N_t$ (net price adjustment) as in Table 4.4-2.
(2a) $NNP_{adj} = NNP_{trad} - (N_t + (i/i+1)V_t)$ for $V_t = uQ_E$ imputed income adjustment as in Table 5.4-1.
(2b) $NNP_{adj} = NNP_{trad} - (N_t + TOT)$ for TOT corresponds to the adjustment for the terms of trade in Table 6.2-1.
(3a) $NNP_{adj} = NNP_{trad} - (N_t + (i/i+1)V_t)$ for V_t=PV3 only applied to the resource exported as in Figure 5.4-1.
(3a) $NNP_{adj} = NNP_{trad} - (N_t + (i/i+1)V_t)$ for V_t=PV1 only applied to the resource exported as in Figure 5.4-1.

Table 6.2-4: Living beyond its means? Summary of Mexican results 1950-1985

	Genuine Savings Standard Index				Terms of Trade Effects				Technological Change Effects			
					Expected		Actual		Tech Change (only)		Tech Change and Discoveries	
Year	(1) NNDadj	Gross savings	Net savings	(1) Z	(2a) NNDadj	(2a) Z	(2b) NNDadj	(2b) Z	(3a) NNDadj	(3a) Z	(3b) NNDadj	(3b) Z
	% of NNPtrad	% of GDPtrad	% of GDPtrad	% of GDPtrad	% of NNPtrad	% of GDPtrad	% of NNPtrad	% of GDPtrad	% of NNPtrad	% of GDPtrad	% of NNPtrad	% of GDPtrad
1950	98.0	20.3	7.1	5.5	98.3	5.7	n.a	n.a	98.2	5.6	98.1	5.5
1951	98.2	18.4	5.4	3.9	98.4	4.0	n.a	n.a	98.3	3.9	98.3	3.9
1952	98.2	20.6	7.4	5.9	98.6	6.2	n.a	n.a	98.4	6.0	98.3	5.9
1953	98.8	18.6	5.3	4.3	98.8	4.3	n.a	n.a	98.9	4.3	99.2	4.6
1954	98.5	20.4	7.6	6.4	98.6	6.4	n.a	n.a	98.7	6.4	100.1	7.7
1955	98.7	21.4	8.8	7.8	98.8	7.8	n.a	n.a	98.9	7.8	100.1	8.9
1956	98.8	21.5	8.7	7.8	98.9	7.8	n.a	n.a	99.1	7.9	104.8	12.9
1957	98.6	19.8	7.0	5.9	98.7	5.9	n.a	n.a	99.1	6.2	168.0	66.3
1958	98.9	19.0	6.3	5.5	98.9	5.4	n.a	n.a	99.0	5.4	210.4	102.7
1959	99.2	19.7	6.9	6.3	99.2	6.2	n.a	n.a	99.2	6.2	209.6	102.5
1960	99.5	21.2	6.9	6.6	99.5	6.5	99.5	6.5	100.4	7.3	468.9	328.2
1961	99.1	17.5	4.5	3.9	99.2	3.8	99.2	3.8	104.7	8.2	467.6	295.3
1962	99.0	17.4	5.1	4.4	99.1	4.4	98.9	4.2	104.8	8.8	458.8	281.9
1963	99.1	17.6	4.4	3.7	99.2	3.7	98.7	3.3	107.0	10.2	554.4	384.1
1964	99.3	15.7	3.6	3.1	99.3	3.1	99.3	3.0	104.7	7.4	418.5	267.2
1965	99.4	15.5	3.3	2.9	99.4	2.9	99.4	2.8	104.3	6.8	412.5	259.9
1966	99.5	16.9	4.8	4.5	99.6	4.5	99.5	4.4	108.9	12.2	482.2	321.5
1967	99.6	18.7	6.6	6.4	99.6	6.3	99.5	6.1	105.6	11.3	382.8	243.9
1968	99.7	18.7	6.5	6.3	99.7	6.2	99.6	6.2	107.8	13.0	449.8	300.4
1969	99.7	26.0	13.2	13.0	99.7	12.9	99.8	13.0	107.0	19.5	413.2	295.0
1970	99.7	25.8	14.4	14.2	99.8	14.1	99.6	14.0	108.0	21.8	321.2	221.2
1971	99.6	27.5	12.8	12.5	99.6	12.4	99.6	12.4	104.6	17.0	374.5	269.8
1972	99.6	27.4	13.1	12.8	99.6	12.7	99.7	12.8	102.6	15.5	352.6	249.4
1973	99.3	27.0	13.9	13.3	99.3	13.2	99.3	13.2	n.a	n.a	n.a	n.a
1974	97.1	25.7	14.3	11.7	97.2	11.7	96.8	11.3	n.a	n.a	n.a	n.a
1975	96.9	24.3	14.1	11.3	97.2	11.5	96.9	11.2	n.a	n.a	n.a	n.a
1976	96.0	22.4	13.4	9.9	96.7	10.4	95.8	9.5	n.a	n.a	n.a	n.a
1977	94.1	22.3	15.1	9.8	95.7	11.0	94.7	10.2	n.a	n.a	n.a	n.a
1978	94.3	23.5	15.8	10.8	100.6	16.4	94.1	10.4	n.a	n.a	n.a	n.a
1979	92.5	23.6	15.9	9.3	101.9	17.7	91.7	8.3	n.a	n.a	n.a	n.a
1980	86.8	26.5	14.2	2.4	106.9	19.7	83.5	-1.8	n.a	n.a	n.a	n.a
1981	86.2	29.6	13.4	1.1	110.0	21.9	85.7	-0.3	n.a	n.a	n.a	n.a
1982	77.3	36.3	13.1	-6.5	116.1	27.3	79.0	-5.3	n.a	n.a	n.a	n.a
1983	69.9	32.6	13.1	-12.7	126.8	36.0	77.8	-5.9	n.a	n.a	n.a	n.a
1984	90.5	29.9	11.3	3.3	108.2	18.4	90.5	3.2	n.a	n.a	n.a	n.a
1985	79.8	34.4	11.4	-5.7	116.4	25.1	80.4	-5.4	n.a	n.a	n.a	n.a

Sources and notes: traditional indicators as in Appendix D. Insufficient data for the calculation marked n.a.
(2) $NNP_{adj} = NNP_{trad} - N_t$, net price adjustment as in Table 4.4-3.
(2a) $NNP_{adj} = NNP_{trad} - (N_t + (i/i+1)V_t)$ for $V_t = uQ_E$, imputed income adjustment as in Table 5.4-2.
(2b) $NNP_{adj} = NNP_{trad} - (N_t + TOT)$ for TOT corresponds to the adjustment for the terms of trade in Table 6.2-2.
(3a) $NNP_{adj} = NNP_{trad} - (N_t + (i/i+1)V_t)$ for V_t=PV3 only applied to the resource exported as in Figure 5.4-2.
(3a) $NNP_{adj} = NNP_{trad} - (N_t + (i/i+1)V_t)$ for V_t=PV1 only applied to the resource exported as in Figure 5.4-2.

As in the previous exercises, the analyst should bear in mind that savings are for the most part a residual value calculated from the macro economic data analysed in Appendix D, that data refers to average and not marginal costs and that traditional macro indicators are also estimates. Nevertheless, the overall message of the section seems robust enough even when the figures provided are not as precise as desired.

6.3 Measuring the Illusion of Oil Wealth

This chapter has implications that qualify some of the claims of the historiography reviewed in Chapter 3. In the case of Venezuela, it has been argued that 'due to the nature of oil revenues an increasing gap opened between the real production capacity and its earning and expenditure possibilities'.[36] Also it has been stated that 'after decades of consuming more than they produced, to restore balance, Venezuelans' real incomes and consumption would have to decline'.[37] The results of the previous section can be used to contrast these assertions with the quantitative evidence.

The standard genuine savings indicator may not provide the rule for determining whether a country is on or off a sustainable development path at any one point in time but it does offer a tangible indicator for evaluating these claims. The negative genuine savings obtained for Venezuela in the first exercise (column (1)Z in Table 6.2-3) indicate that consumption was above the income generated from all productive activities, including the contribution of the oil sector (payments to production factors) but excluding the resource rents. Hence it can be said that Venezuelans were consuming more than they produced, that is there was a gap between the real production capacity and the expenditure of the economy. The gap however was not a constantly increasing one. It increased markedly during the 1960s according to these results, but it shrank during the 1970s to widen again in the early 1980s. Moreover, the results presented here do not support the second claim: consumption does not have to decline in the future as a consequence of this gap. The existence of capital gains provided an escape route as discussed above.

The views of the scholars evaluating the 'sowing oil' policies can also be re-examined in the light of this chapter. These scholars maintained that so long as oil tax revenues exceeded public capital investment, it was possible to talk of national impoverishment, given that the economy was failing to undertake investment equivalent to the fiscal resources received from the exploitation.[38] Thanks to the calculations made in the dissertation it can be established that they were inaccurate on at least two grounds. On the one hand, Chapter 4 showed that oil fiscal revenues are not a good measure of the rents generated by the oil sector since the government was only able to appropriate part of those rents. Therefore, their use would underestimate national impoverishment;

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[36] A. Uslar Pietri, 'Los males del petroleo', *El Nacional* (1985) 28th April. The increasing disparity between consumption and production in a country such as Venezuela is also referred by B. Mommer and A. Baptista, 'El Petróleo En Las Cuentas Nacionales: Una Proposicón', *Working Paper IESA* 10 (1983), p.3.
[37] M. Naim and A. Pinango (eds.), *El caso Venezuela: una ilusión de armonia* (Caracas, 1974).
[38] Hector Malave Mata in his remarks during the second session of the conference, in Carrillo Batalla, 'La distribución del ingreso fiscal petrolero entre gastos corrientes y gastos de inversión', p.9.

even if all tax revenues were reinvested, part of the rents generated would escape unseen by these observers. On the other hand, their view, as with standard environmental accounting, neglects the role of capital gains on rescuing the country even if reinvestment is not carried out to replace the depleted resource.

Turning now to the Mexican side, Chapter 3 showed that the belief of the Mexican government in the early part of the twentieth century was that even if Mexico had continued to exploit the oil fields at a rapid pace and had exported the resource, this would not have contributed to higher income levels. Assertions such as 'our effort should lead towards consuming in the country all the oil we produce; wasting not a single drop; we can be certain that when we have achieved this ideal, Mexico will be prosperous, important and respected' made this point very clearly.[39]

Mexican officials did not consider that by renouncing exports of the resource they were also giving up the opportunity of obtaining capital gains that would have increased their income. The dissipation of rents observed in Chapter 4 in the Mexican case acquires further importance in this context precisely because, as a closed economy for most of the century, replacing the depleted asset by means of reinvestment is more crucial for guaranteeing future consumption because capital gains cannot make up for the depletion of the resource. The Mexican strategy was costly not only in terms of efficiency, as suggested in Chapter 4, but also more hazardous in terms of sustainability than would have been thought a priori. Nevertheless, Mexico never lived beyond its means, for the amounts extracted were too small to put at risk the net capital accumulation of the economy. In the 1970s, Mexico's policy changed at the point when it would have become even more relatively expensive to remain a closed economy. Oil continued as a core development resource for the Mexican government, but now it not only supplied economical abundant energy but also, for the first time since the nationalisation, was an earner of export revenues.

The undertaking of environmental accounting over the long run has yielded the reassessment of some of the claims of the historiography. Nevertheless, many pressing aspects of being an oil producer, which are relevant on the political economy side, remain unanswered. Notably the problem that most worried Uslar Pietri of how to transform the transitory income from oil into permanent wealth for the nation remains unsolved. Even when the results presented demonstrate oil producers could evade declining consumption by means of capital gains, the aim of producing different products in order to be less dependent on foreign commodities and to be able to pay with things other than oil still remains on the agenda. Policy makers still have to decide whether to consume all, part or none of the rents generated in the current year and more importantly how to invest the rest for ensuring the survival of the economy. As El Serafy pointed out, even if all the rents were indeed reinvested it may have been wiser to delay extraction if the market interest rate available for financial investment turned out to be lower than the rate at which the resource would appreciate if left in the ground.[40] Nevertheless, policymakers can now take into account that both the need for reinvestment, and the risks of not undertaking it, are associated with whether the country is making a productive use of the resource in a closed economy or exporting most of the resource and expecting capital gains to come to the rescue. Since the strategies of Mexico and Venezuela with respect to oil exploitation were based on these different ways of conceiving the contribution that oil could make to their economies these aspects of their political economies can also benefit from this research.

6.4 Conclusions

This chapter demonstrates that even when most natural resources have not grown scarcer historically, it is still important to account for them in the national accounts. This chapter carried forward environmental adjustments to traditional measures of economic performance, namely GDP and NNP. It found that the adjustments to GDP provide interesting qualifications to the economic performance of Mexico and Venezuela over the twentieth century, although the environmentally adjusted GDP does not do any better than the traditionally computed GDP identifying whether the economy is in a path towards prosperity or extinction, whether it is sustainable or not. For this purpose the analysis of net measures is needed.

The findings of the chapter qualify the hypothesis set out in the introduction of the thesis substantially. As expected income does indeed differ when natural resources are included in national accounts. But traditional income estimates do not always exaggerate income as standard environmental accounting predicts. It has been found that adjusted income can result in greater or smaller incomes than those traditionally estimated. This should not discourage environmental accountants for it implies that the

[39] J.D. Báez, 'Influencia de la guerra en el petróleo mexicano', *Revista de industria* 5 (1939 November) 35.
[40] S. El Serafy, 'The Proper Calculation Of Income From Depletable Natural Resources', in Ahmad, Serafy and Lutz (eds.), *Environmental Accounting For Sustainable Development: a UNEP- World Bank Symposium* (Washington D.C., 1989), p.16.

mismatch between traditional and environmentally adjusted income is even greater than the theoretical models predicted. Traditional measures of income can no longer be considered either as a reliable indicator of sustainable income or taken as guidance of the future consumption possibilities of the economy.

Paradoxically, the levels of consumption encouraged by traditional accounting were not necessarily unsustainable ex-post given the existence of capital gains from trade and technological change. It is through improved terms of trade and through increasing production and lowering costs of extraction, allowed by technological change, that oil producers managed to consume the rents without jeopardising future consumption. Furthermore, the results of the chapter show that the role of technological change in sustaining the historical levels of consumption is substantial since the terms of trade did not improve in the continuous way needed to rescue the two economies from declining levels of consumption. This is an important finding because while gains from trade have now been included in some environmental accounting models, technological change is left out.

These results also have implications for the analysis of the contrasting strategies of Mexico and Venezuela. It would appear that Venezuela's pure-resource-exporter policy was more of a worry for environmental accountants, than Mexico's conservationist approach. Nevertheless, the fact that Mexico opted for a closed economy implies that there was a greater need to set aside the rents to replace the depleted asset than if it had remained an open economy. Only in an open economy does the possibility of capital gains on the depleting asset stock become relevant. In the 1970s, Mexican policy changed at the point when it would have become relatively even more expensive to remain as a closed economy.

This should not however be taken as an endorsement of Venezuelan policies or of those recommending that little or none of the rent should be reinvested for guaranteeing future consumption possibilities. The resource exporter can consume today more not only on account of the expected gains from the terms of trade as shown, but also because more of the resource will be available tomorrow at lower costs thanks to technological change. But technological change is double edged. Technological change can give costs advantages to the competitor producer countries or in the extreme case it can eliminate the economic value of the reserves, etc. making obsolete the whole of the natural capital stock. Then not even reinvesting the whole of the current rent may guarantee the maintenance of the current level of consumption.

Conclusions

Thanks to the literature on environmental accounting, recognition is growing that national income has never been accurately calculated for economies based on natural resource exploitation. Traditional national accounting practice ignores the loss of natural resources. According to standard environmental accounting, this produces exaggerated income, encourages unsustainable levels of consumption and is misleading about the economic prospects of resource extracting countries. Substantial progress has been made during the 1990s in resolving theoretical issues involved in environmental accounting, although there is considerable disagreement on the empirical side about the most appropriate methods for making specific adjustments.

Divorced from the concepts and methods proposed by the environmental accounting literature, the historiography of oil-producing countries contains plenty of arguments that resemble those of the environmental accountants. One of the contributions of the thesis is to show how Mexican and Venezuelan scholars have discussed the concept of national wealth, the ephemeral prosperity delivered by oil depletion and the biases that oil cash introduced in the perceptions of their countries' economic performance. Nonetheless the quantification of this arguments in the historiography was for the most part missing. This thesis fills that gap.

The dissertation has connected these previously disparate literatures and has explored the resulting synergies. A priori it seemed that environmental accounting provided the tools for quantifying the hitherto qualitative observations of the historiography of two countries with very different strategies regarding the depletion of their natural resources. In the end, history has proved to be an excellent laboratory for an ex-post analysis of the concepts, models and methods of environmental accounting. Overall, the thesis is an examination of the tractability and usefulness of environmental accounting as a tool of economic analysis over the long run.

This study contributes to the somewhat surprisingly small amount of comparative historical studies of either the oil industries or the economic histories of Venezuela and Mexico. At the outset, it outlines the historical evolution of the Mexican and Venezuelan economies and their respective oil industries during the twentieth century. The research also reviews the role oil played within each economy and the main themes of the countries' historiography. It establishes that the histories of Mexico and Venezuela are not only linked by their common institutional heritage, but also for the first quarter of the century Venezuela was the recipient of Mexican oil policies, whereas for the second half of the century, Venezuelan conduct affected the Mexican situation. The two countries never lost sight of each other's policies: Mexican nationalists took pride in their independence compared with the foreign exploitation of Venezuela's national wealth; Venezuelan nationalists were envious of the Mexican ability to exploit their own resources. From the comparative perspective the bonds became at least as apparent as the contrasts between the two countries. It also became clear that Venezuela's exploitation policy resembles closely the text-book case of a pure-resource-exporting economy that worries environmental accountants, to whom Mexico's conservationist approach (at least during the period 1938-1976) would prima facie, be more sensible.

As mentioned, there is no established best practice in environmental accounting but an array of seemingly competing approaches. It necessitated setting out the state of the art in order to understand the alternative concepts, methods and objectives of environmental accounting. From the survey of the literature, there are at least three ways of approaching the integration of natural resources into macro-economic indicators: (1) direct inclusion into the System of National Accounts (SNA), (2) the development of separate Satellite Environmental Accounts (SEA), (3) and the more sophisticated attempt of the System of Integrated Environmental and Economic Accounting (SEEA). After exploring each of these and presenting what has been empirically done within each approach, it was possible to establish that the only approaches that are simultaneously useful and tractable were the direct adjustment of the traditional SNA and the partial completion of the entries corresponding to oil depletion in the SEEA.

A brief description of the SNA and of the reasons why it should be adjusted for the depletion of natural resources was the next step. The GDP is not very effective at identifying whether a nation is either building up its capital or living off its capital. The net measures of national income (NDP and NNP) make an allowance for the part of the capital base that is used up in generating the output in the current period and that should be replaced. Notwithstanding several caveats, net income at market prices is, in practice, the best approximation to the level of income that can be considered sustainable (that is Hicksian definition of income). Furthermore, net income provides information about a country's long-run consumption possibilities (that is Weitzman's welfare income). Main stream environmental accounting assimilates the depletion of natural resources to the depreciation of man-made capital. Therefore, since traditional national accounting does not make an allowance for natural capital depreciation, the traditional measures of income can no longer be considered either an indicator of sustainable income or taken as guidance as to the future consumption possibilities of the economy. Conventional national income estimates need to be adjusted for the use of natural resources; such is the aim of environmental accounting. The adjustment tries to address two interrelated but distinct questions: What is the 'true' net income of the economy? What should be done to ensure sustainability? The two are interrelated since the future of the economy is conditioned by current consumption and investment choices.

The issue that generates most of the debate among those practising environmental accounting is how to calculate the adjustment for natural resource depletion. The Fundamental Equation of Asset Equilibrium (FEAE) was used in Chapter 2 as a general framework for presenting an array of seemingly competing theoretical methods. Two of the methods analysed (net price and user cost) have now found their way into the proposed systems of environmental accounting. The survey of the literature demonstrated how most of the recent attempts of applying environmental accounting do not opt for one of these methods, but tend to present the results of both. The other two methods discussed (present value and imputed income) have not previously been used in empirical studies. Within this framework it was shown (1) that the adjustment of traditional NNP can be summarised in a single formulation (equation 2.3-22) for all the methods considered; (2) that all the methods require the estimation of the economic rent generated by the resource in year t (u_t and N_t); (3) that the implementation of each method differs due to different assumptions regarding the future behaviour of the rents.

Nevertheless, the most important conclusion derived from this comparative analysis of the theoretical models of environmental accounting is that, at least in theory, different methods seem to apply to different scenarios. Hartwick, by implication, shows that the user cost method does not apply to a closed economy case.[1] Sefton and Weale argue that the net price method does not apply to open economies, and from their theoretical propositions it can be inferred that, at least in part, the user cost method applies to the open economy case.[2] In open economies the possibility of capital gains from trade on the depleting asset stock becomes relevant. In the light of these findings, the two methods that are considered rivals by the literature can be considered as relevant for different scenarios.

Our two case studies offer very different examples of resource depletion strategies. Chapter 3 showed that the Mexican and Venezuelan governments took different positions regarding the use of natural resources for most of the twentieth century. While Mexico's administration believed that the best way of making use of the oil endowment was to provide affordable energy for the country's industrialisation, Venezuelan governments maintained that the role of oil resources was to finance the development of the nation. Divergent strategies resulted, which affected every aspect of oil exploitation: legislation, management (public vs. private), pace of exploration and exploitation, etc. Importantly in terms of environmental accounting, Mexico approximates very closely the theoretical case of a closed economy and Venezuela that of an open economy willing to sell nearly all the resource to the rest of the world.

Fitting the real world into the theoretical models proved to be an arduous task. In addition to the conceptual issues, the most daunting obstacles were problems involved in estimating quantities of stocks and flows and establishing monetary valuations. A good deal of the work concerned the elaboration of the data series needed for conducting environmental accounting. These series are a contribution in their own right. On the one hand, they permit quantitative comparison of the sharp contrasts between the Mexican and Venezuelan oil industries in terms of basic indicators such as production, exploration policies, labour and capital costs, fiscal policies, etc. On the other hand, oil stocks and flows, values and depreciation estimates are major components of environmental accounts. This will be of use for those attempting the

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[1] J.M.Hartwick, , 'Natural resources, national accounting and economic depreciation', *Journal of Public Economics* (1990) 43.

[2] J.A.Sefton, and M.R. Weale, 'The net national product and exhaustible resources: The effects of foreign trade', *Journal of Public Economics* 61 (1996).

more ambitious objective of producing a complete set of environmental historical national accounts including all the other natural resource depletion plus pollution and ecosystem changes for Mexico and Venezuela. These historical series can also serve as benchmarks for comparison with other oil-producing countries. Therefore, data series produced will be useful for those currently working on the generation of environmental accounts as much as for those working on more orthodox quantitative explorations of the histories of these two oil industries.

In relation to the conceptual issues, the contrast between the historical evolution of the values taken by the variables and the assumptions generally adopted in theoretical models of resource depletion has a number of important implications. The empirical exercises disclosed gaps between theory and practice of environmental accounting that do not appear in theoretical and shorter-term exercises. For instance, environmental accounting theory does not contemplate the possibility of persistently negative rents. However, these have been obtained for Mexico. The issue of negative rents requires further investigation by environmental accounting theory, for the depletion continues to take place but no cost can be assigned to it if the resource rent is the basic input to valuation methods. Furthermore, the negative rents obtained for Mexico seem to indicate that the Mexican strategy was expensive in terms of efficiency. This results also rises interesting economic questions. Was Mexico's strategy sensible in limiting its production because costs were so high? Should it have limited its output to zero? Or were the high costs of production a consequence of the policy? Was Mexico inefficient because of the closure to foreign investment and foreign markets? Nevertheless, these questions are far beyond the scope of this research. What it can be established with the data presented is that the strategy chosen by the Mexican government could have been better implemented. It is plausible to argue that at the time of the nationalisation Mexico simply ran out of oil deposits that could be extracted at competitive costs, given prices, technology and competitive sources. However, the data presented suggests that for most of the period after the nationalisation costs could have been reduced by changing policies (for instance, reducing the labour force and increasing production to take advantage of economies of scale).

A simple but crucial observation also derives from the historical evolution of the rents: they were not constant nor did they grow at the rate of interest over time, contradicting the two main assumptions adopted by the literature. It was also found that the rent accounted for an increasing share of the price of oil throughout the century. The implicit consequence is that costs of production declined systematically relative to the price of oil. This evolution contrasts with the constant or increasing costs generally assumed in the theoretical discussion of resource rents. The absence of technological change in the theoretical models partly explains the difference between the historical and the theoretical evolution of costs and rents.

An advantage of the historical data set is that it has made possible the relaxation of the most common assumptions of environmental accounting. One of the main conclusions of the exercises in the thesis is that the underlying assumptions regarding the behaviour of rents over time in the theoretical models are crucial to the actual level of the adjustments. That comes as no surprise. What is new, however, is that the conclusions obtained in the theoretical literature about the bias of the different methods are also linked to these assumptions. Therefore, the biases in the methods, as commonly believed in the literature, only hold under the most restricted scenario of constant rents over time. It was also found that the value assigned to the resource is very much related to the expected life expectancy of the resource. Most theoretical exercises assume the initial stock of the resource will not change over time. In those models capital gains/losses can only arise from changes in the price of the resource. In these two countries the life expectancy of the resource has varied due to changes in the pace of extraction and/or new discoveries. As a consequence, a great deal of the variations in the observed value of the resource comes from changes in the life expectancy of the resource.

