The Political Economy of King Midas

Resource Abundance and Economic Growth

Elissaios Papyrakis

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The Political Economy of King Midas: Resource Abundance and Economic Growth

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Elissaios Papyrakis

geboren te Rethymnon, Griekenland

promotor: prof.dr. H. Verbruggen

copromotor: dr. R. Gerlagh

The improvement of the understanding is for two ends: first, for our own increase of knowledge; secondly; to enable us to deliver and make out that knowledge to others.

John Locke (1632-1704)

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There are indeed *no gains without pains* and this thesis was no exception of the general rule. It takes a lot of effort to put down your thoughts on paper, convey your ideas in a clear manner, and present them in an intriguing way. Nevertheless, the result is more than rewarding. Similar to the pride of an architect or sculptor when glimpsing his or her structure or sculpture when complete, I have to say I felt inundated with joy and satisfaction the minute I printed out the last version of my thesis. Writing a thesis is an extremely mind-intensive process, it is a mental seesaw. There are ups and downs, moments you feel extremely frustrated and want to give up and moments you feel really content with yourself and keep smiling to everybody around you. Sometimes, a paper gets rejected and sometimes it gets accepted. Sometimes, people give you fierce criticism and sometimes they provide flattering compliments. But overall, I consider this thesis an inseparable part of me and my life, and as such I bear much affection towards it. I would be, though, at least selfish not to acknowledge that I have to share fatherhood with many other persons that helped me shaping my ideas and approaching my research questions. And there is no better time to acknowledge their invaluable contribution than the very first page of the book.

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Introduction

1. THE POLITICAL ECONOMY OF KING MIDAS

1.1. Introduction

The story of King Midas and his empowerment to transform all he touched into gold is a well-known tale from ancient Greek mythology. One day, Silenus, an elderly satyr and companion of the wine god Dionysus was wandering off drunk close to the palace of King Midas. Some peasants captured him and brought him before the king. King Midas recognised Silenus, released him, and treated him kindly during his stay. When Dionysus heard about King Midas' hospitality, he offered to grant the king any wish. King Midas, a cordial and gracious man but exceptionally greedy and fond of luxury and wealth, asked for the gift of the golden touch. Dionysus asked King Midas to reconsider his choice, foreseeing where this would inevitably lead. The king insisted and Dionysus granted him the gift of the golden