As a result of applying the theoretical arguments spelt out by Sefton and Weale, the dissertation established that the net price and the user cost are not competing methods as such, but are appropriate for different scenarios. While the net price is the correct adjustment for closed economies, open economies need to impute an income to the stock targeted for exports; in the case of a pure resource exporter, user costs approximates this result quite reasonably as the figures for Venezuela demonstrated. This requires a different type of adjustment for each of our two case studies. Since Mexico resembles the closed economy for the period 1938-1970s and Venezuela the pure resource exporter during the twentieth century, the net price is appropriate for adjusting Mexican national accounts for the aforementioned period, whereas the user costs should be used for Venezuela. In fact, implementing the methodology proposed by Sefton and Weale obviates switching from one method to another when Mexico changes its policy in the 1970s, since their method is able to capture the change in policy.

The principal concern of the thesis was the quantification of the claims of environmental accounting; or in other words, to what extent do environmental historical national accounts diverge from traditional national accounts? The dissertation has answered this question for Mexico and Venezuela. In doing so, it has also quantified some of the claims of the historiography. The findings of the dissertation qualify the initial hypothesis substantially. As expected income does indeed differ when natural resources are included in national accounts. But traditional income estimates do not always exaggerate income as standard environmental accounting predicts. It has been found that adjusted income can result in greater or smaller incomes than those traditionally estimated. This should not discourage environmental accountants for it implies that the misfit between traditional and environmentally adjusted income is even greater than the theoretical models predicted. Traditional measures of income can no longer be considered either a reliable indicator of sustainable income or taken as guidance of the future consumption possibilities of the economy.

Paradoxically, the levels of consumption were not necessarily unsustainable ex-post given the existence of capital gains from trade and technological change. It is through improved terms of trade and through increasing production and lowering costs of extraction, allowed by technological change, that oil producers managed to consume the rents without jeopardising future consumption. Furthermore, the results of the thesis show that the role of technological change in sustaining the historical levels of consumption is substantial since the terms of trade did not improve in the continuous way needed to rescue the two economies from declining levels of consumption. This is an important finding because while gains from trade have now been included in some environmental accounting models, technological change is left out.

These results also have implications for the analysis of the contrasting strategies of Mexico and Venezuela. It would appear that Venezuela's pure-resource-exporter policy was more of a worry for environmental accountants than Mexico's conservationist approach. Nevertheless, the fact that Mexico opted for a closed economy implies that there was a greater need to set aside the rents to replace the depleted asset than if it had remained an open economy. Only in an open economy does the possibility of capital gains from the terms of trade on the depleting asset stock become relevant. In the 1970s, Mexican policy changed at the point when it would have become even more relatively expensive to remain as a closed economy.

This should not however be taken as support for Venezuelan policies or for those recommending that little or none of the rent should be reinvested for guaranteeing future consumption possibilities. The resource exporter can consume today more not only on account of the expected gains from the terms of trade as we saw, but also because more of the resource will be available tomorrow at lower costs thanks to technological change. But technological change is double edged. Technological change can give costs advantages to the competitor producer countries or in the extreme case it can eliminate the economic value of the reserves, etc, making obsolete the whole of the natural capital stock. Then not even reinvesting the whole of the current rent may guarantee the maintenance of the current level of consumption.

The results presented here are initial efforts at estimating indicators and are offered in the spirit of transparent exchange of research results and thinking. They are intended to stimulate dialogue and to advance both the methodologies used and the policy applications of indicators for sustainable development. The analysis of different economic strategies and their impact on development and environmental depletion measures yield new questions for the long-term sustainable growth debate. Consequently, the results obtained have implications for political planning over the use of the environment and the use of the recommendations made by the environmental adjustments. We said in the introduction that if these tools turn to be useful in historical perspective, it would allow greater confidence in the implementation of future policies based upon their recommendations. Precisely because we now know more about the biases and the inconsistencies of the methods of environmental accounting in historical terms, the thesis contribute to increase the confidence in the implementation of policies based upon their results in the future.

Appendix A

Oil Production and Consumption

The amount of oil produced in Mexico and Venezuela is well known from the start of production. Governments needed to know the amount produced in order to claim the corresponding taxes and royalties on production. Therefore, official figures on production were well kept. By looking at the evolution of this variable, one can clearly see the different strategies adopted by Mexico and Venezuela. Nevertheless, there are reasons for thinking that production data might be underestimated in the early days. Since exploitation taxes, commonly known as royalties, represented a fixed amount of the production value declared by the company the result is presumably an under-declaration of production by the companies. Underestimation of oil export value in the official accounts seems unavoidable. Indeed, efforts to improve the inspection system always found strong opposition from the companies.[1]

Sources for oil production and domestic oil consumption data in table A.1:

<u>Mexico</u>

Oil production

- 1901-1992: México, Instituto Nacional de Estadística Geografía e Informática, (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994), cuadro 11.1, p.559.

National demand for oil

- Obtained by subtracting exports volume from total production. Volume of oil exports available from the sources and series listed in appendix B.

<u>Venezuela</u>

Oil production

- 1920-1990: Baptista, A., *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)* (Caracas, 1997), cuadro B-5.

National demand for oil

- 1920-1990: Baptista, A., *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)* (Caracas, 1997), cuadro B-5.

[1] See chapter VI in Lieuwen, E., *Petroleum In Venezuela : A History*. University of California Publications in History, Vol. 47 (Berkeley, 1954).

Table A-1 Oil production and national demand for crude oil. Mexico and Venezuela 1901-1990 (thousand barrels)

	OIL PRODUCTION		NAT. DEMAND			OIL PRODUCTION		NAT. DEMAND	
Year	Mexico 000 barrels	Venezuela 000 barrels	Mexico 000 barrels	Venezuela 000 barrels	Year	Mexico 000 barrels	Venezuela 000 barrels	Mexico 000 barrels	Venezuela 000 barrels
1901	10		n.a		1951	77,308	622,000	64,557	20,900
1902	40		n.a		1952	77,278	660,000	73,378	22,600
1903	75		n.a		1953	72,433	644,000	67,666	27,600
1904	126		n.a		1954	83,651	691,000	78,005	32,800
1905	251		n.a		1955	89,395	787,000	83,106	38,800
1906	502		n.a		1956	90,660	899,000	87,502	45,200
1907	1,005		n.a		1957	88,266	1,014,000	87,969	51,700
1908	3,932		n.a		1958	93,533	951,000	93,415	47,800
1909	2,714		n.a		1959	96,393	1,011,000	95,227	49,000
1910	4,634		n.a		1960	99,049	1,041,000	91,776	46,700
1911	12,553		11,652		1961	106,784	1,065,000	99,092	46,500
1912	16,558		8,829		1962	111,849	1,167,000	104,383	55,300
1913	25,696		4,366		1963	114,867	1,185,000	106,766	57,200
1914	26,235		2,870		1964	115,576	1,241,000	108,079	60,500
1915	32,911		8,142		1965	117,959	1,267,000	107,373	64,200
1916	30,516		3,248		1966	121,149	1,230,000	110,877	65,600
1917	55,293		9,270		1967	133,043	1,292,000	133,043	66,900
1918	63,828		12,061		1968	142,360	1,319,000	142,360	70,900
1919	87,063		11,514		1969	149,860	1,311,000	149,860	70,200
1920	157,069	500	11,561	9	1970	156,686	1,353,000	156,686	73,100
1921	193,398	1,400	21,130	19	1971	155,911	1,295,000	155,911	76,900
1922	182,278	2,200	1,412	26	1972	161,367	1,178,000	161,367	83,500
1923	149,584	4,300	13,978	49	1973	164,909	1,228,000	164,909	95,800
1924	139,678	9,100	9,979	97	1974	209,855	1,086,000	204,051	94,100
1925	115,515	19,900	16,657	210	1975	261,589	856,000	227,207	90,200
1926	90,421	35,700	9,047	369	1976	293,117	839,000	258,647	99,500
1927	64,121	60,400	11,149	630	1977	358,090	816,000	284,354	105,100
1928	50,151	106,000	16,764	1,479	1978	442,607	790,000	309,360	116,700
1929	44,688	136,100	17,639	1,406	1979	536,926	860,000	342,441	127,200
1930	39,530	135,200	12,559	1,404	1980	708,593	793,000	405,637	140,700
1931	33,039	116,900	10,536	1,230	1981	843,917	769,000	443,139	149,300
1932	32,805	116,700	10,217	1,232	1982	1,002,436	691,000	457,822	149,400
1933	31,001	118,200	8,975	1,255	1983	972,908	657,000	411,903	145,800
1934	38,172	136,300	13,154	1,445	1984	979,843	659,000	421,839	135,900
1935	40,241	148,500	17,796	1,577	1985	960,133	613,000	436,613	135,100
1936	41,026	154,600	19,991	1,631	1986	886,111	653,000	415,407	141,500
1937	46,803	185,800	37,592	1,945	1987	927,319	664,000	436,394	142,700
1938	38,482	188,000	23,546	2,000	1988	914,909	696,000	436,657	149,120
1939	42,891	204,500	28,248	2,200	1989	917,355	696,000	n.a	141,500
1940	44,045	183,800	35,742	2,600	1990	930,023	779,800	n.a	145,800
1941	43,031	226,800	39,886	2,900					
1942	34,826	152,000	33,908	2,800					
1943	35,153	179,400	35,153	3,000					
1944	38,197	257,000	36,662	3,970					
1945	43,543	323,400	40,832	4,500					
1946	49,240	388,500	46,208	5,700					
1947	56,298	434,900	45,373	9,100					
1948	58,520	490,000	52,459	10,600					
1949	60,902	482,000	48,972	14,500					
1950	72,422	546,000	64,995	18,800					

Sources: described above

Appendix B

Export Dependency Series

Sources for total and oil exports data in table B-1:

Mexico:

Total exports:

- 1901-1990 (in dollars in the original): México, Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994), p. 799-800.

Oil exports:

- 1911-1936: México, Government of, 'Estadística Petrolera', *Revista de Industria. Revista Mensual* 1 (1937 December) 2, p.21 (converted here from volume to value by multiplying the former by the prices shown in Appendix F).
- 1937: Haber, S., N. Mauer and A. Razo, 'When Institutions do not Matter: The Rise and Decline of the Mexican Oil Industry', *Paper presented at the Economic History Seminar at UC Berkeley, September 2001* (no published).
- 1938-1939: PEMEX, (Petróleos Mexicanos), *Informes del Director General Senador Antonio Bermúdez 1947-1952* (México D.F., 1952), p.47.
- 1940-1974: Banco Nacional de Comercio Exterior S.A., *Comercio Exterior de México* (México D.F., Vols. for the period 1948-1973); (there were no exports between 1967 and 1973).
- 1974-1988: PEMEX, (Petróleos Mexicanos), *Anuario Estadístico 1988* (México D.F., 1988), p.121.

Venezuela:

Total exports and oil exports:

- 1911-1963: Venezuela, Ministerio de Fomento, *Anuario Estadístico de Venezuela 1957-1963* (Caracas, 1964), p.1049. From 1911 to 1917, 'oil exports' refer to asphalt exports.
- 1956-1967: Venezuela, Ministerio de Fomento, *Anuario Estadístico de Venezuela* 1967 (Caracas, 1968). p.372, (overlapping years coincide with the previous source).
- 1965-1975: Venezuela, Ministerio de Energía y Minas, *Petróleo y otros datos estadísticos (PODE)* (Caracas, issued annually since 1958) for the years 1970, 1973 and 1975, p. 11 in all cases; (overlapping years coincide). From 1967 to 1975 there are some disagreements in the official published data over the value of oil exports due to different valuation (reference prices, tax prices, market prices)
- 1976-1985: PODE , 1985, pp.1 and 13.

Table B.1 Total exports and oil exports. Mexico and Venezuela 1901-1985 (millions of national currency at current prices)

	Mexico				Venezuela			
year	Oil exports 000 barrels	Oil exports mill pesos	Total exports mill pesos	oil/total value %	Oil exports mill barrels	Oil exports mll Blvs	Total exports mll Blvs	oil/total %
1901		n.a.	160.2	0.0%				
1902		n.a.	182.1	0.0%				
1903		n.a.	206.6	0.0%				
1904		n.a.	191.3	0.0%				
1905		n.a.	209.9	0.0%				
1906		n.a.	269.2	0.0%				
1907		n.a.	249.0	0.0%				
1908		n.a.	242.9	0.0%				
1909		n.a.	231.3	0.0%				
1910		n.a.	259.8	0.0%				
1911	902	0.2	294.0	0.1%		1.3	117.5	1.1%
1912	7,729	1.9	298.5	0.6%		1.5	130.9	1.1%
1913	21,331	6.4	305.3	2.1%		2.9	152.5	1.9%
1914	23,366	7.0	321.3	2.2%		1.4	111.5	1.3%
1915	24,769	9.9	251.0	3.9%		1.7	121.3	1.4%
1916	27,269	15.0	486.1	3.1%		1.4	117.7	1.2%
1917	46,024	39.1	305.9	12.8%		2.0	120.0	1.7%
1918	51,767	72.7	375.0	19.4%		2.6	102.7	2.5%
1919	75,550	138.0	392.8	35.1%		2.6	258.7	1.0%
1920	145,509	291.0	854.6	34.1%	491	3.3	170.6	1.9%
1921	172,268	325.9	766.1	42.5%	1,381	11.8	133.6	8.8%
1922	180,866	332.2	643.5	51.6%	2,174	15.7	137.8	11.4%
1923	135,607	259.2	567.2	45.7%	4,251	28.7	156.7	18.3%
1924	129,700	252.6	614.2	41.1%	9,003	65.5	213.5	30.7%
1925	98,858	256.1	680.8	37.6%	19,690	137.5	330.0	41.7%
1926	81,375	202.6	691.5	29.3%	35,331	246.6	395.4	62.4%
1927	52,972	130.2	632.5	20.6%	59,770	280.8	444.1	63.2%
1928	33,387	67.9	591.8	11.5%	104,521	466.9	609.6	76.6%
1929	27,050	55.7	570.0	9.8%	134,694	593.6	778.6	76.2%
1930	26,971	55.2	430.8	12.8%	133,797	634.1	762.5	83.2%
1931	22,503	52.8	366.6	14.4%	115,670	547.8	651.6	84.1%
1932	22,588	52.1	305.6	17.1%	115,468	531.6	628.3	84.6%
1933	22,026	58.7	368.2	15.9%	116,945	553.2	617.5	89.6%
1934	25,018	83.3	643.7	12.9%	134,855	608.5	671.9	90.6%
1935	22,446	76.6	750.0	10.2%	146,923	649.3	711.7	91.2%
1936	21,036	69.4	775.4	9.0%	152,970	684.2	768.5	89.0%
1937	18,253	89.4	892.4	10.0%	183,855	770.0	871.9	88.3%
1938	9,211	43.6	837.1	5.2%	186,000	828.3	887.3	93.3%
1939	14,936	63.4	1,119.6	5.7%	202,300	895.3	953.3	93.9%
1940	14,643	53.0	1,155.3	4.6%	181,200	809.0	860.9	94.0%
1941	8,303	29.2	1,181.2	2.5%	223,900	1,000.6	1,061.6	94.3%
1942	3,145	12.2	1,321.6	0.9%	149,200	635.7	710.5	89.5%
1943	918	3.8	1,989.0	0.2%	176,400	786.2	862.1	91.2%
1944	655	0.0	2,096.2	0.0%	253,030	1,056.9	1,121.4	94.2%
1945	1,535	5.8	2,428.4	0.2%	318,900	1,025.0	1,107.9	92.5%

Table B.1 Total exports and oil exports. Mexico and Venezuela 1901-1985 (millions of national currency at current prices)

	Mexico				Venezuela			
year	Oil exports 000 barrels	Oil exports mill pesos	Total exports mill pesos	oil/total value %	Oil exports mill barrels	Oil exports mll Blvs	Total exports mll Blvs	oil/total %
1946	2,711	14.0	2,765.0	0.5%	382,800	1,330.7	1,449.1	91.8%
1947	3,032	15.2	3,462.4	0.4%	425,800	2,053.6	2,168.3	94.7%
1948	10,925	96.6	4,107.0	2.4%	479,400	3,340.4	3,484.4	95.9%
1949	6,061	66.5	5,615.8	1.2%	467,500	3,259.0	3,360.5	97.0%
1950	11,930	163.7	4,267.9	3.8%	527,200	3,760.5	3,892.2	96.6%
1951	7,427	113.4	5,116.5	2.2%	601,100	4,371.7	4,533.7	96.4%
1952	12,751	217.7	5,408.8	4.0%	637,400	4,616.3	4,858.4	95.0%
1953	3,900	56.0	4,836.2	1.2%	616,400	4,552.8	4,841.7	94.0%
1954	4,767	83.1	6,983.2	1.2%	658,200	5,337.0	5,661.0	94.3%
1955	5,646	100.0	9,232.5	1.1%	748,200	5,900.8	6,277.7	94.0%
1956	6,289	118.5	10,090.0	1.2%	853,800	6,646.9	7,096.9	93.7%
1957	3,158	76.7	8,826.3	0.9%	962,300	7,289.1	7,924.5	92.0%
1958	297	17.7	8,863.8	0.2%	903,200	7,091.9	7,720.3	91.9%
1959	118	2.3	9,037.5	0.0%	962,000	7,281.5	7,937.0	91.7%
1960	1,166	19.2	9,233.8	0.2%	994,300	7,394.4	8,500.3	87.0%
1961	7,273	155.6	10,043.8	1.5%	1,018,500	7,449.7	8,092.2	92.1%
1962	7,692	176.5	11,331.3	1.6%	1,111,700	8,058.0	8,688.6	92.7%
1963	7,466	169.1	11,801.3	1.4%	1,127,800	8,155.2	8,806.8	92.6%
1964	8,101	187.5	12,833.8	1.5%	1,180,500	10,138.0	10,852.0	93.4%
1965	7,497	174.8	14,080.0	1.2%	1,202,800	10,144.0	10,925.0	92.9%
1966	10,586	244.7	14,623.8	1.7%	1,164,400	9,746.0	10,558.0	92.3%
1967	10,272	239.6	13,786.3	1.7%	1,225,100	10,504.0	11,391.0	92.2%
1968	n.a	n.a	14,562.5	n.a	1,248,100	10,277.0	11,154.0	92.1%
1969	n.a	n.a	16,772.5	n.a	1,240,800	10,681.0	11,644.0	91.7%
1970	17,970	504.0	16,120.0	3.1%	1,279,900	10,973.0	12,125.0	90.5%
1971	7,745	433.0	17,070.0	2.5%	1,218,100	13,479.0	14,840.0	90.8%
1972	5,055	324.0	20,830.0	1.6%	1,094,500	15,090.0	16,273.0	92.7%
1973	4,826	449.0	25,896.3	1.7%	1,132,200	22,306.0	23,642.0	94.3%
1974	5,804	1,668.0	35,665.0	4.7%	991,900	61,827.0	64,062.0	96.5%
1975	34,382	5,288.0	38,280.0	13.8%	765,800	44,666.0	46,704.0	95.6%
1976	34,470	7,003.0	57,354.8	12.2%	739,500	37,089.8	39,244.8	94.5%
1977	73,736	23,431.0	105,504.0	22.2%	710,900	39,481.0	41,640.0	94.8%
1978	133,247	41,796.0	137,996.2	30.3%	673,300	37,528.0	39,548.0	94.9%
1979	194,485	91,691.0	201,219.9	45.6%	732,800	58,519.0	61,908.0	94.5%
1980	302,956	239,503.0	347,325.3	69.0%	652,300	78,328.0	83,072.0	94.3%
1981	400,778	357,538.0	475,974.4	75.1%	619,700	81,723.0	84,647.0	96.5%
1982	544,614	953,188.0	1,275,914.5	74.7%	541,600	67,068.0	71,191.0	94.2%
1983	561,005	1,942,564.0	3,353,571.1	57.9%	511,200	59,948.0	65,146.0	92.0%
1984	558,004	2,762,506.0	2,061,257.2	57.0%	523,100	85,714.0	97,214.0	88.2%
1985	523,520	3,753,144.0	6,784,675.6	55.3%	477,900	78,282.0	92,108.0	85.0%

Sources: described above

Appendix C

Fiscal Obligations

Taxes have always been at the core of the policy-making regarding oil. For governments, taxes have historically been the way of getting the 'just' share of the oil profits for the nation. Royalties, surface taxes, exploitation taxes, exploration rights and concessions are the means by which oil is transformed into revenue for the state. In contrast, the companies mostly saw taxes as part of the costs of production. This appendix does not aim to compare the different fiscal regimes of Mexico and Venezuela or their implications, but only to provide a brief idea of the evolution of oil taxation in each country.

As a consequence of the Spanish legal heritage, the basic principle governing the fiscal regime of oil resources in Mexico and Venezuela is that the subsoil belongs to the Nation and therefore the ownership of minerals below the surface is separate and distinct from ownership of the surface. Therefore, all petroleum legislation has national scope. The Mexican government levied two main kinds of taxes before nationalisation: production taxes and export taxes. The production tax on oil was a tax per unit (cubic meter). It was included within the 'Taxes over the exploitation of natural resources', which also comprised mining surface taxes, mining production, use of public waters, game, fishing, woodlands, etc. No production tax was levied on oil from 1901 to 1912. In Venezuela, the oil concessions were subject to the Mining Codes (Códigos Mineros of 1905, 1909, 1910 and 1918) until 1920, when the first Hydrocarbons Law was passed. Seven other laws subsequently modified this legislation during the period 1921-1938. The amount, rates and formulae of each tax category were carefully laid out in the text. A new Hydrocarbons Law was enforced in 1943 and with some modifications, remained in place until oil was nationalised in 1976.[1] Put simply, the history of the Venezuelan oil industry's fiscal obligations is one of an increasing share for the Nation, which culminated in the nationalisation of the industry.

The first difficulty when trying to compile the amounts involved was learning the definitions of the different tax categories, their nomenclature and the evolution of the fiscal system in order to understand the origin of the numbers provided by different

[1] For a chronology and specification of the basic taxes levied under the different hydrocarbons laws up to 1943 see Appendix A in Venezuela. Ministry of Mines and Hydrocarbons, 'The petroleum industry

sources. In the case of Mexico, for instance, it is difficult to discern the categories included within Pemex's taxation system, except that the export tax seems to be 50 percent of the export value from the 1980s. Therefore, before presenting the series, it is necessary to explain briefly the definitions of petroleum-related fiscal duties. Although not always set out in this manner, one can assign oil taxes to six main categories: royalties, income tax, initial exploitation, exploration, surface taxes, custom duties and others.

Five of those six categories are rather easy to define. Royalty oil is a percentage of the total quantity of oil produced in each field. In order to calculate the royalty in cash, the volume of royalty oil is multiplied by a royalty value in the producing field. The agreements to calculate the royalty value, that is, the 'price' of a metric ton of oil at the well-head, are quite complex and varied throughout the century.[2] 'Income Tax' refers to the different obligations imposed on the net income of the companies.[3] 'Initial exploration' is equivalent to the price of the concession. Therefore, it was levied only once when a new concession was granted. 'Exploration tax' was paid during a specific time period during which the title-holder could explore the area before deciding whether to go for an exploitation concession. The government fixed the time span in advance. A 'surface tax' was levied on all concessionaires from the date on which the government granted the parcel for exploration. It usually took the form of a fixed annual sum per hectare. Surface taxes have been paid since the earliest times. The reason behind this lay in the fact that huge concession areas were lying idle instead of either being developed or returned to the nation. 'Other taxes', depending on the publication, may include any combination of those five or actually include 'other taxes' such as transportation taxes or customs duties.

The six categories can be aggregated in different ways: production taxes, export taxes, hydrocarbon taxes, regular taxes, occasional taxes, etc. Generally, the term 'oil taxes' refers to the aggregation of all the original categories, but occasionally 'total petroleum

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and its fiscal obligations by A. Parra', in *1st Venezuelan Petroleum Congress organized by the Venezuelan Society of Petroleum Engineers* (Caracas, 1962),.

[2] A detailed description of the schedule for determining the royalties on crude oil produced is presented in Appendix C of Ibid.

[3] For Venezuela, net income was determined by subtracting the following items from gross income: operating and administrative costs, wages and salaries, royalty payments to the government, depreciation and amortisation charges and other expenses incurred in the country necessary to produce the income. Ibid., p.27.

taxes' may include just some of the six. Table C-1 has been elaborated as a guideline. It attempts to clarify the commonest aggregate terms used in different publications.[4]

Table C-1: Nomenclature of fiscal obligation aggregations

Exploration	Initial Exploitation	Surface	Royalty	Others	Income tax	Customs duties
Occasional Taxes		Regular Taxes				
Production Taxes			Export Taxes			
Total Oil Taxes						

Source: own elaboration

After the 1940s, the relative importance of the occasional taxes decreased abruptly in Venezuela due to the policy of not granting concessions. This event coincided with the creation of the income tax (in effect from 1 January 1943), which soon became the second most important after the royalties.[5]

Some qualifications are needed regarding the consistency of the data. The fiscal duties levied on oil production, the actual taxes collected and the taxes declared by the companies differ slightly. The basic reason is the time that elapsed between the imposition of the levy and the collection of the tax. In addition, the companies added some taxes to their capital accounts. Whenever possible, the amount used here was that of the actual receipts collected. It is also important to notice that from 1966 taxes were computed at the new higher rate, based on the tax reference price or realised price, whichever was higher. Tax reference prices for crude oils were set according to a mathematical formula articulated on basic gravity differentials. Indeed, the Venezuelan government presented the companies with a retroactive bill back to 1958, claiming the differential between the reference price and the price declared by the companies. Therefore, figures for those years were revised and the most recent were adopted for the series. Figures C-1 and C-2 compare total fiscal income to oil fiscal revenues for Mexico and Venezuela.

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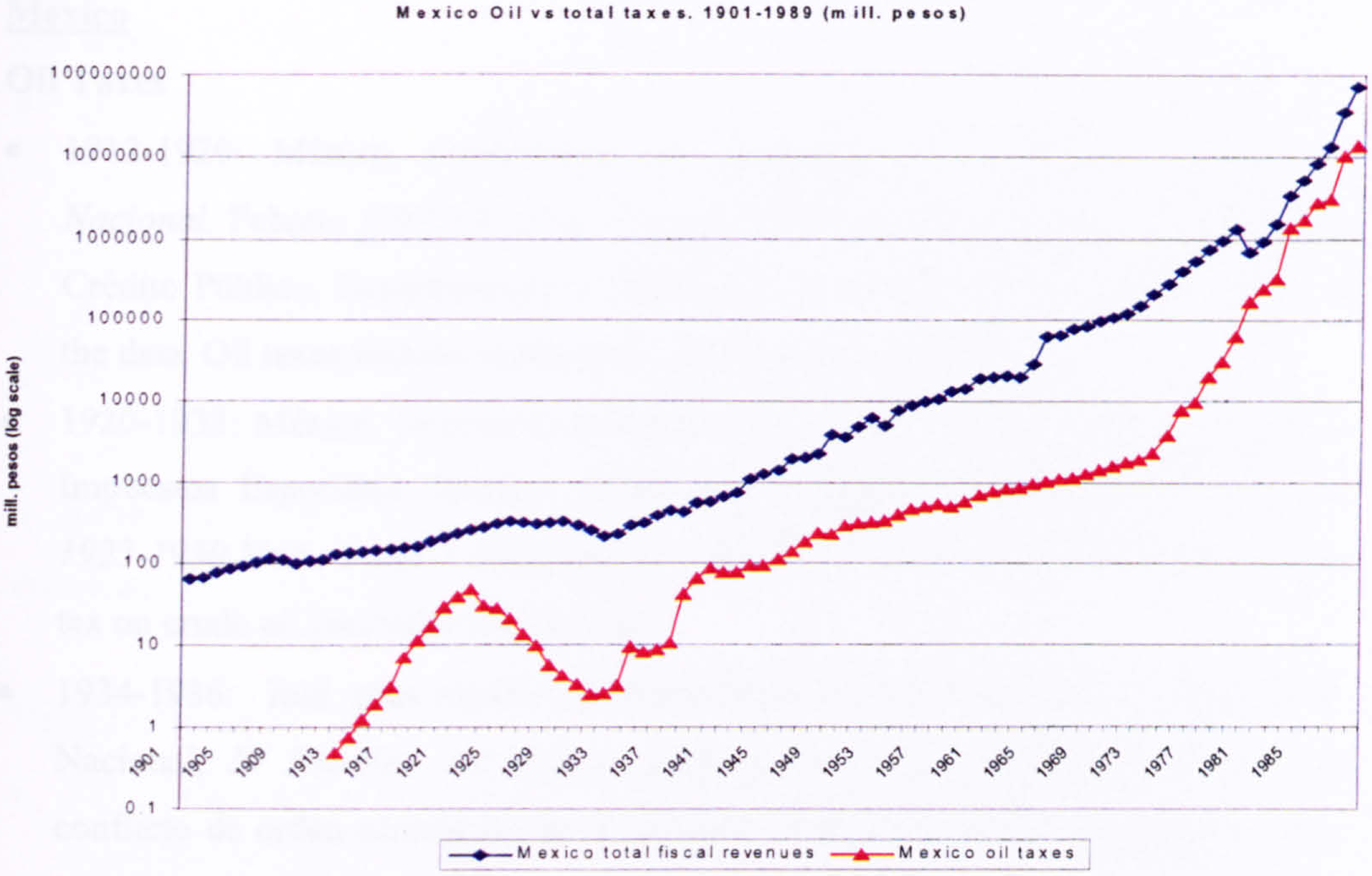
[4] Venezuela. Ministerio de Fomento, *Diversos Aspectos de la Economía Venezolana* (Caracas, 1948) and Venezuela. Ministry of Mines and Hydrocarbons, 'The petroleum industry and its fiscal obligations by A. Parra', were useful in the elaboration of the table alongside with substantial crosschecking of figures.

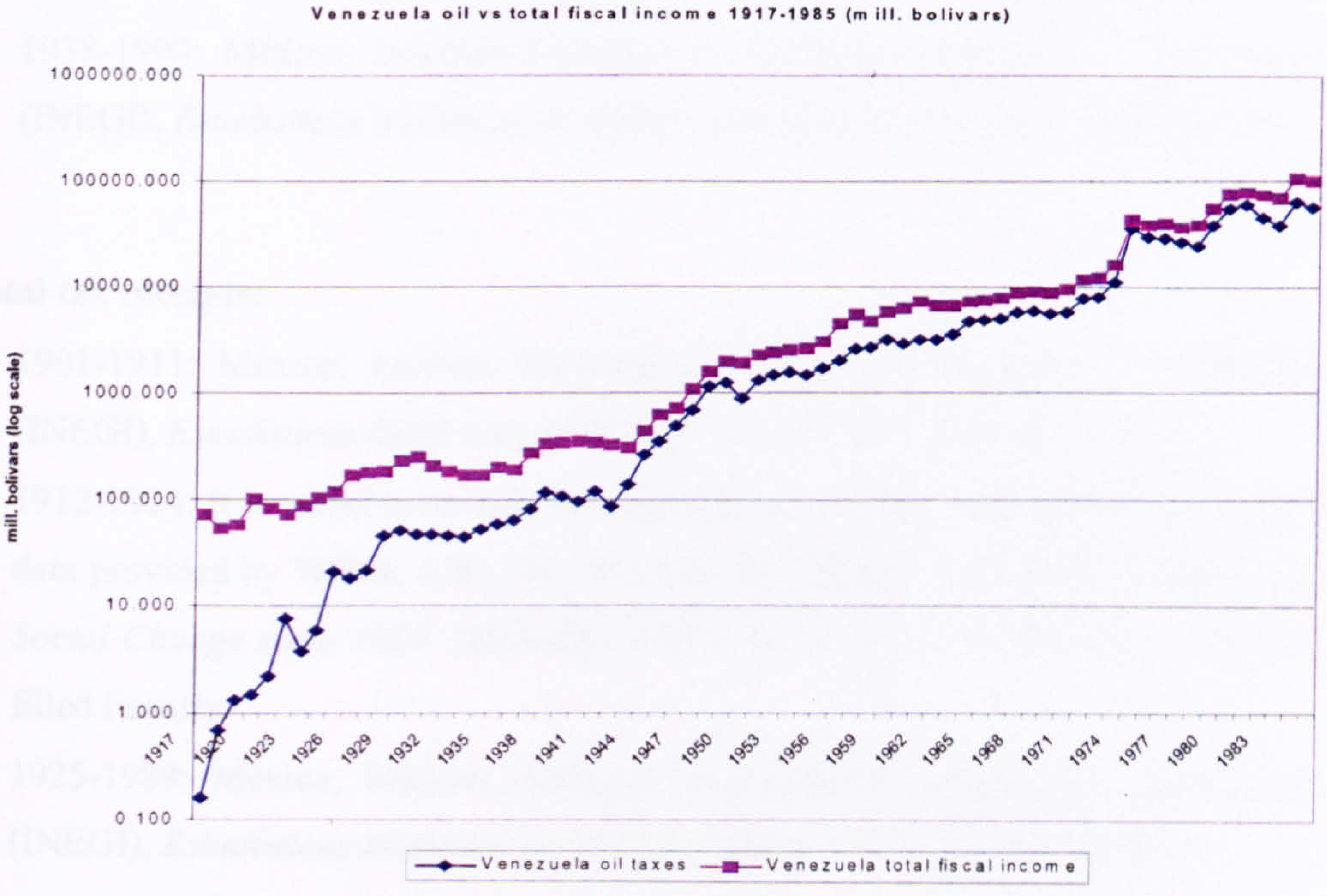
[5] By 1946, income tax accounted for 30 percent of all regular taxes and by 1961, after the application of the 50-50 share with the companies, it accounted for almost 50 percent of all regular taxes. Royalties accounted always for more than 50 percent of all regular taxes from 1938 to 1961. Source: Table D-4, Appendix D in Ibid.

Figure C-1: Oil taxes vs. total fiscal income. Mexico 1901-1989 (mill. pesos)



Sources: same as Table C-2

Figure C-2: Oil taxes vs. total fiscal income. Venezuela1917-1985 (mill. bolivars)



Sources: same as Table C-2

Sources and notes for total and oil taxes data in Table C-2:

<u>Mexico</u>

Oil Taxes

- 1912-1920: México, Government of, 'Estadísticas del Petróleo', *Estadística Nacional.* Febrero (1925) 4, p.26. The source names the Secretaría de Hacienda y Crédito Público, Departamento de Impuestos Especiales as the ultimate origin of the data. Oil taxes include production and export tax of crude oil.
- 1920-1933: México, Secretaría de Hacienda y Crédito Público, Departamento de Impuestos Especiales, Sección de Petróleo, *Cuadros estadísticos del petróleo, 1925-1930* Vols. 1 and 2 (México D.F., 1936). It refers to production and export tax on crude oil (excludes derivatives).
- 1934-1936: Ibid. plus royalty payments from México, Secretaría de Patrimonio Nacional, *El Petróleo de México.* Recopilación de documentos oficiales del conflicto de orden económico de la industria petrolera con una...., (México D.F., 1940 1st ed., 1963).
- 1937: México, Secretaría de Hacienda y Crédito Público, Dirección General Técnica de Ingresos, Oficina de Investigaciones Económicas, *La Industria del Petróleo en México* edited by Manterola, M. (México, D.F, 1938), p. 387.
- 1938-1990: México, Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994), p.574.

Total tax receipts:

- 1901-1911: México, Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994).
- 1912-1924: It is possible to infer government income for 1912 and 1918 from the data provided by Wilkie, J.W., *The Mexican Revolution: Federal Expenditure and Social Change since 1910* (Berkeley, 1967), Table I.II, p.28. The gaps were then filled linearly.
- 1925-1989: México, Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994).

Venezuela:

Oil taxes:

- 1917-1955: Venezuela. Ministry of Mines and Hydrocarbons, *Venezuelan Petroleum Industry. Statistical Data* (Caracas, 1962), Appendix D, Table D-5. Includes royalty, surface tax, income tax (from 1944), customs duties, other taxes, and occasional taxes.
- 1955-1964: PODE 1970, p.155. Regular taxes actually collected by the Exchequer.
- 1964-1974: PODE 1974, p.141. Regular taxes actually collected by the Exchequer.
- 1974-1985: PODE, 1984.Regular taxes levied (excluding gas royalties)

Overlapping years generally coincident, otherwise the most recent source was used.

Total tax receipts:

- 1917-1963 (here only up to 1943): Carrillo Batalla, T.E., *La evaluación de la inversión del ingreso fiscal petrolero en Venezuela [conference sponsored by Universidad Central de Venezuela. Foro Petrolero 1965]*. Colección Foros y Seminarios. Serie Foros. 5, (Caracas, 1968), cuadro no.7, p.234-235.
- 1943-1976: Banco Central de Venezuela, *La economía venezolana en los últimos treinta cinco años* (Caracas, 1978),p. 273 .
- 1977-1985: PODE, 1985, p. 1

Table C-2 Total vs. oil fiscal revenues.
Mexico and Venezuela 1901-1985 (mill. national currency at current prices)

	Mexico			Venezuela		
Year	Governm.total Tax income Mill. pesos	Oil sector Tax paid mill. pesos	Share oil/total	Governm.total Tax income mill. blvs	Oil sector Tax paid mill. blvs	Share oil/total
1901	63		0.0%			
1902	66		0.0%			
1903	76		0.0%			
1904	86		0.0%			
1905	92		0.0%			
1906	102		0.0%			
1907	114		0.0%			
1908	112		0.0%			
1909	99		0.0%			
1910	106		0.0%			
1911	111		0.0%			
1912	126	0.49	0.4%			
1913	131	0.77	0.6%			
1914	137	1.23	0.9%			
1915	142	1.91	1.3%			
1916	147	3.09	2.1%			
1917	153	7.07	4.6%	72.00	0.16	0.2%
1918	158	11.48	7.3%	53.00	0.69	1.3%
1919	181	16.69	9.2%	57.00	1.31	2.3%
1920	205	28.65	14.0%	101.00	1.47	1.4%
1921	228	38.13	16.7%	82.00	2.21	2.7%
1922	252	47.75	19.0%	71.00	7.50	10.6%
1923	275	29.48	10.7%	88.00	3.78	4.3%
1924	299	28.22	9.5%	102.00	5.91	5.8%
1925	322	20.95	6.5%	120.00	20.89	17.4%
1926	309	13.39	4.3%	172.00	17.88	10.4%
1927	307	9.93	3.2%	182.00	21.43	11.8%
1928	311	5.69	1.8%	187.00	46.19	24.7%
1929	322	4.23	1.3%	230.00	50.54	21.9%
1930	289	3.32	1.2%	256.00	47.33	18.5%
1931	256	2.45	1.0%	210.00	46.98	22.4%
1932	212	2.57	1.2%	185.00	45.15	24.4%
1933	223	3.23	1.4%	172.00	44.78	26.0%
1934	295	9.45	3.2%	172.00	52.05	30.3%
1935	313	8.09	2.6%	203.00	59.30	29.2%
1936	385	8.87	2.3%	189.00	63.61	33.7%
1937	451	10.59	2.3%	274.00	81.78	29.8%
1938	438	41.00	9.4%	331.00	118.61	35.8%
1939	566	63.00	11.1%	341.00	109.48	32.1%
1940	577	87.00	15.1%	354.00	97.71	27.6%
1941	665	76.00	11.4%	346.00	121.45	35.2%
1942	746	76.00	10.2%	325.00	87.76	27.0%
1943	1,092	93.00	8.5%	306.00	139.30	45.5%
1944	1,295	92.00	7.1%	446.00	269.39	60.4%
1945	1,404	109.00	7.8%	614.00	353.50	57.6%

(cont.)

Table C-2 **Total vs. oil fiscal revenues.** *(cont.)*

Mexico and Venezuela 1901-1985 (mill national currency at current prices)

Year	Mexico: Governm.total Tax income Mill. pesos	Mexico: Oil sector Tax paid mill. pesos	Mexico: Share oil/total	Venezuela: Governm.total Tax income mill. blvs	Venezuela: Oil sector Tax paid mill. blvs	Venezuela: Share oil/total
1946	2,012	137	6.8%	716.00	489.01	68.6%
1947	2,055	181	8.8%	1,100.00	689.48	62.7%
1948	2,268	231	10.2%	1,562.00	1,158.10	74.1%
1949	3,891	230	5.9%	1,936.00	1,269.34	64.7%
1950	3,641	293	8.0%	1,896.00	901.06	47.5%
1951	4,884	312	6.4%	2,267.00	1,317.10	58.1%
1952	6,338	327	5.2%	2,408.00	1,475.82	61.3%
1953	5,023	339	6.7%	2,534.00	1,589.07	62.7%
1954	7,714	399	5.2%	2,632.00	1,497.90	56.9%
1955	9,024	459	5.1%	2,992.00	1,712.00	57.3%
1956	10,194	493	4.8%	4,380.00	2,037.00	70.9%
1957	10,870	540	5.0%	5,405.00	2,618.00	70.7%
1958	13,183	508	3.9%	4,706.00	2,680.00	57.7%
1959	14,163	576	4.1%	5,743.00	3,153.00	56.2%
1960	19,458	694	3.6%	6,147.00	2,930.00	48.8%
1961	19,941	778	3.9%	7,074.00	3,160.00	45.7%
1962	20,398	840	4.1%	6,486.00	3,142.00	48.9%
1963	19,704	864	4.4%	6,604.00	3,511.00	54.4%
1964	28,976	955	3.3%	7,197.85	4,693.00	65.2%
1965	64,283	1,015	1.6%	7,310.77	4,752.00	65.0%
1966	66,619	1,097	1.6%	7,793.38	4,941.00	63.4%
1967	79,459	1,134	1.4%	8,582.83	5,699.00	66.4%
1968	85,278	1,301	1.5%	8,824.24	5,824.00	66.0%
1969	97,509	1,455	1.5%	8,730.89	5,483.00	62.8%
1970	109,064	1,585	1.5%	9,569.05	5,751.00	60.1%
1971	120,549	1,776	1.5%	11,695.59	7,684.00	65.7%
1972	148,445	1,921	1.3%	12,309.12	7,964.00	64.7%
1973	205,661	2,283	1.1%	16,099.00	11,221.00	69.7%
1974	281,626	3,800	1.3%	42,649.53	36,508.00	85.6%
1975	403,615	7,674	1.9%	38,130.49	29,513.00	77.4%
1976	528,451	9,682	1.8%	39,443.54	28,991.00	73.5%
1977	734,180	19,764	2.7%	36,572.21	26,588.00	72.7%
1978	950,647	30,283	3.2%	38,566.10	24,798.00	64.3%
1979	1,293,073	62,390	4.8%	55,791.00	38,440.00	68.9%
1980	683,781	168,107	24.6%	76,022.13	54,964.00	72.3%
1981	931,777	242,706	26.0%	77,918.95	59,608.00	76.5%
1982	1,515,403	317,040	20.9%	73,376.79	46,154.00	62.9%
1983	3,396,592	1,345,300	39.6%	68,672.57	38,800.00	56.5%
1984	5,089,025	1,710,680	33.6%	104,663.93	63,845.00	61.0%
1985	8,218,361	2,741,998	33.4%	99,333.33	57,216.00	57.6%

Sources: as described above

Appendix D

National Accounts Estimates

National accounts began in Latin America towards the end of the 1940s and, as will be seen, they only started to acquire importance in the early 1950s.[1] At that time, the work consisted of estimates of the gross domestic product by industrial origin and its structure by type of expenditure. In 1947, under the technical guidance of Simon Kuznets, a study by L.M. Domínguez presented national income estimates for Latin American countries based on official publications.[2] By the 1960s, all Latin American countries produced estimates of their GDP, and some of them had managed to draw up -with certain restrictions- a simplified system of accounts following the recommendations of the United Nations. Venezuela and Mexico were two of the first countries to implement the SNA of the United Nations.[3] However, until relatively recently, a problem was the lack of proper independent estimates with which to cross-check the official estimates of product and income.[4] This rather surprising point will be confirmed below when analysing the sources of GDP series for both countries. We are nevertheless attempting to approximate the measures of income and wealth of Venezuela and Mexico as closely as possible taking into account the recent concerns for exhaustible resources.

This appendix justifies the choices made with to regard the national income data sources used in the thesis for Mexico and Venezuela. For each of the two countries the appendix first surveys the successive approximations to national accounting series before entering in the specific problems associated with each country's data series.

[1] C. Noriega, 'The Present State of National Accounts in Latin America', *Review of Income and Wealth* XII (1976) 2.
[2] L.M. Domínguez, *National Income Estimates of Latin American Countries*, Vol. X (New York, 1947).
[3] For a detailed view in the adoption of the new system by Venezuela, see, L. Urdaneta, 'Some aspects of the revision of the system of national accounts in Venezuela', *Review of Income and Wealth* 22 (1976) 1.
[4] C. Noriega, 'The Present State of National Accounts in Latin America', *Review of Income and Wealth* XII (1976) 2, p.136.

D.1 The Evolution and Reliability of Mexico's National Accounts Estimates during the 20th Century

When one first approaches the availability of historical economic indicators, one tends to start by looking first at the official sources and then uses independent estimates to assess their reliability. We show here that, in the case of Mexico, while official sources are readily available there is very little independent work done which permits an immediate assessment of reliability by comparison of the data. Therefore, it is necessary to look closely at the official sources in order to identify their potential biases and to establish the quality of the data provided. With this aim in mind, we start by briefly reviewing the individuals and institutions involved in the development of economic indicators of Mexico throughout the century. We then assess the quality and reliability of the most recent estimates and conclude by summarising the qualifications one should make for different periods.

The Evolution of the Mexican National Accounts Estimates

The study of the economic development of Mexico from the end of the 19th century to the present day has been hindered by the absence of systematic data until 1939, when the Banco de México began to prepare such information. Although the economic statistics of the Porfiriato (1900-1910) were relatively advanced for their time, the changes brought by the revolution and the reform plunged the country into a statistical dark age. Therefore, work on national income estimates for Mexico did not begin until the late 1930s. The first printed estimate of national income by Emilio Alanis Patiño appeared in 1938 published by the Dirección General de Estadística (General Bureau of Statistics).[5] It was prepared on the basis of his own estimates of national wealth for 1929, to which an arbitrary coefficient of 0.2 was applied to provide a national income estimate. In 1942, ex-president Abelardo L.Rodríguez released statistics on national income for 1929 and 1941 that appear to have been developed on the basis of Alanis Patiño's earlier estimates.[6]

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[5] México. Secretaría de la Economía Nacional. Dirección General de Estadística, *México en cifras* (México D.F., 1938) A fine review of national statistics before 1930 can be found in México. Departamento de la Estadística Nacional, *Anuario de 1930* (México D.F., 1932). Specialised references to historical estimates of national income prepared before 1950 are E. Vargas Torres, 'Estimaciones del ingreso nacional de México', in *Primera Reunión de Técnicos sobre el Banco Central* (México D.F., 1946) and G.H. Aubrey, 'The National Income of Mexico', *I.A.S.I. Estadística* (1950 June) A more recent study on the historical statistics of Mexico is Peña, Sergio de la and J.W. Wilkie, *La estadística económica en México : los orígenes* (México, D.F, 1994). However, most of this section relies on C.W. Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth* (London, 1970).

[6] 'Sacrificios de la población rural', in *El Universal*, 28 December 1942, as quoted in Aubrey, 'The National Income of Mexico', p.190.

After Alanis Patiño, the major figure in Mexican national accounting was Josué Sáenz. He was Director of the General Bureau of Statistics in the 1940s and he was largely responsible for the first consistent time series of national income estimates covering the period 1929 to 1945. His work was subsequently expanded to include later years.[7] These series are an estimate of 'net domestic output of goods and services', in which gross production of the various groups was adjusted wherever possible for payments to other industries for raw materials, fuel and power, depreciation, cost of transport and indirect taxes.

Despite the significant contribution made by the General Bureau of Statistics, a report to the Banco de México in 1946 called attention to the wide discrepancies in existing estimates of the net national product for 1942, ranging from a figure by Alanis of 4,079 million pesos, Sáenz's second estimate of 8,928 million pesos (net domestic output) and a further estimate by the Banco de México of 11,972 million pesos.[8]

As from 1947, the Banco de México itself embarked upon a major effort to prepare more reliable benchmark estimates of national income for the years 1939 to 1945, partly in response to a request of the IBRD.[9] The resulting estimates were used as a basis for interpolation of intervening years, utilising indices of the volume of production of goods and services, which were reflated by a combination of wholesale price indices. The IBRD continued to provide a stimulus for improving the national income estimates as a requirement for the evaluation of the performance of the Mexican economy and loans policies towards the country.

In 1951, a joint working party of Mexican and World Bank economists prepared a GNP series based upon four benchmark years (1939, 1944, 1946 and 1949). Income was classified by principal production sector, by distributive shares and on a functional basis, with annual statistics interpolated for the entire period 1939-49 and estimates for 1950.[10] The World Bank study, despite its numerous weaknesses, represented a milestone in Mexican economic statistical research. Successive improvements in the quality and coverage of post War data eventually revealed a much more rapid rate of growth of real output than earlier series had indicated.

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[7] The figures first appeared in J. Sáenz, 'El ingreso nacional neto de México, 1929-1945', *Revista de Economía* (1946 February) 28. A subsequent updated series appeared in México. Secretaría de la Economía Nacional. Dirección General de Estadística, *Compendio estadístico 1947* (México D.F., 1947 January), p.534.

[8] Vargas Torres, 'Estimaciones del ingreso nacional de México'.

[9] Banco de México, *Informe anual* (México D.F., 1950).

[10] R. Ortiz Mena, V. Urquidi, et al., *El desarrollo económico de México y su capacidad para absorber capital del exterior* (México D.F., 1953).

One year later, the Nacional Financiera began estimating total supply and demand in the economy, based upon the Banco de Mexico's gross product estimates plus its own series on trade, public and private investment, public consumption, and net inventory change. As a result of those efforts, a GDP series at factor cost by branch of activity from 1939 to 1950 was published in 1953.[11]

In 1955, the Banco de México drew upon the results of the 1950 population and agricultural censuses to revise its national income and product series for the years 1939 to 1949. These figures have been revised in the Annual Reports of the Bank for each year since 1954.

A third, but still institutional source of national income figures for Mexico is the United Nations Economic Commission for Latin America (ECLA), which has been estimating the 'producto bruto real' (real gross product) in constant prices since 1950.[12] The method used was weighting physical production indices by the relative values of the base year (1950). In addition to these estimates, in 1957 ECLA sponsored a study of the actual and projected trade conditions of Mexico. It was based upon a relatively detailed set of estimates of the principal components of Mexican national income and product for the period 1945-1955 with projections up to 1965, all expressed in 1950 pesos.[13]

Recognising the need for improved national income estimates, the Mexican government and the Banco de México drew upon the services of Martin Ekker and Cornelius Oomens to prepare a detailed survey of national accounts and economic statistics in Mexico and an input-output table. Though the table refers to 1950, it was not completed until 1958.[14] All subsequent Banco de México official estimates of GDP and GNP through the end of 1968 relied upon the adjusted 1950 input-output table.

It is not until the 1960s that attention was directed to quantitative indicators of Mexican economic history. A number of gaps in the data for the Porfiriato were filled

[11] Ibid.

[12] United Nations. Economic Commission for Latin America, *Economic Survey of Latin America* (New York, 1950) and subsequent years.

[13] United Nations. Economic Commission for Latin America, *External Disequilibrium in the Economic Development of Latin America: The case of Mexico* (New York, 1957) as quoted in Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth*, p. 336.

[14] The original 1950 input-output table appears condensed in the article by Ekker in S. Kuznets, *Income and Wealth series* (Cambridge, 1951). See also Banco de México, *Estructura y proyecciones de la economía de México, 1950,1960 y 1965* (México D.F., 1958), as cited in E. Vargas Torres, 'Las estimaciones del ingreso nacional en México', *El Trimestre Económico* (1960) 27.

by scholars at El Colegio de México.[15] Nevertheless, the first detailed estimate of gross national product on an annual basis from 1895 to 1964 (with no data for the revolution years, 1911-1920) was prepared by Enrique Pérez López in constant pesos of 1950.[16] The pre-1939 estimates were calculated extrapolating the distribution of the 1939 total domestic product by sector (agriculture, livestock, mining, petroleum, manufactures and transport) back to 1895. The estimates were described as 'provisional' by the author and only cover half of the gross national product before 1939. For the period after 1939, he used data prepared by the Banco de México.[17]

Pérez López's estimates for the period 1895-1939 were revised, by Mario Gutiérrez Requenes under the direction of L. Solis, Chief of Economic Studies of the Banco de México, and extended to 1967.[18] It looks as if the Banco de México retained Pérez López's results for 1939-1960, changing the weights from 1950 to 1960. It redid his estimates for 1921-1939, but did not bother to modify his results for 1895-1921.[19] The other independent estimate of gross domestic product for the years 1900,1910,1925,1930 and 1940 is by Reynolds in 1970. This author recalculated production indices for the periods 1900-1907 and 1907-1929. His results are not that much different from those of Gutiérrez.

In the late 1970s, the Instituto Nacional de Estadística, Geografía e Informática (INEGI) replaced the Banco de México as the provider of estimates. Therefore the new official series from 1960 onwards are those by INEGI.[20] Since 1985, it has also published a historical GDP series extending from 1895 to the present day.[21] To conclude this summary, one should add that Reyes Heroles and Sidaoui produced a detailed reconciliation of the Banco de México figures and those of the INEGI.[22]

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[15] Colegio de México, *Estadísticas económicas del Porfiriato: comercio exterior de México, 1877-1911* (México D.F., 1960).
Colegio de México, Seminario de Historia Moderna de México, *Estadísticas económicas del Porfiriato: fuerza de trabajo y actividad económica por sectores* (México D.F, 1965).

[16] E. Pérez Lopez, 'The National Product of Mexico: 1895 to 1964', in Pérez López and et al (eds.), *Mexico's Recent economic growth* (Austin, 1967).

[17] Banco de México, 'Informe sobre la revisión preliminar de las estimaciones del producto nacional de México para los años de 1950 a 1962', *Comercio Exterior* (September 1963).

[18] Banco de México, *Producto bruto interno y series básicas, 1895-1967* (México D.F., January 1969).

[19] The comment corresponds to A. Maddison and associates, *The Political Economy of Poverty, Equity and Growth. Brazil and Mexico* (Washington, D.C., 1992), p.219.

[20] México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Sistema de cuentas nacionales de México: cuentas consolidadas de la nación, oferta y utilización, producto interno bruto, 1980-86* (México D.F., 1987).

[21] México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994).

Table D-1:
Successive approximations of Mexican National Income for the years 1929/1939/1942/1950 and 1960

Author	Date	Concept used	Million current pesos				
			1929-30	1939	1942	1950	1960
Alanis Patiño	1938	National Income	2,042 (1929)				
Alanis Patiño	1943	National Income		3,070			
Sáenz	1942	National Income	2,044 (1929)		6,916 (1941)		
Sáenz	1943	National Income	2,835 (1929)		6,918		
Sáenz	1945	Net Domestic Output	2,835 (1929)	6,139	8,928		
World Bank Study	1951-52	National Product		5,737	9,255	37,816	
Ortiz/N.Financiera♠	1953	GDP		5,824	9,393	38,077	
ECLA	1957	GDP				43,299	
Banco de México	1959	National Income		5,900	9,500	37,500	
Banco de México♣	1959	GNP		6,657		41,500	
Perez López[a]	1960	GNP	4,111 (1930)			41.500	
Banco de México	1962	National Income				36,630	
Banco de México	1964	GNP		6,460	10,172	40,577	
Banco de México	1964	GDP		6,559	10,332	41,060	
Gutierrez[c]	1969	GDP	4,111 (1930)				
Solis-Banco de México[d]	1969	GDP				44,016	
Reynolds[b]	1970	GDP	3,954 (1930)			41,060	
Banco de México[e]	1986	GDP				42,163	159,703
INEGI[f]	1994	GDP	4,668 (1930)	7,785	10,681	42,163	159,703

Sources and notes
The table is a combination of C.W., Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth* (London, 1970). pp. 330-31, 340-41] plus own elaboration.
Note that some of the differences in the figures correspond to differences in the concept used.
♠ R. Ortiz Mena, and et al (eds.), *The Economic Development of Mexico* (Baltimore, 1953)., table 2, pp.8-13 .
♣ Elaborated by Banco de México but published by México. Secretaría de Industria y Comercio. Dirección General de Estadística, *México en Cifras, 1959* (México D.F., 1959), p.55.
a Based on the GNP estimate of 15,538 million 1950 pesos converted to current values using the wholesale price index for Mexico, D.F. (1930 = 100; 1950 = 378) quoted in C.W. Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth* (London, 1970).
b Based on a 1930 GDP estimate of 14,946 million 1950 pesos converted to current values as in **a**.
c Based on a GDP estimate of 15,540 million 1950 pesos converted as in **a**.
d Banco de México, *Informe anual* (México D.F., 1960).
e Banco de México, *Indicadores económicos* (México D.F., May 1986).
f México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994).

One reason for the tendency of policy-makers in the early years to disregard aggregate economic indicators was the wide variation in data available on crucial matters such as the level and rate of growth of agricultural and industrial production and the current value of national income and product. As a result, national income statistics until well into the 1950s were used primarily to reflect the successes or failures of political administrations rather than as basis for policy formulation.[23]

[22] J. Reyes Heroles and D. Sidaoui, 'Cuentas nacionales y análisis macroeconómico'. (México D.F., 1981).
[23] Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth*, p.330.

Table D-1 summarises the main approximations to national income and product made over the period 1938 -1994.[24] As was mentioned above, no regular data collection or analysis was done until 1939. Therefore, if one were to analyse data reliability by periods, one should first divide the century into pre- and post-1939. Nevertheless, it should be obvious from the table figures that until well into the 1950s the range of variation of the estimates made them of little more than decorative value. The best that could be obtained as late as the mid-1960s was a reasonably accurate set of estimates of GDP and GNP by sector of industrial origin and by functional distribution.[25] However, the successive efforts described above improved the quality of the data available to the researcher by quite a margin. Indeed, it is almost axiomatic that successive revisions of national income estimates have tended to shift revealed growth rates upward.[26]

It may be worth recalling the sources used and qualifications made by Maddison in two of his approximations to Mexican historical GDP series.[27] In his 1992 comparative work on Brazil and Mexico, he only used series going back to 1950.[28] He used Banco de México data for GDP at current market prices to 1979, thereafter, until the end of his series in 1988 he uses the INEGI's data.[29] Despite recognising that 'the INEGI series, now the official source for national accounts, is wider in coverage than the earlier Banco de México estimates', he still uses Banco de México figures for most of his series.[30] Nevertheless, at least for the years 1921-1950, it seems as if the whole Banco de Mexico series have been revised by the INEGI according to the figures presented in the table above, since INEGI figures are always above those previously calculated by the Banco de México. In his 1995 work, Maddison presented the levels of GDP and GDP per capita in constant dollars of 1970 from 1820 to 1994. Sources going back to 1950 are identical to those of his previous work.[31] The 1900-1950 estimates are based on sector weights for 1947 and data for the pre-1900 period is taken from INEGI, Estadísticas Históricas de México, 1985. He argues that the reason

[24] For another comprehensive survey of the quantitative history of Mexico see Statistical Abstract of Latin America Suplements, V.27 'The Development of Quantitative History in Mexico since 1940'.
[25] Reynolds, *The Mexican Economy. Twentieth-Century Structure and Growth* .
[26] Ibid., p. 335.
[27] A. Maddison, *Monitoring The World Economy, 1820-1992* (Paris, 1995)
Maddison and associates, *The Political Economy of Poverty* .
[28] Ibid., p.221, sources to Table B.2.
[29] Banco de México, *Indicadores económicos* (México D.F., May 1986) and México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Anuario Estadístico de los Estados Unidos Mexicanos* (México D.F., 1990).
[30] Maddison and associates, *The Political Economy of Poverty* , p. 219.
[31] Maddison, *Monitoring The World Economy, 1820-1992* , p.143.

for inferring the 1900-1950 data instead of using official sources is that 'for 1895-1960 the official estimates, by the Banco de México, are not adequately described. For 1895-1921 they are identical in movement with the estimated of E. Pérez López. He describes his estimates as provisional, and, as he assumed that service output (half of GDP) moved at the same rate in real terms as commodity output, his estimates probably overstate growth (and)...the official Banco de México series are very close to the estimates of Pérez López for 1939-60 but show lower growth than he does for 1921-39'.[32] Therefore, he decided to infer the data from 1947 backwards. However, other historical studies have used and continue using data from the official sources, that is the Banco de Mexico and INEGI.[33]

The GDP data used on the present research corresponds to the most recent publication of the historical series of Mexico by the INEGI (1994).[34] According to the evidence presented here, this is the most consistent source available at least from 1950 to the present day.

A Note on Mexican on Physical Capital Depreciation and Savings

In absence of complete series historical national accounting is not possible to find a set of fixed capital consumption estimates readily available for Mexico pre-1970s that could be used in Chapter 6 for comparison with natural capital depreciation. However, there are a number of possibilities to reconstruct the series. For instance, one can estimate the fixed capital consumption on the basis of the national income estimates available, i.e. by difference between the GDP and the NDP (approximated by the national income). A complete set of national income can be put together from different sources for the period 1929-1992. However, it seems as if the national income produced by Banco de México was calculated as a fixed proportion of the GDP. From 1948 to 1960 that proportion is invariably 87 per cent. Alternatively, one should be able to produce series of fixed capital consumption if the gross and net stock of capital of the nation is known. Hofman has recently produced series of gross and net stocks of

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[32] Maddison and associates, *The Political Economy of Poverty*, p.219.

[33] Among others E. Cárdenas, *La industrialización mexicana durante la Gran Depresión* (México D.F., 1987); E. Cárdenas, *La política económica en México 1950-1994* (México D.F., 1996) and R. Thorp, *Progress, Poverty and Exclusion. An Economic History of Latin America in the 20th Century* (New York, 1998).

[34] These series going back to 1950 fully match the figures presented by Maddison and associates, *The Political Economy of Poverty*.

capital for nine Latin American countries from 1950 at constant 1980 prices.[35] Fixed capital consumption can be obtained by difference of the gross and net series.

As a result of the lack of data, three different series of consumption of fixed capital were produced and analysed for the present research. 'Series 1' covered from 1929 to 1968 and used as its starting point the national income estimates from three different sources (see Figure D.1-1): Sáenz, Banco de México and Nacional Financiera. 'Series 2' covered from 1950 to 1979, in which the series of Hofman serve as a base for calculating the consumption of fixed capital in current prices using the corresponding capital price indices supplied by the INEGI.[36] 'Series 3' used the data from Mexican national accounts available from 1970 to 1992. The respective fixed capital consumption series resulting from each estimation are plotted in Figure D.1-1
The best way to obtain a coherent series for the whole period seems to be to connect all three series in the following way: Pre-1960 the national income estimates (i.e. Series 1) are used as NDP and the corresponding consumption of fixed capital calculated. From 1960 to 1978, Series 2 are used, and from that date to the end of the period official national accounts are used (i.e. Series 3). Once the series of fixed capital consumption has been constructed it was used to construct the NDP (by subtracting fix capital consumption from the GDP) and the gross savings series that appear in Chapter 6.

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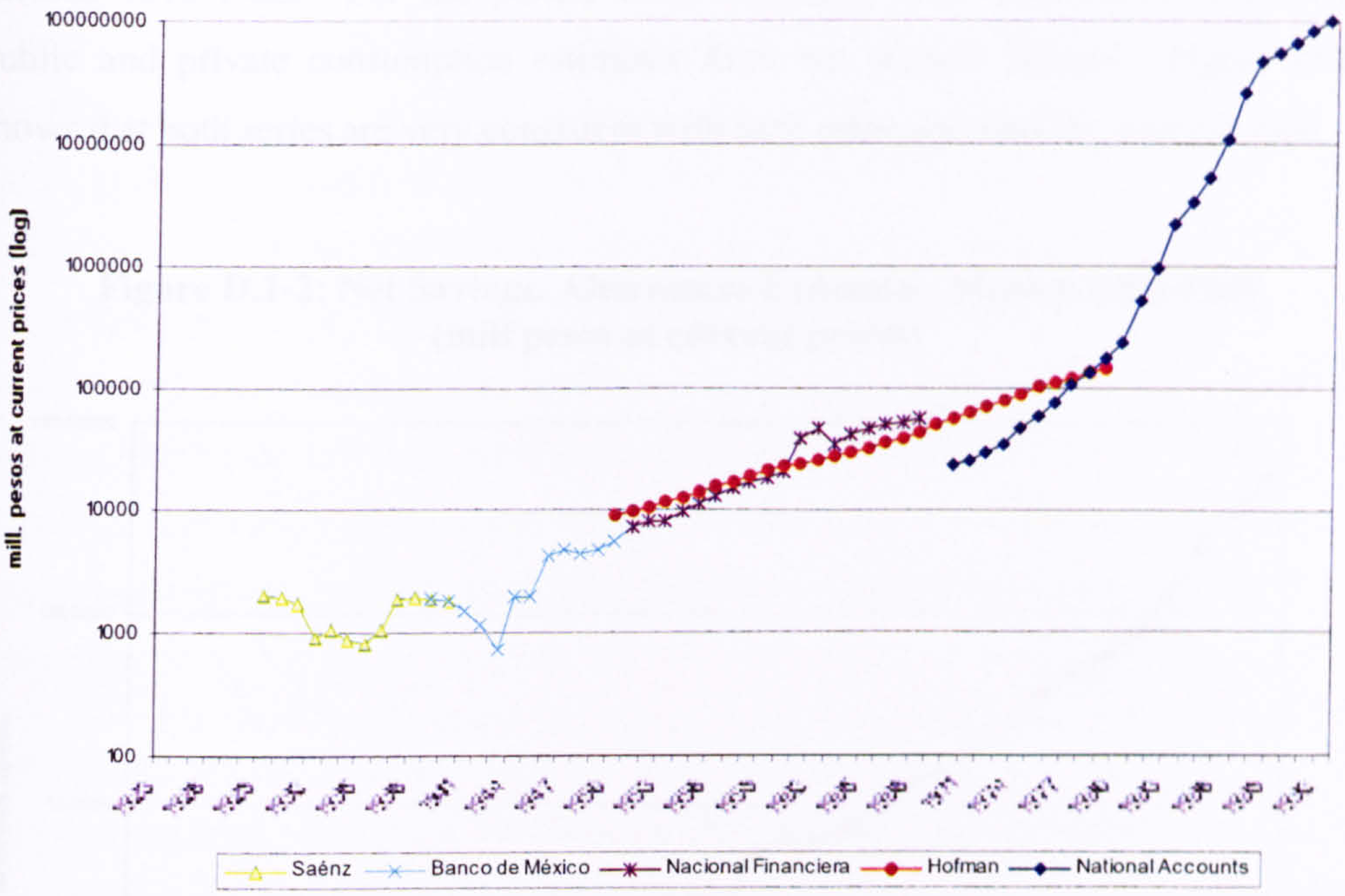
[35] A.A. Hofman, *The Economic Development of Latin America in the Twentieth Century* (Cheltenham, UK, 2000). He also summarises the previous attempts to generate estimates of the capital stock.
[36] México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México*, pp. 966-967.

Figure D.1-1: Consumption of fixed capital from different sources. Mexico 1929-1989 (mill. pesos at current prices)



Sources and notes:

Series 1:

Consumption of fixed capital inferred from the difference between national income and national product. National income sources as follow:

1929-1940 J. Sáenz, *El ingreso nacional neto de México, 1929-1945* (1946 February), p.32

1939-1960 Banco de México, *Informe anual* (México D.F., 1960), p.73

1939-1968, Nacional Financiera, *Statistics on the Mexican Economy* (México D.F., 1974), table 2.3 (only taken from1950 onwards), ultimate source is Banco de México.

Series 2:

1950-1979: consumption of fixed capital calculated as the difference between the gross stock and the net stock of capital estimated by A.A. Hofman, *The Economic Development of Latin America in the Twentieth Century* (Cheltenham, UK, 2000), Table E.20 reflated to current prices by the corresponding average price indices for buildings/infrastruture and machinery and equipment by México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994), pp.966-967.

Series 3:

Consumption of fixed capital reported in the following sources:

1970-1978 México. Secretaría de Programación y Presupuesto, *Sistema de cuentas nacionales de México* (México D.F., 1981), p.57

1977-1980 México. Secretaría de Programación y Presupuesto, *Anuario Estadístico de los Estados Unidos Mexicanos, 1981* (México D.F., 1981), p.309

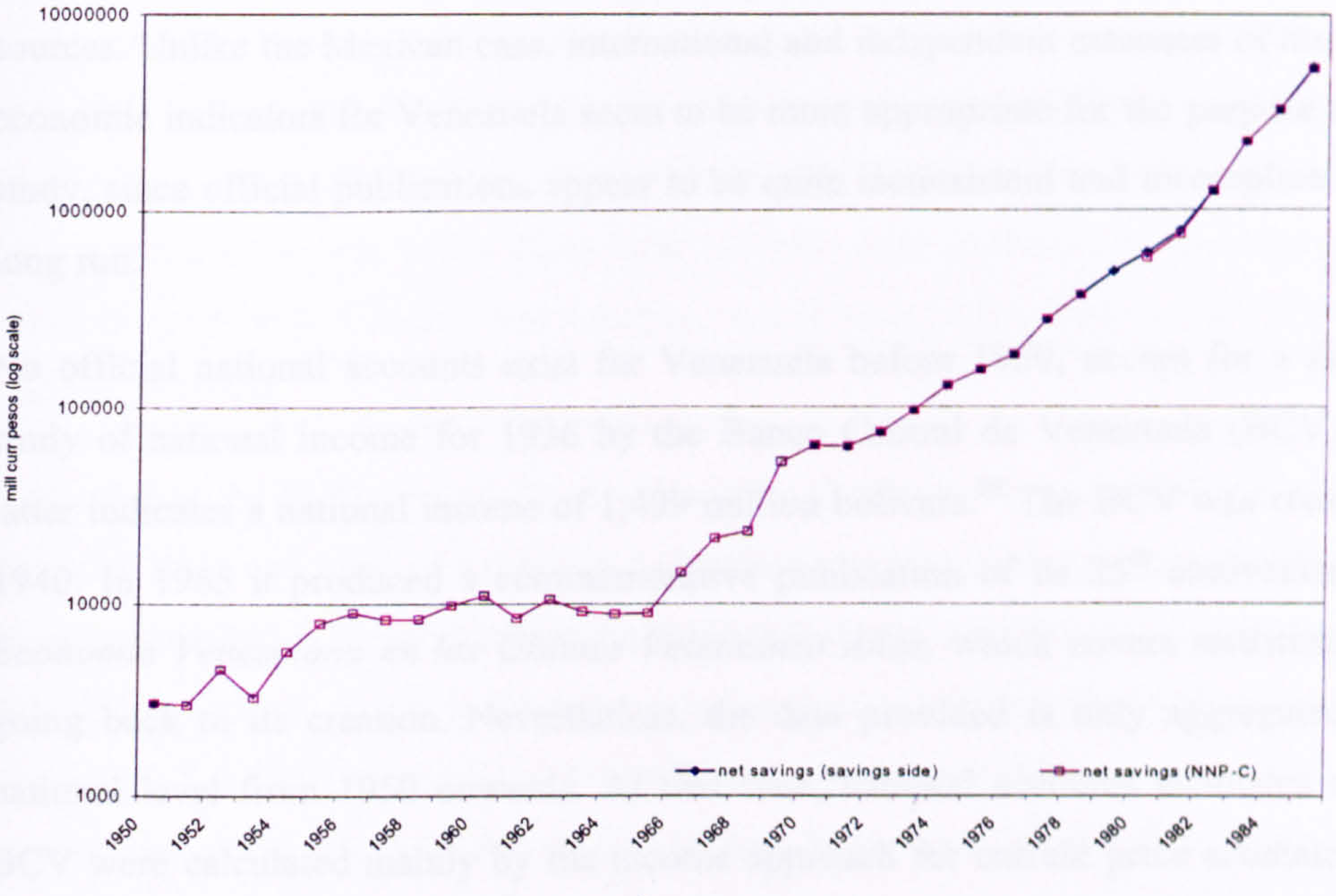
1980-1988 Nacional Financiera, La economia mexicana en cifras 1990, p146-147

1988-1989 México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Anuario Estadístico de los Estados Unidos Mexicanos* (México D.F., 1990). p.569

1990-1992 México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Sistema de Cuentas Nacionales de México1989-1992. Resumen General*, Vol. I (México D.F., 1994), p.33

In relation to the saving data, net savings were only found from official sources for the periods 1970-1985. For the period 1950-1970 they were constructed subtracting public and private consumption estimates from net income figures. Figure D.1-2 shows that both series are very consistent with each other and lists the sources used.

Figure D.1-2: Net Savings. Alternative Estimates. Mexico 1950-1985 (mill pesos at current prices)



Sources: Net savings from official documents as follow 1970-1978 from México. Secretaría de Programación y Presupuesto, *Mexico: System of National Accounts. General Summary* Vol. I (México D.F., 1981), p.58 and for 1979-1985 from México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Sistema de cuentas nacionales de México: cuentas consolidadas de la nación, oferta y utilización, producto interno bruto, 1980-86* (Aguascalientes, 1987), cuadro 2.
Prior to 1970 net savings were calculated as the difference of NNP (as listed at the end of this appendix) minus public and private consumption from: 1950-1960 Nacional Financiera, *La Economía Mexicana en Cifras* (México D.F., 1978), cuadro 2.8; 1960-1978 México. Secretaría de Programación y Presupuesto, *Mexico: System of National Accounts. General Summary* Vol. I (México D.F., 1981), Table 1 and 1980-1988 Nacional Financiera, *La Economía Mexicana en Cifras* (México D.F., 1990), pp.146-147.

Gross savings were estimated adding to these net savings the consumption of fixed capital series described above. Note 'the irony that physical capital, not natural capital, appears to be the greater source of data problems for estimating genuine savings [...] Developing better estimates of physical capital should perhaps be a higher priority for green accountants than developing improved measures of natural capital'.[37]

The sources for Mexican GDP, NNP and consumption of fixed capital used in this research are listed at the end of this Appendix.

D.2 Brief History of National Accounting in Venezuela

A brief review of the availability of historical national accounts data for Venezuela is undertaken in this section, together with an assessment of the quality of such data. A priori, it should be easier to gather data for Venezuela since data is only needed from 1920s onwards –when oil production started. As in the earlier review of the availability of national accounts data for Mexico, official sources are observed first. Then international and independent estimates are introduced and compared with the official sources. Unlike the Mexican case, international and independent estimates of historical economic indicators for Venezuela seem to be more appropriate for the purpose of this study, since official publications appear to be quite inconsistent and incomplete in the long run.

No official national accounts exist for Venezuela before 1950, except for a sketchy study of national income for 1936 by the Banco Central de Venezuela (BCV). The latter indicates a national income of 1,499 million bolivars.[38] The BCV was created in 1940. In 1965 it produced a commemorative publication of its 25th anniversary, *La Economía Venezolana en los Últimos Veinticinco Años,* which covers statistical data going back to its creation. Nevertheless, the data provided is only aggregated at a national level from 1950 onwards. At that time, national accounts estimates of the BCV were calculated mainly by the income approach for current price estimates and by the production method for constant price estimates. Because of this dichotomy, considerable difficulties are encountered when seeking to reconcile series in current and constant prices. As a consequence of the introduction of several important modifications to the estimates after 1959, the data for the periods 1950-1959 and 1960-65 were not comparable. Moreover, because of frequent small changes in definitions and in basic sources and methods, the detail with which the estimates are provided varied almost from year to year as did the reliability of the data.[39]

Two other BCV anniversary publications, marking the bank's 30th and 35th anniversaries, provide the best general outlook of the historical evolution of

[37] J.R. Vincent, 'Are Greener National Accounts Better?', (2001) (unpublished paper), pp.32-33.
[38] Banco Central de Venezuela, *Ingreso Nacional de Venezuela* (Caracas, 1949), p.93.
[39] The analysis corresponds to Organisation for Economic Cooperation and Development (OECD), *National Accounts of Less Developed Countries, 1950-1966* (Paris, 1968), p, 210-211.

Venezuela's national accounts.[40] Despite being consistent, the accounts maintained by the BCV went through important methodological changes during the late 1960s. The earlier accounts were available in current and 1957 prices. Beginning in 1968, the BCV changed the system of accounts and the price base year changed to 1968.[41] As a result of the conceptual changes introduced and the change in methodology, the BCV concluded that the old and the new systems were not comparable.[42] The BCV then considered the possibility of reconstructing the series from 1950 onwards under the new methodology. However, it was not possible since data were not available for most of the sectors in the new methodology. The main problem was that the old method took 1957 as base year reconstructing the intertemporal variations for a wide variety of aggregates through physical indicators and quantity indices, so no actual data existed. As a consequence, the series from both systems were included in the anniversary publication of 1978. The declared intention was to amalgamate both series statistically via interpolations.

It seems that the BCV revised the new system's figures once again during the 1980s. Between 1984 and 1986, it published a Yearbook of National Accounts covering the period 1968-1985.[43] These GDP figures are systematically higher than those published in 1978. A further change in the base year occurs during the mid-1980s, when 1984 was adopted as the new base year. The most interesting contribution of this study is its observation of the effects of the change of base year from 1968 to 1984. Changes in the base year should not substantially modify the portrait of an economy. However, for Venezuela, some important variations in the trend of GDP take place when the base year. According to Baptista, 'it is enough to draw attention to the rhythm of the economic activity between 1973 and 1975. For the 1968 accounts, GDP growth was very accelerated in between those years. Yet according to the 1984 accounts, GDP

[40] Accounts Banco Central de Venezuela, *La economía venezolana en los últimos treinta años* (Caracas, 1971)and Banco Central de Venezuela, *La economía venezolana en los últimos treinta cinco años* (Caracas, 1978).

[41] The system change is described in Banco Central de Venezuela, *Metodología de las Cuentas Nacionales de Venezuela* (Caracas, 1976). Until the adoption of the United Nations method of National Accounting in 1968, the real aspects of the economy were depicted through two aggregates: the Producto Territorial Bruto (Gross Territorial Product) and the Ingreso Nacional (National Income). The former provided an estimate of the production for final use carried out within the nation's territory; the latter reflected the income received by the country's residents for their contribution to the production process.

[42] Banco Central de Venezuela, *Aspectos Metodológicos de las Cuentas Nacionales de Venezuela* (Caracas, 1972), p.20.

[43] Banco Central de Venezuela, *Anuario de Cuentas Nacionales: 1968-1985* (Caracas, 1984-86), as quoted by A. Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991)

decreases in the same period'.[44] One has to be aware of the fact that the distortions coincide with the price explosion of the first oil shock. Baptista's explanation of the problem is the ill effect generated by the rent earned from oil. This is not the place to take this point any further or analyse the way he attempted to solve the problem. It is sufficient to mention it to draw the attention towards the risks of using constant prices in oil producing economies.

International organisations also provided estimates of the economic position of Venezuela. The United Nations in 1950, simply took the 1949 BCV figure for 1936 without further comment.[45] The United Nations Economic Commission for Latin America (ECLA) did not consider Venezuela's income or product figures until well into the 1950s.[46] The ECLA in 1960 and the IBRD in 1961 assessed the position of the Venezuelan economy during the 1950s in some detail.[47] Their analysis mainly focused on the external sector and dependence on oil production as much as on the regional disparities, but they did not produce aggregate economic indicators. Much later, in 1978, the ECLA produced a historical set of series for Latin American economic growth.[48] However, according to Baptista, the disproportionate figures presented there for the contribution of the public sector to the GDP alter completely the overall image of Venezuela's economic development over the 1940s and 1950s.[49] More recently, the ECLA again published the historical series of national accounts of several Latin American countries. It simply put together the official estimates, keeping the original base year constant for each period –that is, 1957 for the period 1950-68, 1968 for the period 1968-84, and 1984 from that year to 1994.[50]

The IMF *International Financial Statistics* provides GDP and GNP figures from 1950 onwards, which could indicate the use of the official data of the BCV. However, data from 1967 onwards are below the estimates of the BCV.[51] However, the ultimate

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[44] Ibid., p. 98.
[45] United Nations, *National Income Statistics of Various Countries* (New York, 1950).
[46] The ECLA produced an estimate of an annual rate of growth of GNP per capita of 4 percent between 1947 and 1955, yet it did not provide the yearly data. See United Nations. Economic Commission for Latin America, *Economic Survey of Latin America, 1955* (New York, 1956), p.4, Table 3.
[47] United Nations. Economic Commission for Latin America, 'Economic Developments in Venezuela in the 1950s', *Economic Bulletin for Latin America* 1 (1960) 1 and International Bank for Reconstruction and Development (IBRD), *The Economic Development of Venezuela* (Baltimore, 1961).
[48] United Nations. Economic Commission for Latin America, *Series históricas para el crecimiento de América Latina*, Vol. 3 (Santiago de Chile, 1978).
[49] Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989*, p.47.
[50] United Nations. Economic Commission for Latin America, *América Latina y el Caribe: Series Regionales y Oficiales de Cuentas Nacionales, 1950-1994*, Vol. 23 (Santiago de Chile, 1996).
[51] International Monetary Fund, *International Financial Statistics* (Washington D.C., several volumes), July 1972.

sources of those figures and revisions remain obscure.[52] The pay-off of that constant revision by the World Bank is the substantial modification of the figures over the years. The amendment of the World Bank always resulted in higher GDP values as shown in Table D-2, which presents several of the successive approximations to Venezuela product and income for selected years.

Table D-2: Successive approximations to Venezuela Product and Income for the years 1936/1950/1960/1969 and 1975

Author	*Date of Publication*	*Concept Used*	*Estimate (million current bolivars)*				
			1936	*1950*	*1960*	*1969*	*1975*
BCV	1949	National Income	1,499				
IBRD˅	1961	GDP		11,826			
OECD♦	1968	GDP		11,826	25,620		
BCV♣	1971	GDP		11,826	25,671	46,867	
BCV (modified)♠	1978	GDP				47,568	
ECLA	1978	GDP				46,057	
World Bank	1980	GDP		11,743	25,340	46,334	116,351
Baptista♥	1991	GDP	2,504	13,784	27,832	52,068	120,919
BCV★	1992	GDP		11,826	25,671	46,283	118,098
World Bank♦	1992	GDP					134,540
Baptistaˠ	1997	GDP	2,041	14,081	29,533	51,738	147,469

Notes and sources:

Banco Central de Venezuela, *Ingreso Nacional de Venezuela* (Caracas, 1949).

˅International Bank for Reconstruction and Development (IBRD), *The Economic Development of Venezuela* (Baltimore, 1961). The BCV seems to be the ultimate source.

♦ Organisation for Economic Cooperation and Development (OECD), *National Accounts of Less Developed Countries, 1950-1966* (Paris, 1968)., p.214.The ultimate source of the data is BCV but not specific source is provided.

♣ Although the ultimate source is Banco Central de Venezuela, *La economía venezolana en los últimos treinta años*. Colección XXX aniversario, (Caracas, 1971), the figures here are taken from Allen, L., *Venezuelan Economic Development. A Politico-Economic Analysis*. Contemporary Studies in Economic and Financial Analysis, edited by Altman, E.I. and I. Walter, Vol. 7 (Connecticut, 1977), p.269

♠ Banco Central de Venezuela, *La economía venezolana en los últimos treinta cinco años* (Caracas, 1978).value obtained multiplying a value of 46,819 million of 1968 bolivars times the wholesale price index for 1969 of 101.6

United Nations. Economic Commission for Latin America, *Series históricas para el crecimiento de América Latina*. Cuadernos Estadísticos de la Cepal, Vol. 3 (Santiago de Chile, 1978).

World Bank, *World Tables, 1980* (Washington, D.C., 2nd ed., 1980).

♥ These figures correspond to the GDP in 1968 prices multiplied by the GDP deflator provided by the author Baptista, A., *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991).pp. 35-36 for GDP and 300-301 for the deflactor. His figures in current bolivars are also available in the same source (pp.37-38).

★Banco Central de Venezuela, *Series estadísticas de Venezuela de los últimos cincuenta años* Vol. I (Caracas, 1992), pp.47-65

ϕ World Bank, *World Tables, 1992* (Washington, D.C., 1992), for some years are in purchaser values and not at factor costs

γ Baptista, A., *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)* (Caracas, 1997). Current prices GDP obtained using 1968 data times the deflator provided by the author

Summarising, national and international official sources, due to constant changes of methods and uncertain linkage among them, provide only partial and rather

[52] The World Bank seems to provide its own estimates combining economic data provided by the economic missions to member countries which 'is systematically analysed, refined, updated and stored. These data are complemented from other official sources, notably the statistical offices and publications of other international agencies'. From the Preface to the World Bank, *World Tables, 1980* (Washington, D.C., 2nd ed., 1980).

[53] J.A. Hanson, 'Cycles of Economic Growth and Structural Change since 1950', in Martz and Myers (eds.), *Venezuela: The Democratic Experience* (Caracas, 1st ed., 1977) uses BCV figures, whereas Maddison, *Monitoring The World Economy, 1820-1992* and Hofman, *The Economic Development of Latin America in the Twentieth Century* use Baptista's series for the earlier periods of their studies.

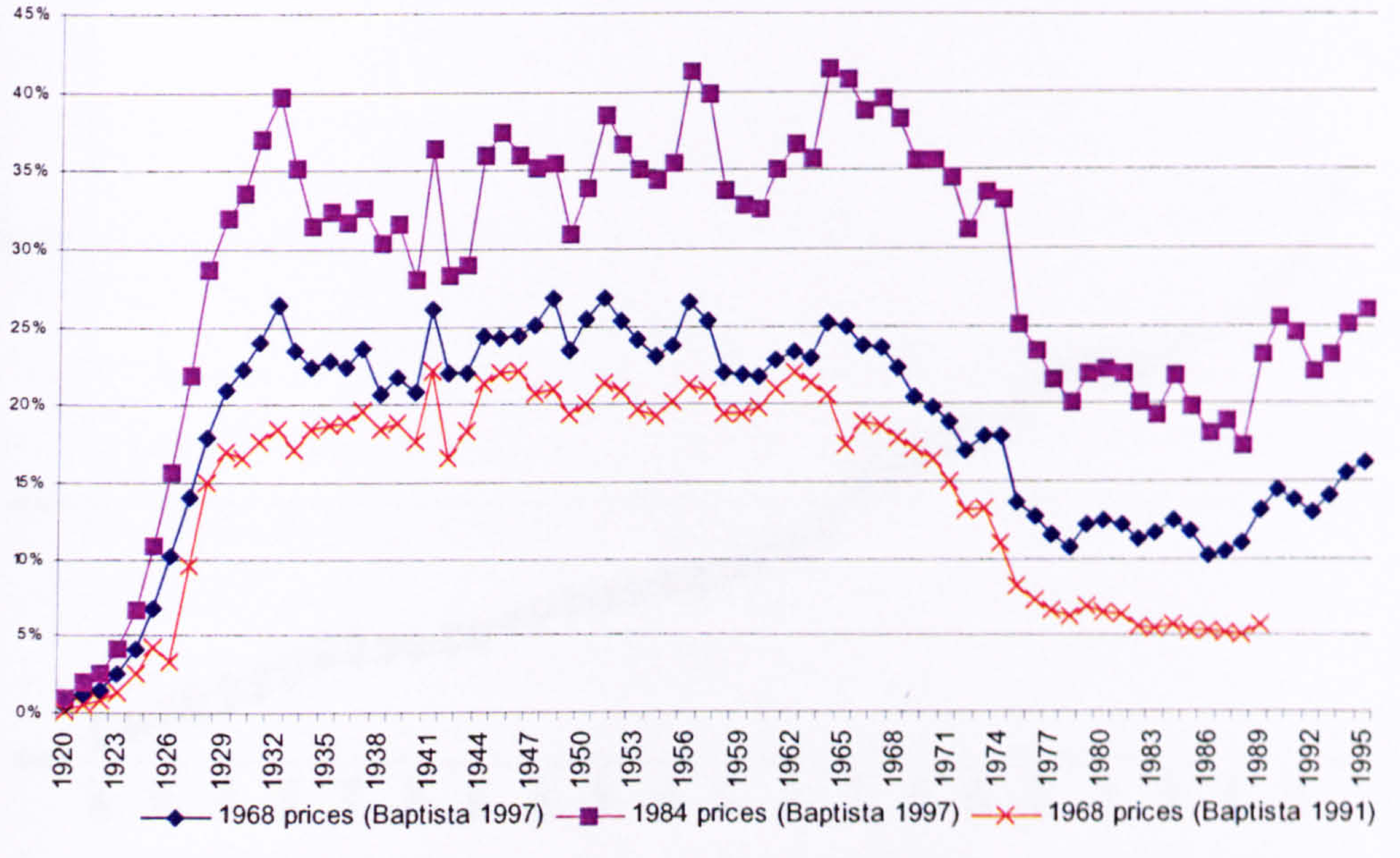
inconsistent series of economic indicators dating back to 1950. It is necessary to turn to independent estimates in order to get, on the one hand, some grasp of Venezuelan GDP before that year and, on the other hand, a more coherent/systematic series for the whole period.

There are two main private contributions to the historical quantification of Venezuela economy for the period under consideration. The one by Izard, *Series Estadisticas para la Historia de Venezuela* of 1970, constitutes the first attempt to summarise historical statistical data of Venezuela and covers most of the century. His analysis seems to be mostly sectoral rather than aggregate. The second and more useful study is the one by Baptista. He presents GDP estimates for Venezuela in current and constant bolivars of 1968 and 1984. From 1920 to 1950, the GDP does not strictly correspond to the sum of the sectoral contributions. Once again, the reason is the lack of information for most sectors. Therefore, from 1920 onwards Baptista put together all the available information in order to elaborate a series up to 1960. He does not explicitly describe the specific method followed. It is also very difficult to ascertain the different sources and devices used to put the numbers together since sources are not discussed by dates. For the period 1950s-1989, covered by the official sources, he used the ones discussed above. However, it is not obvious how he linked the two systems. It is possible that he connected the series regardless of their different nature.

Despite reservations over the reliability of these estimates (including the official sources), the truth is that the BCV ones were the most widely used until Baptista's figures appeared. His are now the common source used by other authors to evaluate Venezuela's economic history.[53] Maddison, for instance, took the 'economic activity' in four sectors in 1936 bolivars for the period 1900-1920 and linked it to the 1920-1970 GDP by industry of origin in 1968 figures from Baptista. It is not clear from his description whether the data for 1900-1920 is also that provided by Baptista in the same work. From 1970 to 1990, Maddison used the World Bank tables elaborated in 1992.

Baptista has redone part of his work and enhanced the database available for Venezuela up to 1995.[54] However, one additional problem with his data in this last publication is that GDP in current prices is not provided directly. He gives the GDP in constant bolivars of 1968 and 1984, as in his previous publication. Nevertheless, on this occasion, when the deflators provided are used to turn the constant series into current prices, the results diverge slightly from one to the other and from his previous estimates. The GDP in current prices obtained from the GDP series in 1984 prices is rather unstable compared to the one obtained from multiplying the GDP in 1968 prices by the correspondent deflator. The fact that some of the most recent works on Venezuela use his series at 1968 prices seems to confirm this observation.[55]

Figure D.2-1: Share of the oil sector in total GDP at constant prices. Venezuela 1920-1995



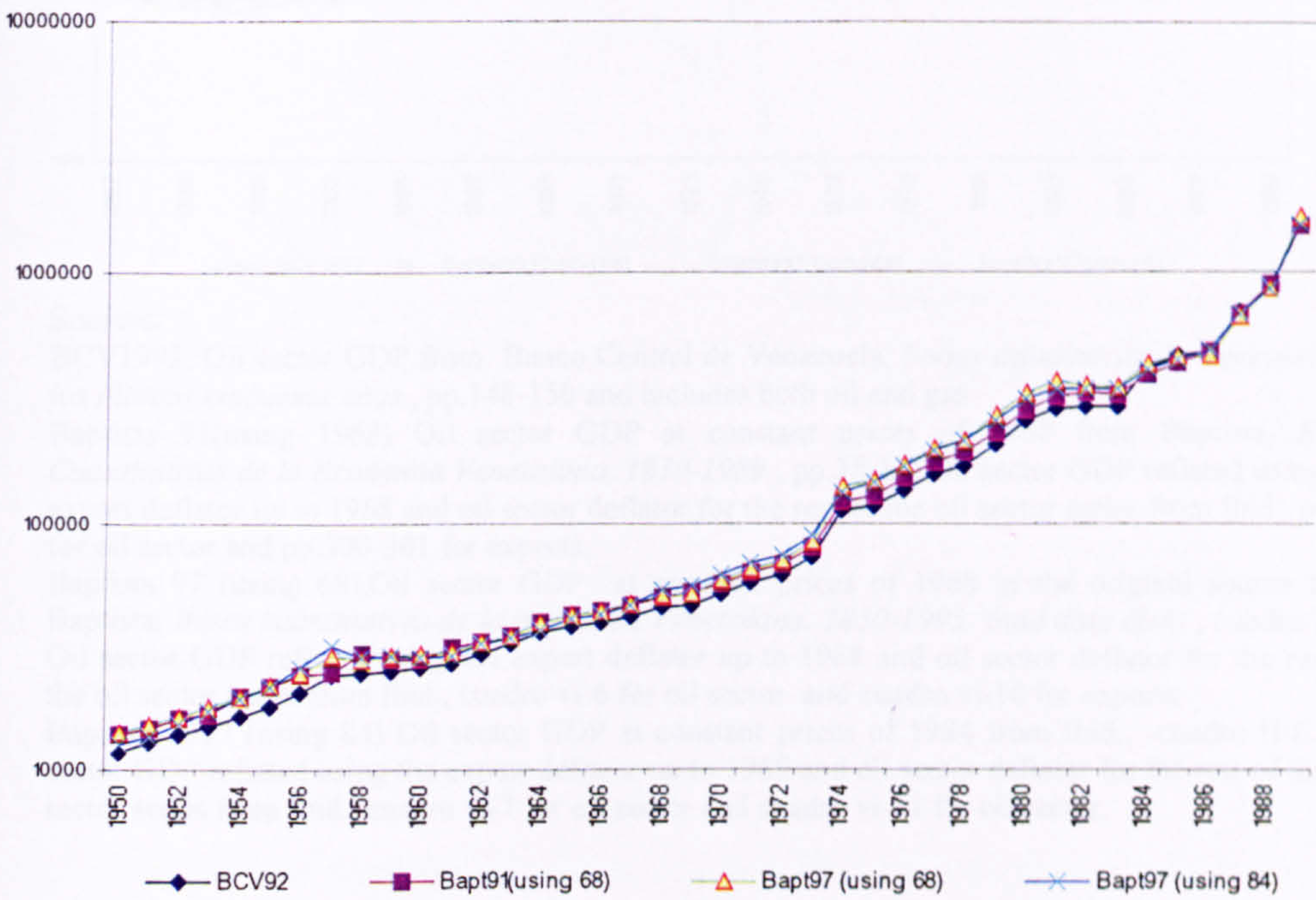
Sources:
Total GDP and oil sector GDP at constant prices of 1968 from Baptista, *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)*, cuadro II-2; Total GDP and oil sector GDP at constant prices of 1984 from Ibid, cuadro II-;Total GDP and oil sector GDP at constant prices of 1968 from Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989*, pp.35-36

It is well known that a difference of a few years in the choice of base year could change gross domestic product by more than 30 per cent per capita in some instances.[56] In the case of Venezuela, the effects are not only on the levels of the GDP obtained from different sources and base years but more crucially, the relative sizes of the

[54] A. Baptista, *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)* (Caracas, 1997).
[55] Thorp, *Progress, Poverty and Exclusion. An Economic History of Latin America in the 20th Century*, p.320.
[56] M. Urrutia, 'Twenty-Five Years of Economic Growth, 1960-1985', in Urrutia (ed.), *Long-Term Trends in Latin American Economic Development* (Inter-American Development Bank, Washington D.C., 1991), p.28.

different macroeconomic aggregates change considerably. In order to establish the best series to be used some checks should be undertaken. Take for instance the share of the oil sector in the total GDP at constant prices as portrayed by the different series of Baptista shown in Figure D.2-1. The share of the oil sector in the total GDP of Venezuela ranges from well above the 30 percent to levels of below 1920 depending on the series used, where the 1984 series are systematically above both estimates with base 1968. How different are the estimates at current prices?

Figure D.2-2: Venezuela GDP at current prices. 1920-1989 (mill. of bolivars, different sources, log scale)



Notes and sources:

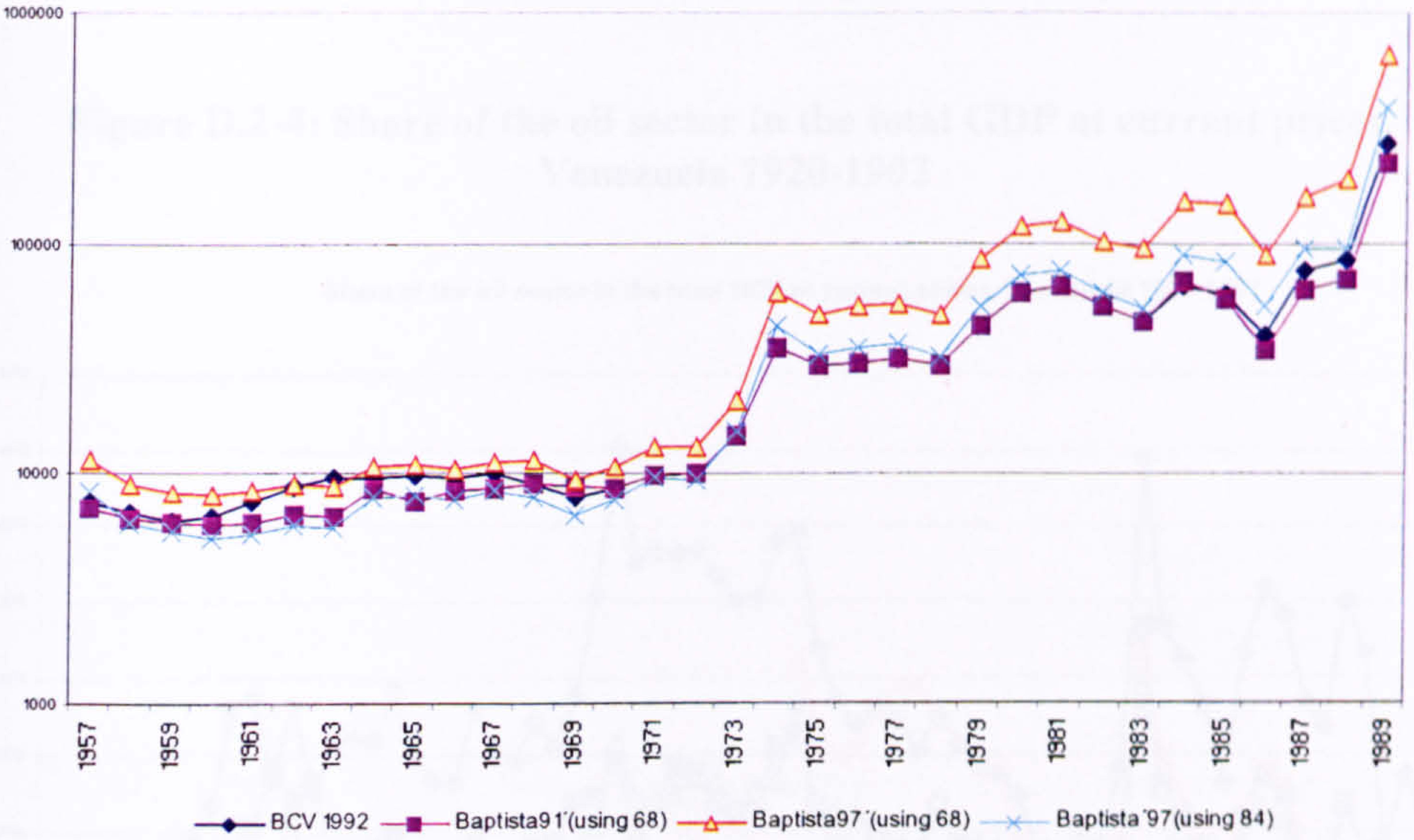
BCV92 from 1950-1989 total GDP series at current prices Banco Central de Venezuela, *Series estadísticas de Venezuela de los últimos cincuenta años*, Vol. I (Caracas, 1992), tomo I, p.47-65. The series was calculated over three different base years, 1957, 1968 and 1984 for the periods 1957-1968, 1968-1984, and 1984-1989 respectively

Bapt91(using 68), base series of total GDP at constant prices of 1968 from Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989* , pp.35-36 reflated by the corresponding deflator for GDP Ibid., pp.300-301

Bapt97(using 68), base series of total GDP and oil sector GDP at constant prices of 1968 in the original source from Baptista, *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)* , cuadro II-2 reflated by the corresponding deflator for GDP Ibid., cuadro vi-10.

Bapt97(using 84) Base series of total GDP and oil sector GDP at constant prices of 1984 from Ibid., cuadro II-6 reflated by the corresponding deflator for GDP Ibid. , cuadro vi-11

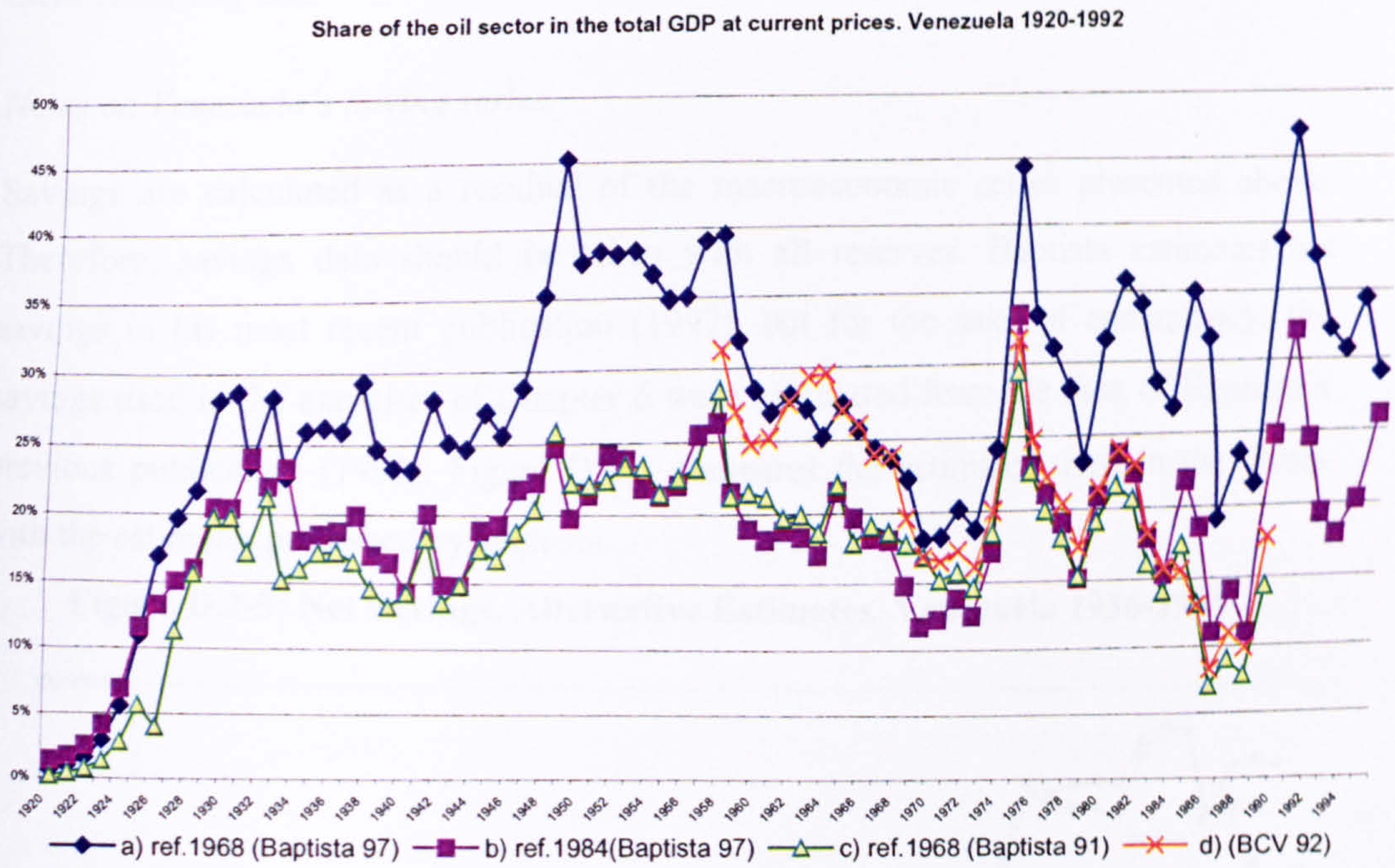
Figure D.2-3: Venezuela oil GDP from different sources. 1957-1989 (mill. of bolivars at current prices, log scale)



Sources:
BCV1992, Oil sector GDP from Banco Central de Venezuela, *Series estadísticas de Venezuela de los últimos cincuenta años*, pp.148-150 and includes both oil and gas
Baptista 91(using 1968) Oil sector GDP at constant prices of 1968 from Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989*, pp.35-36. Oil sector GDP reflated using the export deflator up to 1968 and oil sector deflator for the rest of the oil sector series from Ibid., p.294 for oil sector and pp.300-301 for exports.
Baptista 97 (using 68),Oil sector GDP at constant prices of 1968 in the original source from Baptista, *Bases cuantitativas de la economía Venezolana. 1830-1995 (and data disk)*, cuadro II-2. Oil sector GDP reflated using the export deflator up to 1968 and oil sector deflator for the rest of the oil sector series from Ibid., cuadro vi-6 for oil sector and cuadro vi-10 for exports
Baptista 1997 (using 84) Oil sector GDP at constant prices of 1984 from Ibid., cuadro II-6. Oil sector GDP reflated using the export deflator up to 1968 and oil sector deflator for the rest of the oil sector series from Ibid., cuadro vi-7 for oil sector and cuadro vi-11 for oil sector.

Notwithstanding the inconsistencies of the BCV series, we can compare the estimates for GDP and the GDP of the oil sector at current prices by the BCV for the period 1950-1989 with those resulting from applying the corresponding deflators to Baptista's data. Regarding the total GDP shown in Figure D.2-2, the only systematic bias is the one of the BCV estimate permanently remains below the levels of any of the three estimates of Baptista. For their part, Baptista's series swing around each other without a clear pattern. However, the data on the oil sector in Figure D.2-3, show how the latest series that Baptista elaborated at 1968 prices considerably exceeds the other estimates when reflated to current prices. In fact, my own calculations demonstrate that the level indicated by the newest 1968 series when reflated is well above the actual gross income of the oil sector itself, that is, exceeds the amount obtained by multiplying oil prices by the amount of oil produced. As a result, the share of the oil sector in total GDP at current prices in Figure D.2-4 diverges from the one presented in Figure D.2-1 at constant prices.

Figure D.2-4: Share of the oil sector in the total GDP at current prices. Venezuela 1920-1992



Sources: as in Figures D.2-2 and D.2-3 above

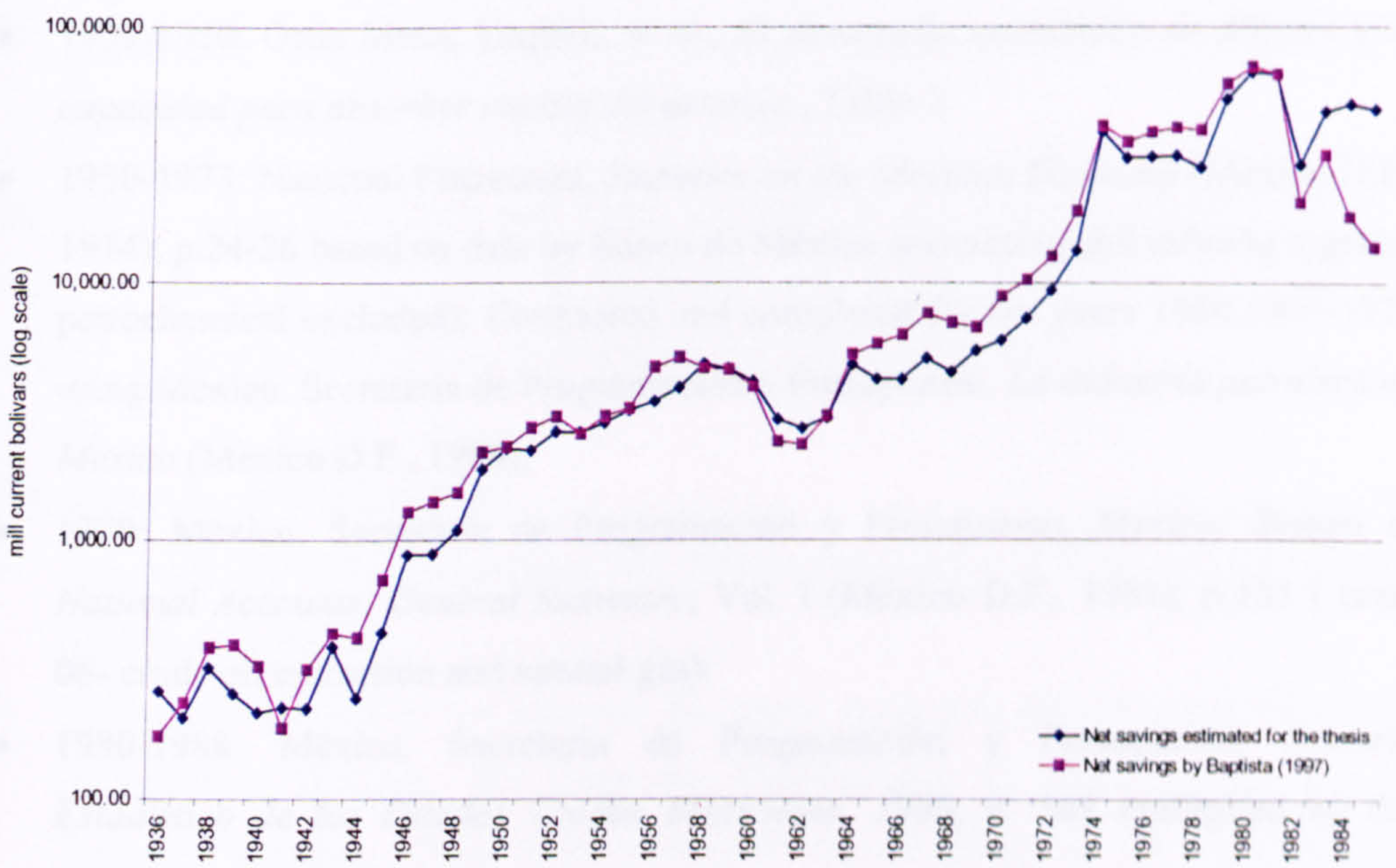
In the latest work of Baptista, the series that use 1968 as base year are the ones that indicate a bigger share of the oil sector in the total GDP. Per contra, it is noticeable that the other two series of Baptista result in relatively similar shares once they are both deflated. These exercises together with the warnings expressed above leave us to decide whether to use one of series elaborated by Baptista for the sake of internal coherence of the series or to emulate Maddison by taking the World Bank tables back to 1970 and to use Baptista's calculations for the rest of the period. The final working choice was to use the old series of Baptista elaborated at 1968 constant prices transformed into current prices, which seems to be the most stable and coherent of the ones produced.

In sum, Venezuela's official national accounts cover a bit more than half of the period need by this research. Within the period a change in methodology in 1968 leave us with two not comparable series. Therefore, coherence and reliability can only be assured from 1968. One should also be aware of the distortions introduced by the changes in base year, which alert us to the danger of using constant prices. Prior to 1968 and back to 1950, the official estimates are coherent but not comprehensive since fewer sectors were included than under the new methodology. As for the period 1920-1950, the best approximation seems to be the figures by Baptista, yet one has to take them cautiously too.

Notes on Venezuela's Saving series

Savings are calculated as a residual of the macroeconomic series presented above. Therefore, savings data should be taken with all reserves. Baptista estimates net savings in his most recent publication (1997), but for the sake of consistency, the savings used in the exercises of Chapter 6 were calculated from the data of Baptista's previous publication (1991). Figure D.2-5 compares the estimates used in the thesis with the estimates published by Baptista.

Figure D.2-5: Net Savings. Alternative Estimates. Venezuela 1936-1985



Sources: In order to obtain net savings estimates, gross savings were calculated first as the residual of GNP minus total consumption from A. Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991), pp.37-38. Note that national (as opposite to domestic) product is only available from 1936. Net savings equal gross savings minus the consumption of fixed capital listed below in the sources to Table D-3b. These are compared with the net savings in A. Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1995* (Caracas, 1997), cuadro V-1.

Despite the caveats regarding the discrepancies between Baptista's two data sets described above, net savings come remarkably close to each other. Yet as residual value they should be regarded with caution.

Sources for national accounting data in Table D-3a:

Mexico:

Total GDP:

- 1901-1970 & 1990: México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* , p.401-402, cuadro 8.1.
- 1987-1988, México. Secretaría de Programación y Presupuesto, *Anuario Estadístico de los Estados Unidos Mexicanos, 1989* (México D.F., 1989), p.569, cuadro, 4.11.
- 1971-1987: México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 2nd ed., 1990), p.318.

Oil sector GDP:

- 1929-1940: Sáenz, 'El ingreso nacional neto de México, 1929-1945', p.32.
- 1939-1950: Ortiz Mena, Urquidi, et al., *El desarrollo económico de México y su capacidad para absorber capital del exterior* , Table 2.
- 1950-1973: Nacional Financiera, *Statistics on the Mexican Economy* (México D.F., 1974), p.24-26 based on data by Banco de México (extracting and refining together petrochemical excluded); Contrasted and completed for the years 1960,1965-1978 using México. Secretaría de Programación y Presupuesto, *La industria petrolera en México* (México D.F., 1980).
- 1979: México. Secretaría de Programación y Presupuesto, *Mexico: System of National Accounts. General Summary*, Vol. I (México D.F., 1981), p.133 (rama 06- crude oil extraction and natural gas).
- 1980-1988: México. Secretaría de Programación y Presupuesto, *Anuario Estadístico de los Estados Unidos Mexicanos, 1989*, p. 568 multiplied by the appropriate value index.
- 1989-1992: México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Sistema de Cuentas Nacionales de México1989-1992. Cuentas de producción a precios constantes y corrientes*, Vol. III (México D.F., 1994), p.37.

NDP/NNP (national income figures):[57]

- 1929-1940: (National income) Sáenz, 'El ingreso nacional neto de México, 1929-1945', p.32.
- 1939-1960: (Net National income) Banco de México, *Informe anual* (México D.F., 1960), p.73 (only used until 1950).
- 1939-1968: (Net national income used only from 1950 to 1960), Nacional Financiera, *Statistics on the Mexican Economy*, table 2.3), ultimate source is Banco de México.
- 1950-1978: NDP equals the GDP from the sources above minus the consumption of fixed capital calculated from Hofman series (see next heading below).
- 1979-1981: (NNP) México. Secretaría de Programación y Presupuesto, *Anuario Estadístico de los Estados Unidos Mexicanos, 1981* (México D.F., 1981), p.26.
- 1980-1988: (NNP) Nacional Financiera, *La Economía Mexicana en Cifras* (México D.F., 1991) 1990, p146-147.
- 1989-1992: (NNP) México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Sistema de Cuentas Nacionales de México1989-1992. Resumen General*, Vol. I (México D.F., 1994), p.33.

In order to obtain a complete data series for NDP, its series for the period 1979-1992 were calculated by subtracting the consumption of fixed capital from the GDP. The results are compatible with the NNP official series just referenced.

Consumption of fixed capital:

- The years pre-1960 calculated as the difference between the GDP and the national income, (see above).
- 1960-1978: the difference between the gross stock and the net stock of capital estimated in Hofman, *The Economic Development of Latin America in the Twentieth Century* , Table E.20 reflated to current prices by the corresponding average price indices for buildings/infrastructure and machinery and equipment by México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* , pp.966-967.
- 1977-1980: México. Secretaría de Programación y Presupuesto, *Anuario Estadístico de los Estados Unidos Mexicanos, 1981* , p.309.
- 1980-1988: Nacional Financiera, La economia mexicana en cifras 1990, p146-147

[57] See section D.1 above and Figure D.1-1.

- 1984-1987: México. Instituto Nacional de Estadística Geografía e Informática, Anuario estadistico 1988-89 p.559.
- 1988-1989: México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Anuario Estadístico de los Estados Unidos Mexicanos*, p.569.
- 1990-1992: México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Sistema de Cuentas Nacionales de México1989-1992. Resumen General*, p.33.

Sources for national accounting data in Table D-3b:

<u>Venezuela:</u>

Total GDP:

- 1920-1989: base series at constant prices of 1968 from Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989*, pp.35-36 reflated by the corresponding deflator for GDP Ibid., pp.300-301.

Oil sector GDP:

- 1920-1989: base series at constant prices of 1968 from Ibid., pp.35-36 reflated using the export deflator up to 1968 and oil sector deflator for the rest of the oil sector. Ibid., p.294 for oil sector deflator and pp.300-301 for exports deflator.

NNP:

- 1920-1989: Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989*, cuadro IV, p.48. NDP Calculated subtracting from the GDP the **consumption of fixed capital** at current prices found in Baptista, *Bases Cuantitativas de la Economía Venezolana, 1830-1989*, cuadro IV, p.48.

Table D-3a: Total GDP, oil sector GDP, consumption of fixed capital and NNP. MEXICO

Year	GDP mill. pesos	oil GDP mill. pesos	% oil in GDP	Consumption of fixed capital mill. pesos	NNP mill. pesos
1920	n.a				
1921	5,455				
1922	4,590				
1923	5,014				
1924	4,633				
1925	5,239				
1926	5,469				
1927	4,987				
1928	5,018				
1929	4,863	80	2%	2,028	2,835
1930	4,668	71	2%	1,967	2,701
1931	4,218	68	2%	1,781	2,437
1932	3,206	66	2%	929	2,277
1933	3,782	79	2%	1,060	2,722
1934	4,151	110	3%	901	3,250
1935	4,540	119	3%	826	3,714
1936	5,346	117	2%	1,093	4,253
1937	6,800	156	2%	1,894	4,906
1938	7,281	134	2%	1,958	5,323
1939	7,785	104	1%	1,885	5,900
1940	8,249	107	1%	1,849	6,400
1941	9,232	120	1%	1,532	7,700
1942	10,681	141	1%	1,181	9,500
1943	13,035	165	1%	735	12,300
1944	18,081	203	1%	1,981	16,100
1945	20,566	244	1%	1,966	18,600
1946	27,930	321	1%	4,230	23,700
1947	31,023	383	1%	4,723	26,300
1948	33,101	449	1%	4,301	28,800
1949	36,412	526	1%	4,712	31,700
1950	42,163	1,320	3%	5,533	36,630
1951	54,375	1,504	3%	7,086	47,289
1952	60,993	1,628	3%	8,026	52,967
1953	60,664	1,638	3%	8,063	52,601
1954	73,936	1,895	3%	9,504	64,432
1955	90,053	2,377	3%	11,335	78,718
1956	102,920	2,622	3%	13,177	89,743
1957	118,206	2,917	2%	15,129	103,077
1958	131,377	3,434	3%	16,689	114,688
1959	140,772	4,570	3%	17,952	122,820
1960	159,703	5,089	3%	22,886	139,084
1961	186,781	6,001	3%	24,275	147,802
1962	207,952	6,469	3%	25,746	160,476
1963	207,952	7,256	3%	27,503	173,800
1964	245,501	8,101	3%	29,810	203,200
1965	267,420	8,594	3%	32,655	219,600
1966	297,196	8,886	3%	35,812	246,200
1967	325,025	9,996	3%	39,496	272,700
1968	359,858	10,726	3%	43,903	302,400
1969	397,796	11,192	3%	51,069	358,016
1970	444,271	12,049	3%	57,348	415,536
1971	490,011	12,042	2%	64,385	458,760
1972	564,727	13,307	2%	72,032	528,337
1973	690,891	13,511	2%	80,638	646,468
1974	899,707	22,439	2%	90,670	839,495
1975	1,100,050	28,040	3%	102,060	1,024,149
1976	1,370,968	33,605	2%	112,708	1,268,524
1977	1,849,263	58,380	3%	122,488	1,703,427
1978	2,337,298	76,001	3%	133,224	2,160,363
1979	3,067,526	85,957	3%	178,389	2,817,101
1980	4,276,490	81,818	2%	236,591	3,928,832
1981	5,874,386	225,958	4%	527,202	5,353,899
1982	9,417,089	301,911	3%	956,298	8,299,932
1983	17,141,694	950,351	6%	2,176,257	14,692,943
1984	28,748,889	1,263,416	4%	3,358,693	24,571,149
1985	47,402,349	1,640,713	3%	5,331,186	40,267,558
1986	79,353,450	2,001,439	3%	10,870,871	64,704,574
1987	195,614,485	7,036,561	4%	25,278,330	160,365,650
1988	389,258,523	8,943,670	2%	46,762,736	331,944,644
1989	503,667,765	6,302,209	1%	53,657,467	441,615,147

Sources: as described above

Table D-3b: Total GDP, oil sector GDP, consumption of fixed capital and NNP. VENEZUELA

Year	GDP mill. bolivars	Oil GDP mill. bolivars	% oil in GDP %	Consumption of Fixed capital mill. bolivars	NNP mill. bolivars
1920	1208.3	2.3	0%	51.1	
1921	943.9	4.5	0%	43.1	
1922	932.3	7.2	1%	36.3	
1923	1075.1	15.3	1%	37.5	
1924	1420.7	41.1	3%	37.5	
1925	1942.0	110.4	6%	37.7	
1926	2780.7	112.6	4%	39.0	
1927	2591.2	293.4	11%	39.1	
1928	2887.9	452.4	16%	41.2	
1929	3225.3	637.3	20%	44.6	
1930	3175.0	627.7	20%	47.8	
1931	2277.9	393.1	17%	53.9	
1932	2215.3	469.0	21%	59.7	
1933	1971.3	299.0	15%	55.7	
1934	2049.8	328.6	16%	49.0	
1935	2152.7	370.9	17%	57.5	
1936	2504.6	433.1	17%	65.9	2,053
1937	3087.7	512.5	17%	71.7	2,559
1938	3230.1	470.0	15%	81.8	2,746
1939	3416.8	453.4	13%	91.0	2,887
1940	3238.9	462.9	14%	102.8	2,737
1941	3321.4	596.7	18%	116.6	2,598
1942	3005.7	407.6	14%	134.3	2,495
1943	3401.6	506.3	15%	156.6	2,885
1944	4430.7	776.1	18%	175.3	3,654
1945	5904.5	989.9	17%	201.8	5,047
1946	7535.4	1,414.0	19%	246.9	6,318
1947	10616.8	2,165.3	20%	316.5	8,729
1948	12830.7	3,314.6	26%	355.8	10,312
1949	13705.8	3,055.9	22%	390.0	11,544
1950	13784.4	3,055.9	22%	436.3	11,168
1951	14759.3	3,316.4	22%	492.1	11,864
1952	16048.5	3,765.3	23%	537.8	12,938
1953	17865.3	3,936.6	22%	608.6	13,529
1954	19888.4	4,245.7	21%	690.6	16,125
1955	22139.9	4,866.1	22%	799.7	17,427
1956	24187.8	5,593.1	23%	931.0	19,089
1957	28822.5	6,997.7	24%	1,079.9	18,382
1958	29176.2	6,234.0	21%	1,209.6	24,087
1959	30899.2	5,975.2	19%	1,371.0	22,599
1960	31798.1	5,897.9	19%	1,513.8	22,121
1961	31465.8	6,072.3	19%	1,687.1	24,760
1962	32855.7	6,548.4	20%	1,945.0	26,021
1963	34681.3	6,481.9	19%	2,211.6	27,327
1964	39197.1	8,630.4	22%	2,805.4	30,694
1965	42172.2	7,565.4	18%	3,166.5	32,731
1966	43532.9	8,322.4	19%	3,452.2	33,836
1967	46303.5	8,640.2	19%	3,722.3	36,372
1968	49810.2	8,865.0	18%	3,951.1	39,066
1969	52068.6	8,808.8	17%	4,211.6	41,444
1970	56683.2	8,607.9	15%	4,520.0	45,832
1971	62587.6	9,881.0	16%	4,897.0	50,017
1972	67726.2	9,897.8	15%	5,269.3	55,851
1973	79242.2	14,653.0	18%	5,951.8	64,931
1974	120919.8	35,606.7	29%	7,135.4	104,440
1975	129439.3	29,330.1	23%	8,434.2	112,629
1976	150419.8	30,068.2	20%	9,560.9	130,864
1977	176316.6	31,821.1	18%	11,105.9	151,908
1978	192023.8	29,379.1	15%	12,907.2	161,724
1979	231856.4	44,384.1	19%	15,028.7	195,515
1980	282564.0	60,997.8	22%	18,355.3	237,708
1981	318147.4	65,631.2	21%	21,720.7	265,015
1982	329649.9	53,267.8	16%	25,170.1	265,069
1983	326292.5	45,854.1	14%	30,050.8	251,704
1984	391825.1	68,287.8	17%	40,659.1	302,809
1985	433594.8	57,197.1	13%	49,860.5	333,320
1986	483463.2	34,247.9	7%	61,611.3	370,212
1987	689026.3	62,540.8	9%	106,566.5	522,961
1988	898281.4	70,369.1	8%	145,973.5	687,948
1989	1533437.9	220,566.2	14%	273,906.8	1,121,984

Appendix E
Oil Reserves

Oil Reserves in Mexico: A Short Historical Note

The evidence presented here will make clear that the late discovery of Mexican oil reserves was mainly the result of the indolence of the national company. Confirmation of this is provided by contemporary sources, and also by some more recent reviews of the state of exploration activities. The conclusion is that if foreign companies had continued exploiting Mexican oil during the century, more oil reserves could have been available by the late 1920s or 1930s at the latest and the pace of discoveries would have been faster.

Although it can be argued that nationalist tendencies in Mexico paralysed exploration and reduced production several years before the nationalisation actually took place, the real cessation of exploration came with nationalisation. Exploration never played an active role in Pemex's oil policy and always lagged behind extraction. Prospecting activities were almost completely abandoned during some years. As late as 1970, only one-tenth of the area geologically recognised as a possible store of crude and gas had been explored.

Contemporary and revisionist literature points to three main causes for the poor performance of Pemex's exploratory activity before the 1970s. The first reason is Pemex's insufficiency of technical knowledge, personnel and equipment. The second is the deficient financial situation of the national company, which thus could not afford the costs of undertaking exploration. Last but not least is the perception by the authorities that exploration, after all, was not an urgent matter. All three causes are briefly analysed below.

The lack of technical knowledge, personnel and equipment was the principal problem in the years immediately after the nationalisation, and it continued to hamper exploration until relatively recently.[1] The problem was first pointed out by foreigners

[1] Although widely accepted, some authors question Pemex's shortage of skilled labour. 'Pemex has always prided itself on the competence of its workers. The foreign companies were obliged by law to train and utilise Mexican nationals in the operations of their Mexican subsidiaries. Thus, even in the days immediately following the expropriation, skilled labour was one of the few areas in which Pemex did not suffer a severe shortage' R.B. Mancke, *Mexican Oil and Natural Gas. Political, Strategic and Economic Implications* (New York, 1979). The rest of this section will disprove this argument.

but also recognised early on by the Mexicans. In the words of the Standard Oil Company:

> 'The Government makes much of the fact [...] that it has bettered the companies' record (in number of wells completed and drilled). Not only is the figure below the average of the wells drilled by the companies during the three years preceding expropriation, but the Government has drilled almost exclusively in fields defined and developed by private initiative. Worst of all no new fields are being developed, possibly due to lack of technical personnel'.[2]

British companies expressed their doubts along the same lines, claiming that 'Cárdenas [the president of the Republic at that time] will have to call foreign technicians and experts for training Mexicans to operate the industry now under his custody'.[3]

From the Mexican point of view, prospecting activities had to be reduced to a minimal level since data were not available. Foreign companies had taken with them most of the available information, including geological photographic evidence of an area around 3.000 square kilometres of Tabasco and Veracruz.[4] But the companies also controlled the petroleum geologists, who left the country with them. Therefore, information had to be patiently reconstructed by Pemex technicians who even lacked the materials to undertake the necessary fieldwork.[5] Hence, even if the information had been available, there were no competent people in Mexico to interpret it promptly. The production department was said to have only five engineers in the period after expropriation.[6] Consequently, the key point was the lack of qualified personnel. This situation forced the national company to sign drilling contracts in 1949 with a US group that included American Independent Oil Company, Signal Oil and Gas and Edwin W. Pauley. Foreign companies undertook a great deal of the exploratory activity between 1950 and 1970 as shown in Figure E-1.

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[2] Standard Oil Company, *The Reply to Mexico* (New York, 1940). Parentheses added.

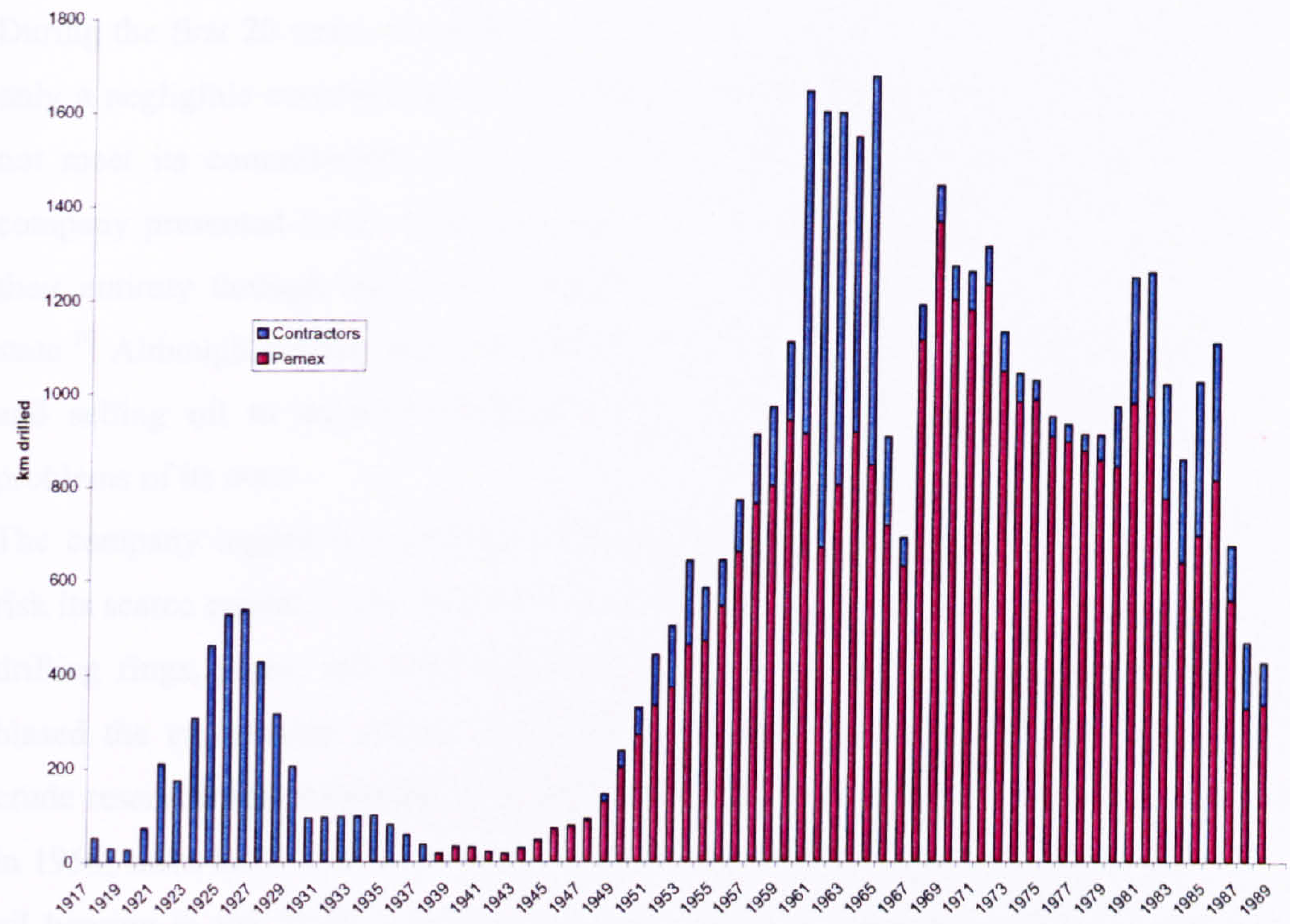
[3] *The Economist*, March-April 1938. As quoted in E. Gonzalez Aparicio, 'La Economía Nacional y el Problema Petrolero', *Revista de Economía* II (1938) 7-12.

[4] A.M. Sordo and C.R. López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985* (México D.F., 1st. ed., 1988). For more information see J. Meneses de Gyves, *El nuevo petróleo de México* (México D.F., 1983).

[5] PEMEX, (Petróleos Mexicanos), *Informes del Director General Senador Antonio J.Bermúdez 1947-1952* (México D.F., 1952), 1948 report, p.29.

[6] R. Sheldon, 'Poza Rica Field: Backbone of Oil Industry in Mexico', *Oil and Gas Journal* (1939), p. 104 as quoted in .J.R. Powell, *The Mexican Petroleum Industry 1938-1950* (Berkeley, 1956).

Figure E-1: Drilling by Pemex and contractors. Mexico 1917-1988 (km)



Sources: PEMEX, (Petróleos Mexicanos), *Anuario Estadístico 1988* (México D.F., 1988), p.34

The Mexican oil industry had to wait until 1965 for the government to create the Mexican Petroleum Institute, an institution exclusively dedicated to the transfer of technology. By the 1970s, the Institute had become a major source of strength for the Mexican oil industry and a major influence in Latin America.[7] Its main contribution to exploratory activities was the systematic interpretation of the available geophysical information. Before 1965, foreign companies processed most of the information because Mexico had not generated enough capacity for processing and interpreting exploration data.[8] Therefore, it is clear that the national company lacked human resources for exploration, which hindered the discovery of new reserves for a period of over 25 years since the nationalisation.

However, exploration was also handicapped by two other constraints, namely the insufficient financial resources of the national company and the management's

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[7] G. Philip, *Oil And Politics In Latin America. Nationalist Movements And State Companies* (Cambridge, 1982).

[8] Sordo and López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985* . Parenthesis added.

indifference towards exploration.[9] Financial problems were a long lasting issue. During the first 20 years of operation of the monopoly, Pemex appears to have made only a negligible contribution to investment programmes. Furthermore, Pemex could not meet its commitments to the state and owed arrears of tax. From 1954, the company presented losses in its accounts. New investments were financed almost in their entirety through long-term or short-term loans and by arrears of debt to the state.[10] Although Pemex was able to maintain its central function (that of producing and selling oil to stimulate Mexican industry) the organisation increasingly had problems of its own.

The company lagged in exploratory drilling, apparently because it was unwilling to risk its scarce capital.[11] The dearth of exploration was largely due to inability to import drilling rings, pipes, and other necessary equipment from the United States.[12] This biased the exploratory activity towards low cost programmes. The finding cost of crude reserves was calculated at $0.048 per barrel in 1952 and only $0.035 per barrel in 1956, since most of the drilling took place in areas which were already known to be oil bearing in the 1930s.[13] Owing to the relative stagnation of exploratory drilling, most of the additions to the proven reserves in the period 1960-1970 came from the re-examination of evaluation methods.[14] Financial capital constraints, as much as limits on human capital, constituted the major obstacles to the early expansion of Mexico's oil reserves.

These obstacles were just perpetuated and enhanced by administrative inaction. Exploration never played an active role in Pemex's oil policy. This was justified because the reserves/production ratio, though declining, gave a certain margin of stability to exploitation from 1938 up to 1970.[15] Immediately after expropriation, the richness of the existing fields and the disappearance of export outlets seemed to minimise the need for exploration. In 1953, Bermudez's Directors' Report mentioned for the first time the fact that Pemex was maintaining a 20-year reserves/production

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[9] A contract made some years earlier -1947- with a small Louisiana oil company to drill one hundred test wells lapsed because the company was unable to get equipment. Powell, *The Mexican Petroleum Industry 1938-1950* this author quotes *Excelsior*, 21 August 1947 as the origin of this info.

[10] On 31 December 1958, the accumulated deficit totalled 215 million pesos. United Nations. Department of Economic and Social Affairs, *Petroleum Exploration: Capital Requirements and Methods of Financing* (New York, 1962), quoted in Philip, *Oil And Politics In Latin America. Nationalist Movements And State Companies*.

[11] Powell, *The Mexican Petroleum Industry 1938-1950*.

[12] Ibid.

[13] Data from A.J. Bermudez, *The Mexican National Petroleum Industry: A case study in Nationalisation* (Stanford, 1963), Appendix, Table 6. The comment corresponds to Philip, *Oil And Politics In Latin America. Nationalist Movements And State Companies*.

[14] Sordo and López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985*.

ratio as a matter of policy.[16] There was no long-run strategy. Although the scarce financial capacity was a important, even more crucial was the authorities' perception that exploration development was not urgent. For supplying domestic energy needs, the pace of extraction still guaranteed an average availability of reserves of around 20 years.[17] Pemex's decision-makers were able to overcome technical and financial problems to revitalise exploratory activity when the shortage of reserves threatened the company by the late 1960s. Hence, it should be obvious that the authorities' inaction is at least as important as the lack of human and physical capital for the slow pace of oil discoveries in Mexico. One can argue that all three causes of the late discovery of oil are directly linked to the nationalisation process.

[15] Ibid.
[16] PEMEX, (Petróleos Mexicanos), *Informe del Director General, 1953-1960* (México D.F., 1953-1960). This view was still supported in later years as can be seen in PEMEX, (Petróleos Mexicanos), *Programa de actividades para el año 1959* (México D.F., 1959), p.1.
[17] Sordo and López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985*.

Source: Sordo and Lopez (1988), Map 1, p.18

Source: Powell (1956), p.55

Source: Sordo and Lopez (1988), p.61

Map E-1: Mexico's oil producing areas, 1901-1938, 1950 and 1978-1982

The historical map series in Map E-1 confirm the aforementioned fact that new areas were discovered only after the 1970s; until then, exploitation was concentrated in the previously known areas. New oil areas were found in the south of the country (Chiapas, Tabasco and Campeche) in the mid-1970s. These reserves increased by 60 percent during 1978. However, their relevance to the national reserves diminished from 64 percent in 1977 to 41 percent in 1978. This was due to the incorporation of the proven reserves of Chicontepec, which participation in the national total achieved 44 percent. The relevant fact for our purposes is that the existence of hydrocarbons in Chicontepec was known since 1931, but the field was not developed owing to all three problems discussed previously.[18] As for the southern fields, it could be argued that their late development depended on the improvement of oil drilling technologies. The reason was that the fields of Tabasco and Chiapas lie at a depth of 12,000 to 14,000 feet, far deeper than Mexico's previously discovered oil reserves and Campeche's oil was offshore -a novelty for Mexican engineers. [19] Against the depth problem, one is persuaded by the fact that American companies drilled beyond 12,000 feet by 1935.[20] The technology was available. Yet it is also true that of the 16 drilling machines Pemex owned in 1939, 8 could only drill up to 900 meters (3,000 feet) and the rest could not go beyond 2,200 meters (7,300 feet), and still by 1947 none of the ones in use could drill beyond 3,000 meters (10,000 feet).[21] Similarly, drilling in shallow coastal waters and lakes up to 150 meters deep began in the 1920s in the Caspian Sea near Baku and in Lake Maracaibo in Venezuela. It seems clear that a technological breakthrough was not required for the development of most of the fields discovered in the 1970s, just the financial resources.

If foreign companies had continued exploiting Mexican oil throughout the century, more oil reserves could have been available by the late 1920s or 1930s at the latest and the pace of discoveries would have been faster. The reasoning is that under this hypothetical scenario, all the reasons for the late discovery of oil reserves are removed. Foreign companies had the human and physical capital to undertake exploratory activities. In addition, they could not allow themselves to disregard exploration drilling

[18] Data from the second chapter of Ibid..

[19] R.B. Mancke, *Mexican Oil and Natural Gas. Political, Strategic and Economic Implications* (New York, 1979), p. 62. The author refers to the Tabasco and Chiapas areas as the Reforma field.

[20] American Petroleum Institute, *Petroleum Facts and Figures* (New York, 5th ed., 1937). The well was located in West Texas. Among the listed deep tests, there are two Mexican fields. Indeed, a well in the Mexican state of Veracruz reached 10,000 feet in 1931; it was the first one reaching that depth outside of US and held the world's record for almost two years.

[21] PEMEX, *Informes del Director General Senador Antonio J.Bermúdez 1947-1952*, 1948 report, p. 34.

as Pemex did. Finally, no major technical breakthrough impeded an earlier development of the fields ultimately discovered in the 1970s. All these facts explain how, despite of its bigger overall endowment of oil, Mexicans have used a smaller proportion of reserves than Venezuelans.

Notes and sources for oil reserves data in Table E-1:

Proven reservoirs of hydrocarbons in million of barrels as by 31 December. The gaps in the series were filled by linear interpolation.

<u>Mexico</u>

- 1918: PEMEX, *Informe del Director General, 1953-1960*
- 1938-1992: México, Instituto Nacional de Estadística, Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994) p.536.

For Mexico, reservoirs seems to include gas along with oil and therefore, the production of natural gas –converted into oil equivalents- were included included at the time of calculating the reserves/production (R/P) ratio. The R/P presented in Chapter 4 diverge slightly from the series provided by British Petroleum, *BP Statistical Review of World Energy* (yearly). Yet the average of BP separate estimates for oil and gas (over 40 years for oil and above 70 years for gas in 1985) coincides with the figures presented here. The fact that our calculation is consistent with the R/P described by Sordo and Lopez (1988) for the history of Pemex provides some reassurance about its reliability.

Note the sudden change in the reserves figures in 1976. At 31 of December 1976, proven reserves were estimated at 6480 million of barrels by the 'conservative' method, based on wheels under development. Another estimation included in 'proven reserves' the reserves, which were economically and technically feasible of development. Thanks to that formula, 4680 million barrels were incorporated to the total proven reserves, resulting in 11160 million barrels. The new method offered two main advantages: lower costs and better looking prospects. Both characteristics were essential to a Mexican economy lacking the financial resources and needing a promising international projection.[22]

[22] Sordo and López, *Exploración, Reservas y Producción de Petróleo en México, 1970-1985*, pp. 102-103.

Venezuela

- 1919, 1924, 1929, 1934 and 1939: A.R. Martínez, 'El papel de la explotación petrolera en el proceso de modernización de la sociedad venezolana y la perspectiva inmediata', in Mieres (ed.), *Hacia la Venezuela Post-petrolera [conference sponsored by la Academia Nacional de las Ciencias Económicas in 1985]*, Vol. 1 (Caracas, 1989), p.166.
- 1925 and 1935: United Nations. Economic Commission for Latin America, 'Economic Developments in Venezuela in the 1950s', *Economic Bulletin for Latin America* 1 (1960) 1, p.59.
- 1944-1970: Banco Central de Venezuela, *La economía venezolana en los últimos treinta años* (Caracas, 1971), p114.
- 1968-1976: Banco Central de Venezuela, *La economía venezolana en los últimos treinta y cinco años* (Caracas, 1978), p. 65 (data back to 1944; overlapping years coincide with the previous source).
- 1944-1985, PODE 1985, published the whole series.

At least until 1967, Venezuelan reserves included condensed materials. In 1982, the reserves of the Orinoco river in Amazonia were also included in the proven reserves despite the technical difficulties involved in their potential exploitation. From 1970 onwards, there are some important discrepancies between the figures published by the national offices and independent sources. These discrepancies obliged OPEC to publish two different sets of data for member countries. In the case of Venezuela, there is no a systematic relationship between the official and independent figures (mostly from the Oil and Gas Journal). 1970-1979 data available in the OPEC, *Annual Report* of 1979, p. 148.

Table E-1: Hydrocarbon reserves and reserves/production ratio. Mexico and Venezuela, 1918-1990

	Mexico		Venezuela			Mexico		Venezuela	
Year	Reserves mill. barrels	R/P years	Reserves mill. barrels	R/P years	Year	Reserves mill. barrels	R/P years	Reserves mill. barrels	R/P years
1918	1,200	18.8			1956	2,959	25.9	13,955	15.5
1919	1,204	13.8	6	21.0	1957	3,374	28.4	15,592	15.4
1920	1,208	7.7	106	29.6	1958	4,070	28.4	16,721	17.6
1921	1,211	6.3	185	38.1	1959	4,348	27.4	17,003	16.8
1922	1,215	6.7	270	46.7	1960	4,787	29.3	17,402	16.7
1923	1,219	8.1	360	51.0	1961	4,990	28.5	16,879	15.8
1924	1,223	8.8	503	55.3	1962	5,008	27.5	16,805	14.4
1925	1,227	10.6	500	25.1	1963	5,150	27.0	17,011	14.4
1926	1,230	13.6	611	17.1	1964	5,227	25.2	17,195	13.9
1927	1,234	19.2	722	11.9	1965	5,078	24.1	17,250	13.6
1928	1,238	24.7	833	7.9	1966	5,357	24.2	16,873	13.7
1929	1,242	27.8	943	6.9	1967	5,486	22.7	15,959	12.4
1930	1,246	31.5	1,258	9.3	1968	5,530	22.0	15,676	11.9
1931	1,249	37.8	1,572	13.5	1969	5,570	21.0	14,890	11.4
1932	1,253	38.2	1,887	16.2	1970	5,568	19.7	13,762	10.2
1933	1,257	40.5	2,201	18.6	1971	5,428	19.6	13,919	10.7
1934	1,261	33.0	2,516	18.5	1972	5,388	18.8	13,812	11.7
1935	1,265	31.4	2,900	19.5	1973	5,432	18.6	18,567	15.1
1936	1,268	30.9	3,197	20.7	1974	5,773	16.5	18,567	17.1
1937	1,272	27.2	3,494	18.8	1975	6,338	15.5	18,398	21.5
1938	1,276	30.0	3,791	20.2	1976	11,160	25.4	18,266	21.8
1939	1,190	24.3	4,088	20.0	1977	16,002	22.9	18,035	22.1
1940	1,225	25.4	4,605	25.1	1978	40,194	64.9	18,277	23.1
1941	1,225	25.0	5,123	22.6	1979	45,126	61.1	18,524	21.5
1942	1,236	30.6	5,640	38.1	1980	60,126	63.0	19,687	24.8
1943	1,257	31.7	6,157	34.3	1981	72,008	64.1	20,144	26.2
1944	1,548	36.2	6,674	26.0	1982	72,008	55.6	24,578	35.6
1945	1,515	31.2	7,038	21.8	1983	72,500	57.9	25,887	39.4
1946	1,437	26.5	7,214	18.6	1984	71,750	57.9	28,028	42.5
1947	1,388	22.2	7,296	16.8	1985	70,900	58.7	29,326	47.8
1948	1,367	21.0	7,642	15.6	1986	70,000	62.4		
1949	1,650	23.8	8,233	17.1	1987	69,000	59.0		
1950	1,608	19.1	8,724	16.0	1988	67,600	58.5		
1951	1,919	20.5	9,064	14.6	1989	66,450	57.1		
1952	2,241	23.6	9,221	14.0	1990	65,500	55.4		
1953	2,233	24.8	10,152	15.8					
1954	2,549	25.1	10,932	15.8					
1955	2,751	24.6	12,429	15.8					

Sources: described above.

Appendix F
Oil Prices

A note about oil quality and pricing

Crude oil pricing is one of the most controversial issues of the international petroleum industry. However, something can be said about some of the variables that influence the price of oil. There are two main aspects of crude oil quality that influence the price: the distillate content and the sulphur content. Additionally, the price differential of a crude oil varies with its location, and naturally reflects transportation cost.

The gravity scale of the American Petroleum Institute (API) is the main quality criterion for crude oil pricing; the higher the gravity the higher the price of crude oil of a particular type. According to this classification, crudes are divided into three categories: heavy, medium and light oils.[1]

Heavy oils are those crude oils of API gravity in the range of 7 to 22 degrees. Approximately 1% of the free world crude oil is in this category.[2] Traditionally most Mexican oil was heavy and therefore of low value.[3] Venezuela was the main source of heavy crude oils to international markets by the mid-1980s.

Table F-1: Oil gravity classification

HEAVY 7° to 22° Venezuela and Mexico
MEDIUM 22.1° to 30° Venezuela, Nigeria
LIGHT >30° Middle East

Sources: Jenkins, G., *Oil Economist's Handbook 1985* (London, 1985).

Crude oils of API range 22.1 to 30 are considered medium crude oils. Two well known crudes of this class are Nigerian and Tia Juana (Venezuela). Venezuela has historically produced heavy and medium crudes.[4] On Venezuelan crudes the price differential was about 5cents/API gravity -identical value for US indigenous crude.

Light crude oils are those of API gravity of more than 30 degrees. Light crude oils command a higher price than other grades because of their high distillate contents and

[1] Definitions and data from G. Jenkins, *Oil Economist's Handbook 1985* (London, 1985).
[2] 'Free world' was used to signal the exclusion of communist countries in the oil reports.
[3] US Tariff Commission, 'Production cost of petroleum products and of refined petroleum products'. (Washington, D.C., 1932), p.51'. See also 'The next shock?', in *The Economist*, 6 March 1999,. The article refers to the decreasing price of oil, which may drive heavy oil producers as Mexico or Venezuela out of business.
[4] Gravity available at Venezuela. Ministry of Mines and Hydrocarbons, *Venezuelan Petroleum Industry Statistical Data* (Caracas, 1962), p.9.

also because they invariably have low sulphur contents. Important suppliers of light crude oils include all countries of the Middle East.

Still, the main difficulty consists in deciding what prices to use: posted prices, realised prices, discounted prices, etc. Posted prices are most relevant to our discussion, since they are the real foundation of revenue of the host governments of producing countries. Historically speaking, posted prices originated in the United States and they were buyer's price, not seller's prices. That is, they were announced by refiners, who thus defined the prices they were prepared to pay for crude oils at the well-head from any producers connected to their pipeline gathering system. After adequate transportation costs were added, posted prices were determined at export terminals on the U.S Gulf Coast.[5] One should be aware of the fact that realised prices were well under posted prices and therefore, using posted prices will overestimate the actual value of the resource. In any case one should also be aware that a price per barrel, whether posted, realised or discounted, is the result of a number of averages: the average yearly price in different markets of different oil qualities. Therefore, any price given is just an approximation to the actual value of oil produced in a year.

Notes for Mexico's oil prices series:

The historical time series for Mexican oil did not exist as such. For the purpose of this research, historical Mexican oil prices were compiled putting together diverse sources. This section summarises the range of sources available and their consistency.

From 1901 to 1935, two sources provide the commercial value of oil production in Mexican pesos. Given that the amount produced is known, can obtain the price per barrel (a) by a simple division one. An alternative calculation is also possible for the years 1924-1937. The annual average posted price in New York of crude oil in Mexican pesos per metric tone (m^3) is available for those years. We can convert pesos per m^3 into pesos per barrel (b) by a mere multiplication.[6] A consistent disparity appears when contrasting the outputs of each source, as shown in Table F-2.

[5] T. Rifai, *The Pricing of Crude Oil* (London, 1974), p. 8.

Table F-2: Oil prices per barrel in Mexico, 1925-1935, alternative sources									
Year	Pesos/m^3	Pesos per barrel		Differential	Year	Pesos/m^3	Pesos per barrel		Differential
		(a)	(b)	(a-b)			(a)	(b)	(a-b)
1925	24.61	2.590741	3.910529	-1.31979	1931	15.36	2.346616	2.440704	-0.09409
1926	24.54	2.489713	3.899406	-1.40969	1932	17.61	2.307149	2.798229	-0.49108
1927	23.73	2.456978	3.770697	-1.31372	1933	21.37	2.665702	3.395693	-0.72999
1928	18.63	2.032789	2.960307	-0.92752	1934	30.53	3.331229	4.851217	-1.51999
1929	17.62	2.059293	2.799818	-0.74052	1935	27.58	3.413635	4.382462	-0.96883
1930	16.30	2.047368	2.59007	-0.5427					

Sources:

(a) For the years 1901-1923, data published in México, Departamento de la Estadística Nacional, *El progreso económico de México. Un estudio económico estadístico* (México D.F., 2nd ed., 1924), p.28. Same data, but extended up to 1935 are available at México, Government of, 'Estadística Petrolera', *Revista de Industria. Revista Mensual* 1 (1937 December) 2 p.21. Both sets are fully consistent.

(b) México. Secretaría de Patrimonio Nacional, *El Petróleo de México* (México D.F., 1940 1st ed., 1963) p. 45 for 1923-1933 data and pp. 74-75 for 1933-1937 data. New York posted prices.

The price of crude oil in the New York market for 1925-1937 is consistently above the price resulting from the commercial value of the production by about one peso per barrel. The difference is most probably due to the transportation cost, since transport costs were included in the posted prices in the USA. The New York price was the official price used to calculate taxes by Mexican governments before the nationalisation.[7] Therefore, the consistency should not be surprising. For our purposes, nevertheless, prices excluding transport costs are more appropriate since they are closer to the price at well-head.

As mentioned in the relevant section of Chapter 4, official price series for crude oil do not to exist in Mexico from 1938 to 1975. The price series for this period have been constructed assembling value and volume for exports of crude oil from the sources listed below.

Prices for the period 1975-1985 are available from the *BP Statistical Review of World Energy, 1987*. These are official government selling prices on the first of January and first of July each year (average taken) for the Isthmus crude. Official government selling prices, although not withdrawn, became largely irrelevant from the beginning of 1986, when OPEC introduced a pricing new pricing system.[8] Thereafter, the Brent and West Texas Intermediate spot prices were the principal crude markers in international prices. Brent prices are the ones used here because they reflect better the price of heavy oil.

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[6] We know X pesos/m3, if we multiply that by 0.1589 m3/barrel, we would have X pesos per barrel. That is the formula applied from 1925 to 1937.

[7] México. Secretaría de Industria y Comercio, *El petróleo en la República Mexicana* (México D.F., 1917).

[8] The new price system is referred as netback.

Sources for oil prices data on Table F-3:
Mexico:

Oil prices:

Oil prices series knowing volumes and values produced and/or exported, oil prices were inferred from the following sources:

- 1901-1923: México. Departamento de la Estadística Nacional, *El progreso económico de México. Un estudio económico estadístico* (México D.F., 2nd ed., 1924),p. 28.
- 1923-1935: México, Government of, 'Estadística Petrolera', *Revista de Industria. Revista Mensual* 1 (1937 December) 2, p.21.
- 1938-1939: PEMEX, (Petróleos Mexicanos), *Informes del Director General Senador Antonio J.Bermúdez 1947-1952* (México D.F., 1952), p.17.
- 1940-1973: Banco Nacional de Comercio Exterior S.A., *Comercio Exterior de México* (México D.F., Volumes for the period 1948-1973) and Banco Nacional de Comercio Exterior S.A., *6 años en el comercio exterior de México* (México D.F., 1964).
- Prices 1975-1985: British Petroleum, *BP Statistical Review of World Energy, 1987* p.14. Official Government selling prices on the first of January and July each year (average taken) for the Isthmus crude.

Exchange rate (peso/US dollar):

- 1901-1987: México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 2nd ed., 1990), p. 855.
- For 1980-1989: México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Anuario Estadístico de los Estados Unidos Mexicanos* (México D.F., 1990), p.810.

Venezuela:

Oil prices:

- 1921-1991: (in dollars per barrel in the original) Baptista, A., *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991).

Exchange rate (bolivar/US dollar):

- up to 1938: Venezuela. Ministerio de Fomento, *Anuario estadístico de Venezuela, 1938,* pp.417-420.
- 1939-1963: Venezuela. Ministerio de Fomento, *Anuario estadístico de Venezuela, 1957-1963,* p.1046.
- 1963-1985: *PODE, 1985,* p.151.

Table F-3 Oil prices and dollar exchange rates: Mexico and Venezuela 1901-1989
(National currency and dollars per barrel)

	Mexico			Venezuela		
Year	Exchange Rate pesos/$	Oil price pesos/barrel	Oil price $/barrel	Oil price $/barrel	Oil price blvs/barrel	Exchange rate blvl/$
1901	2.11	0.20	0.09			
1902	2.39	0.20	0.08			
1903	2.38	0.20	0.08			
1904	1.99	0.20	0.10			
1905	2.02	0.20	0.10			
1906	1.99	0.20	0.10			
1907	2.01	0.20	0.10			
1908	2.01	0.20	0.10			
1909	2.01	0.20	0.10			
1910	2.01	0.20	0.10			
1911	2.01	0.20	0.10			
1912	2.01	0.25	0.12			
1913	2.08	0.30	0.14			
1914	3.30	0.30	0.09			
1915	11.15	0.40	0.04			
1916	23.83	0.55	0.02			
1917	1.91	0.85	0.45			
1918	1.81	1.40	0.78			
1919	1.99	1.83	0.92			
1920	2.01	2.00	1.00	2.69	15.06	5.60
1921	2.04	1.89	0.93	1.23	7.38	6.00
1922	2.05	1.84	0.90	1.31	7.07	5.40
1923	2.06	1.91	0.93	1.46	7.74	5.30
1924	2.07	1.95	0.94	1.74	8.87	5.10
1925	2.03	2.59	1.28	1.80	9.18	5.10
1926	2.07	2.49	1.20	1.77	9.29	5.25
1927	2.12	2.46	1.16	1.24	6.45	5.20
1928	2.08	2.03	0.98	1.02	5.30	5.20
1929	2.08	2.06	0.99	1.16	6.03	5.20
1930	2.12	2.05	0.96	1.15	6.15	5.35
1931	2.43	2.35	0.97	0.72	4.33	6.01
1932	3.17	2.31	0.73	0.81	5.51	6.80
1933	3.53	2.67	0.76	0.61	2.75	4.50
1934	3.60	3.33	0.93	0.88	3.34	3.80
1935	3.60	3.41	0.95	0.84	3.28	3.90
1936	3.60	3.30	0.92	0.88	3.43	3.90
1937	3.60	4.90	1.36	0.96	3.17	3.30
1938	4.52	4.73	1.05	0.93	2.88	3.10
1939	5.18	4.24	0.82	0.80	2.47	3.09
1940	5.40	3.62	0.67	0.93	2.87	3.09
1941	4.86	3.52	0.72	0.98	3.03	3.09
1942	4.85	3.88	0.80	1.01	3.12	3.09
1943	4.85	4.14	0.85	1.03	3.18	3.09
1944	4.85	3.96	0.82	1.05	3.24	3.09
1945	4.85	3.78	0.78	1.06	3.28	3.09

(cont.)

Table F-3 Oil prices and dollar exchange rates: Mexico and Venezuela 1901-1989

(cont.) (National currency and dollars per barrel)

Year	Mexico Exchange rate pesos/$	Mexico Price pesos/barrel	Mexico $/barrel	Venezuela Price $/barrel	Venezuela blvs/barrel	Venezuela Exchange rate blvl/$
1946	4.85	5.16	1.06	1.26	3.89	3.09
1947	4.85	5.01	1.03	1.75	5.41	3.09
1948	5.74	8.84	1.54	2.41	7.45	3.09
1949	8.01	10.98	1.37	2.25	6.95	3.09
1950	8.65	13.72	1.59	2.12	6.55	3.09
1951	8.65	15.27	1.76	2.00	6.18	3.09
1952	8.65	17.08	1.97	2.14	6.61	3.09
1953	8.65	14.36	1.66	2.30	7.11	3.09
1954	11.34	17.44	1.54	2.31	7.14	3.09
1955	12.50	17.71	1.42	2.34	7.23	3.09
1956	12.50	18.85	1.51	2.36	7.29	3.09
1957	12.50	24.28	1.94	2.65	8.19	3.09
1958	12.50	59.44	1.74	2.50	7.73	3.09
1959	12.50	19.26	1.54	2.23	6.89	3.09
1960	12.50	16.43	1.31	2.12	6.55	3.09
1961	12.50	21.40	1.71	2.12	6.55	3.09
1962	12.50	22.94	1.84	2.08	6.43	3.09
1963	12.50	22.65	1.81	2.03	6.27	3.09
1964	12.50	23.15	1.85	1.94	8.54	4.40
1965	12.50	23.32	1.87	1.88	8.27	4.40
1966	12.50	23.12	1.85	1.88	8.27	4.40
1967	12.50	23.33	1.87	1.85	8.14	4.40
1968	12.50	23.25	1.86	1.86	8.18	4.40
1969	12.50	22.63	1.81	1.81	7.96	4.40
1970	12.50	23.00	1.84	1.84	8.10	4.40
1971	12.50	29.38	2.35	2.35	10.22	4.35
1972	12.50	31.50	2.52	2.52	10.84	4.30
1973	12.50	46.38	3.71	3.71	15.58	4.20
1974	12.50	131.63	10.53	10.53	44.23	4.20
1975	12.50	140.00	11.20	10.99	46.16	4.20
1976	15.69	190.63	12.15	11.15	47.39	4.25
1977	22.69	303.48	13.38	12.54	53.67	4.28
1978	22.76	301.57	13.25	12.04	51.53	4.28
1979	22.82	418.75	18.35	17.96	76.87	4.28
1980	22.95	763.09	33.25	26.44	113.16	4.28
1981	24.51	919.13	37.50	29.71	127.16	4.28
1982	57.18	1,929.83	33.75	27.47	117.57	4.28
1983	150.29	4,621.42	30.75	25.31	108.58	4.29
1984	85.19	2,470.51	29.00	26.70	159.93	5.99
1985	310.28	8,649.06	27.88	25.89	155.08	5.99
1986	637.87	9,172.57	14.38	12.82	160.25	6.77
1987	1,405.80	25,908.89	18.43	16.32	202.50	9.62
1988	2,289.58	34,252.12	14.96	13.51	168.88	12.33
1989	2,483.37	45,197.33	18.20	16.87	210.88	15.25

Sources: described above.

Appendix G

Labour Force and Operation Costs Series

Notes and sources on labour force estimates for Mexican oil fields:

Aggregated labour costs of the oil industry –that is including all the labour involved from the discovery of oil to its actual delivery in the gas station- are available from México, Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994). Knowing oil production and quantity refined it was possible to estimate what amount of the labour force (and labour costs) belonged to each branch of the industry.

Employees in oil fields are only available for:

- 1934-1935: México, Secretaría de Hacienda y Crédito Público, Dirección General Técnica de Ingresos, Oficina de Investigaciones Económicas, *La Industria del Petróleo en México* edited by Manterola, M. (México, D.F, 1938).
- 1970-1979: México. Secretaría de Programación y Presupuesto, *La industria petrolera en México* (México D.F., 1980), p.360.

As a consequence the data on employees in oil fields in Mexico needed to be estimated. The series were estimated using refining as control variable. The amount of oil processed was obtained from the following sources:

- Crude processed 1921 and 1924-1935 and installed refining capacity in 1937 from Secretaría de Hacienda y Crédito Público. Dirección General Técnica de Ingresos. Oficina de Investigaciones Económicas, *La Industria del Petróleo en México* edited by Manterola, M., (México, D.F, 1938).
- 1938-1959: PEMEX, (Petróleos Mexicanos), *Informe del Director General, 1953-1960* (México D.F., 1953-1960).
- 1938-1985 also available from PEMEX, (Petróleos Mexicanos), *Anuario Estadístico 1988* (México D.F., 1988). These series coincide with the data on barrels processed per day published by Instituto Mexicano del Petróleo (ed.), *Memorias de Labores 1965-1973* Vol. I (México D.F, 1984) and *Memorias de Labores 1974-1979* Vol. II (México D.F.,1984).

- 1985-1990 from Nacional Financiera, *La Economía Mexicana en Cifras* (México D.F., 1991), p.89.

The amount refined allowed to estimate the amount of people employed in refinery and therefore in oil fields. These estimates, based on the proportion of refining and production activities, are actually quite close to the limited actual figures available. These are compared in Table G-1. Even discounting the labour employed in refining activities, the estimated figures of labour force in the oil fields still overestimate the personnel directly involved in production activities as the table below shows. Yet for the sake of consistency the whole of the series used correspond to our estimation.

Table G-1: Actual vs. estimated labour force in Mexican oil fields, 1970-1979

Distribution of labour force in Mexican oil industry

	Official estimates					Estimation done for the thesis	
	Total	Primary activities[i]	Industrial[ii]	Transport[iii]	Administration	Primary activities	Other (refining)
1970	71,062	36,501	16,775	7,474	10,313	42,136	28,926
1971	75,498	38,532	19,417	7,540	10,009	44,028	31,470
1972	75,748	38,652	17,929	7,829	11,338	42,088	33,660
1973	76,656	38,969	18,174	8,008	11,505	38,196	38,460
1974	77,679	39,479	19,376	8,199	10,619	37,959	39,720
1975	81,203	40,167	20,891	9,125	11,020	36,983	44,220
1976	88,052	39,019	27,509	9,434	12,909	38,252	49,800
1977	91,680	41,422	28,408	9,864	11,986	44,232	47,448
1978	95,655	43,368	29,635	10,459	12,193	48,207	47,448
1979	103,271	45,342	35,099	11,486	11,343	46,949	56,322
			Percentages over total			Percentages over total	
1970		51%	24%	11%	15%	59%	41%
1971		51%	26%	10%	13%	58%	42%
1972		51%	24%	10%	15%	56%	44%
1973		51%	24%	10%	15%	50%	50%
1974		51%	25%	11%	14%	49%	51%
1975		49%	26%	11%	14%	46%	54%
1976		44%	31%	11%	15%	43%	57%
1977		45%	31%	11%	13%	48%	52%
1978		45%	31%	11%	13%	50%	50%
1979		44%	34%	11%	11%	45%	55%

i Exploration and exploitation
ii Refining and Petrochemical
iii Marine and Sales

Sources: official estimates from México. Secretaría de Programación y Presupuesto, *La industria petrolera en México* (México D.F., 1980).p.360.

Once the labour force was divided between primary and other activities, it was possible to allocate the labour costs proportionally to the different categories. Labour cost sources are as follow:

- 1934-1936: México. Secretaría de Patrimonio Nacional, *El Petróleo de México* (México D.F., 1940 1st ed., 1963), pp.477-510.
- 1937 PEMEX, (Petróleos Mexicanos), *Informes del Director General Senador Antonio J.Bermúdez 1947-1952* (México D.F., 1952).
- 1938-1992 México. Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994), p.573.

Venezuela:

Labour force:

- 1921-1990 Baptista, A., *Bases Cuantitativas de la Economía Venezolana, 1830-1995* (Caracas, 1997), cuadro B-5.

Wages in oil industry:

- 1921-1990 Baptista, A., *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991), pp.139-141.

Notes and sources on operation costs data in Table G-2:

Mexico:

- 1921: México, Secretaría de Hacienda y Crédito Público, Dirección General Técnica de Ingresos, Oficina de Investigaciones Económicas, *La Industria del Petróleo en México* edited by Manterola, M., (México, D.F, 1938). p.152 quoting the report by the Ingeniero Felipe Llanas, Cámara de Senadores, in 1923, titled 'Mexico y su petroleo', notified a cost per barrel of 0.317 pesos in the Panuco zone at well-head and it was of 0.076 pesos per barrel in the Tuxpan zone .
- 1927-1930: Operating costs from US Tariff Commission, 'Production cost of petroleum products and of refined petroleum products'. (Washington, D.C., 1932). Cost per barrel in dollars in the original source multiplied by the exchange rate and the production here.

- 1934-1936: México, Secretaría de Patrimonio Nacional, *El Petróleo de México.* Recopilación de documentos oficiales del conflicto de orden económico de la industria petrolera con una...., (México D.F., 1940 1st ed., 1963)., pp. 477-510.
- 1970-1979: Official operating costs in oil fields published in México, Secretaría de Programación y Presupuesto, *La industria petrolera en México* (México D.F., 1979), pp.402-403.

The gaps of the operating cost series were filled by linear interpolation of the cost per barrel. Then the inferred cost per barrel was multiplied by the specific production each year, thereby obtaining the value of the total production costs. As control of this procedure we had the labour costs of the industry. Calculating the proportion of operating costs that corresponds to labour costs the series such a ratio are very consistent throughout inferred and actual data providing a quite a good reassurance of the figures obtained for operation costs.

Venezuela:

- 1920-1926: Operation costs data inferred assuming a participation 50 percent of wages in the operating costs (see wages sources above)
- 1927-1930: Operating costs data from US Tariff Commission, 'Production cost of petroleum products and refined petroleum products'. (Washington, D.C., 1932). Cost per barrel in dollars in the original source multiplied here by the exchange rate and the production (see appendices E and A respectively).
- 1930-1936: Inferred linearly, controlling for the share of wages in operating costs.
- 1936-1938: *PODE, 1940*
- 1938-1947: inferred using the same method than above.
- 1947-1985: *PODE,* several years, from the table headed 'Distribution of income per barrel' in the finance section every year, multiplied by the number of barrels produced a year. When figures were revised, the most recent estimate was taken. Depreciation, amortisation and retirements are not included within the operating cost category.

Table G-2: Employees, labour and operating costs in the oil industry. Mexico and Venezuela 1920-1985

Year	Venezuela			Mexico		
	Operating cost mill. blvs	Wages mill. blvs	Employees	Operating costs mill. pesos	Wages mill. pesos	Employees in oil fields
1920	24.6	12.3	3,463			
1921	28.4	14.2	5,158	61.3		17,110
1922	32.8	16.4	8,126	90.4		16,313
1923	47.6	23.8	12,148	80.8		15,637
1924	76.6	38.3	16,175	119.3		14,720
1925	114.6	57.3	21,174	119.4		14,286
1926	169.6	76.3	21,240	109.7		12,672
1927	237.5	99.9	27,221	89.3	31.1	15,753
1928	305.5	100.2	21,009	75.1	28.3	16,249
1929	361.0	128.3	12,064	67.4	26.4	16,063
1930	392.1	106.6	8,832	51.1	19.4	14,718
1931	203.7	61.1	10,855	53.7	22.0	14,573
1932	149.3	44.8	11,546	64.2	26.1	13,218
1933	163.3	53.9	12,333	71.0	24.8	11,274
1934	211.4	74.0	13,754	100.1	18.1	8,070
1935	197.5	79.0	21,268	115.0	23.0	8,996
1936	217.8	91.0	22,496	127.6	30.4	10,416
1937	260.1	122.9	22,392	203.9	35.9	10,844
1938	265.6	149.8	18,627	215.6	48.4	12,339
1939	285.8	157.2	19,186	293.8	72.8	14,926
1940	284.4	156.4	16,470	356.6	73.1	16,045
1941	265.5	146.0	17,021	402.1	66.8	13,755
1942	290.7	159.9	22,145	368.8	72.3	14,294
1943	269.3	148.1	26,235	416.1	80.7	15,728
1944	339.1	186.5	44,585	499.8	104.5	16,140
1945	453.1	249.2	51,788	624.0	131.0	17,969
1946	709.6	390.3	61,077	767.0	178.0	22,303
1947	765.4	520.5	46,878	947.2	181.4	20,911
1948	1,171.1	681.4	44,335	1,057.5	200.7	20,624
1949	1,224.3	703.1	43,592	1,176.5	242.6	20,694
1950	1,288.6	563.0	45,109	1,489.3	235.2	23,732
1951	1,405.7	624.0	44,784	1,686.2	303.9	26,383
1952	1,518.0	714.0	43,327	1,781.9	330.2	25,416
1953	1,674.4	743.0	42,851	1,760.4	354.1	25,949
1954	1,769.0	780.0	44,103	2,137.4	449.5	27,826
1955	1,534.7	787.0	45,652	2,395.6	526.3	29,065
1956	1,681.1	835.0	44,720	2,542.5	573.2	27,977
1957	1,875.9	1,024.0	43,331	2,585.4	667.8	29,939
1958	1,959.1	1,040.0	40,690	2,856.3	710.6	29,467
1959	2,011.9	1,047.0	37,324	3,063.8	772.4	28,253
1960	2,009.1	1,183.0	34,818	3,271.7	811.2	27,665
1961	1,917.0	1,071.0	33,742	3,660.4	803.5	26,874
1962	1,820.5	978.0	33,262	3,973.4	901.3	27,919
1963	1,872.3	1,015.0	24,521	4,223.8	982.2	28,950
1964	2,420.0	1,108.0	31,838	4,394.0	1,047.7	28,496
1965	2,217.3	1,106.0	29,448	4,631.7	1,258.0	32,643
1966	2,214.0	1,119.0	25,419	4,908.0	1,400.8	33,505
1967	2,222.2	1,137.0	27,072	5,555.7	1,608.9	37,016
1968	2,123.6	1,065.0	23,472	6,122.2	2,017.2	42,955
1969	2,254.9	1,032.0	23,993	6,631.6	1,963.9	39,323
1970	2,421.9	1,147.0	23,714	7,129.0	2,277.5	42,136
1971	2,771.3	1,156.0	23,328	7,664.0	2,559.5	44,028
1972	2,874.3	1,209.0	22,674	7,787.0	2,659.8	42,088
1973	3,119.1	1,245.0	23,097	8,537.0	2,515.3	38,196
1974	3,388.3	1,560.0	23,824	16,627.0	3,008.7	37,959
1975	5,213.0	1,948.0	25,102	18,097.0	3,224.1	36,983
1976	3,876.2	1,581.0	26,120	18,991.0	3,897.2	38,252
1977	4,447.2	1,257.0	30,493	24,920.0	6,188.6	44,232
1978	6,027.7	1,921.0	33,424	31,867.0	7,998.1	48,207
1979	7,473.4	2,242.0	36,606	46,516.0	10,083.8	46,949
1980	11,554.0	3,968.0	39,189	63,966.0	14,072.5	51,348
1981	12,165.6	4,472.0	39,595	76,285.2	16,782.7	58,839
1982	11,788.5	4,515.0	40,105	153,888.5	33,855.5	65,515
1983	13,415.9	5,121.0	38,401	439,024.8	96,585.5	77,096
1984	14,893.4	5,682.0	38,915	213,807.1	47,037.6	72,328
1985		5,963.0	39,138	726,738.8	159,882.5	69,362

Appendix H

Capital Investment in the Oil Industry

The amounts invested in both countries also offers a big contrast. Figure H-1 illustrates the different pattern of capital investment per barrel produced in Mexico and Venezuela from 1921 to 1985, although Mexican data is very sketchy before 1938. The data series used are the following.

Mexico:

- 1924: Dept. Estadística Nacional, as quoted in Gordon, W.C., *The Expropriation of Foreign-Owned Property in Mexico* (Washington D.C, 1941), p.53.
- 1935: México, Secretaría de Patrimonio Nacional, *El Petróleo de México* (México D.F., 1940 1st ed., 1963), cuadros 145-160.
- 1938-1979: México, Instituto Nacional de Estadística Geografía e Informática (INEGI), *Estadísticas históricas de México* (México D.F., 3rd ed., 1994), p. 574.
- 1960-1985: PEMEX, (Petróleos Mexicanos), *Anuario Estadístico 1988* (México D.F., 1988).

Venezuela

- 1920-1946: Baptista, A., *Bases Cuantitativas de la Economía Venezolana, 1830-1989* (Caracas, 1991), cuadro V-30, allocating 60 percent of total investment to the production branch of the industry.
- 1947-1961: Net capital investment in fixed assets in the production branch of the oil industry, Venezuela. Ministry of Mines and Hydrocarbons, *Venezuelan Petroleum Industry. Statistical Data* (Caracas, 1962), p.24
- 1960-1970: Net capital investment in fixed assets in the production branch of the industry calculated from data in total net capital investment in fixed assets multiplied by the corresponding percentage of the production branch of the industry, *PODE, 1970*, p.142.
- 1964-1974: same procedure over data in *PODE, 1974*, p.13ff.
- 1975-1985: same procedure over data in *PODE, 1985*, p. 131

Overlapping data coincident, otherwise the most recent source was used.

Table H-1 **Capital investment in the production branch of the oil industry. Venezuela and Mexico 1921-1985**

Year	Venezuela: Capital investment in oil industry			Mexico: Capital investment in oil industry		
	$/barrel	mill. blvs	mill. $	$/barrel	mill. pesos	mill. $
1921	0.99	8.28	1.48			
1922	1.62	19.27	3.44			
1923	1.49	33.91	6.05			
1924	1.57	72.85	13.01	0.00	1.07	0.51
1925	1.77	179.90	32.12			
1926	1.76	329.76	58.89			
1927	1.51	474.38	84.71			
1928	1.05	579.14	103.42			
1929	1.05	739.85	132.12			
1930	1.08	780.37	139.35			
1931	1.07	751.06	134.12			
1932	0.85	678.14	121.10			
1933	1.18	629.28	112.37	0.01	1.00	0.28
1934	1.01	521.53	93.13			
1935	0.86	498.29	88.98	0.04	6.10	1.69
1936	0.85	512.51	91.52			
1937	0.88	541.16	96.63			
1938	1.13	661.30	118.09	0.05	8.00	1.77
1939	1.16	734.67	131.19	0.12	27.00	5.21
1940	1.34	761.80	136.04	0.33	79.00	14.63
1941	1.08	760.33	135.77	0.10	20.00	4.12
1942	1.67	762.86	136.22	0.12	20.00	4.12
1943	1.54	852.47	152.23	0.13	23.00	4.74
1944	1.12	890.40	159.00	0.26	49.00	10.10
1945	1.08	1,078.82	192.65	0.55	117.00	24.12
1946	1.20	1,444.62	257.97	0.47	112.00	23.09
1947	1.63	2,193.00	391.61	0.32	88.00	18.14
1948	1.81	2,739.00	489.11	0.52	173.00	30.14
1949	2.00	2,981.00	532.32	0.47	231.00	28.84
1950	1.79	3,018.00	538.93	0.57	358.00	41.39
1951	1.62	3,105.00	554.46	0.53	355.00	41.04
1952	1.72	3,515.00	627.68	0.56	373.00	43.12
1953	1.84	3,660.00	653.57	0.77	484.00	55.95
1954	1.74	3,724.00	665.00	0.90	858.00	75.66
1955	1.61	3,916.00	699.29	0.89	989.00	79.12
1956	1.83	5,095.00	909.82	0.80	902.00	72.16
1957	2.13	6,681.00	1,193.04	1.20	1,328.00	106.24
1958	2.37	6,966.00	1,243.93	1.38	1,612.00	128.96
1959	2.41	7,534.00	1,345.36	1.33	1,605.00	128.40
1960	2.21	7,095.00	1,266.96	2.05	2,537.00	202.96
1961	2.02	6,657.62	1,188.86	1.73	2,315.00	185.20
1962	1.72	6,203.42	1,107.75	1.39	1,940.00	155.20
1963	1.58	5,784.72	1,032.99	1.30	1,871.00	149.68
1964	1.02	5,544.94	990.17	1.77	2,558.00	204.64
1965	0.98	5,484.99	979.46	1.56	2,293.00	183.44
1966	0.94	5,065.33	904.52	2.06	3,121.00	249.68
1967	0.83	4,720.91	843.02	3.10	5,154.00	412.32
1968	0.85	4,927.99	880.00	2.92	5,188.00	415.04
1969	0.86	4,965.73	886.74	2.71	5,081.00	406.48
1970	0.80	4,789.96	855.35	2.35	4,604.00	368.32
1971	0.82	4,641.79	828.89	2.35	4,574.00	365.92
1972	0.54	2,749.06	490.90	2.59	5,234.00	418.72
1973	0.92	4,742.90	846.95	3.47	7,150.00	572.00
1974	1.15	5,222.99	932.68	3.71	9,738.00	779.04
1975	1.34	4,815.76	859.96	4.28	13,981.00	1,118.48
1976	1.44	5,119.12	914.13	5.20	23,912.00	1,524.03
1977	1.67	5,839.79	1,042.82	4.38	35,627.00	1,570.16
1978	2.22	7,507.65	1,340.65	6.22	62,703.00	2,754.96
1979	2.77	10,184.25	1,818.62	6.81	83,472.00	3,657.84
1980	4.09	13,868.45	2,476.51	9.70	157,664.00	6,869.89
1981	6.06	19,949.50	3,562.41	11.33	234,332.00	9,560.67
1982	10.03	29,660.03	5,296.43	5.66	324,669.00	5,678.02
1983	13.15	37,054.18	6,616.82	1.60	233,769.00	1,555.45
1984	10.65	42,054.83	7,509.79	2.52	210,264.00	2,468.18
1985	12.55	46,095.19	8,231.28	2.12	631,231.00	2,034.39

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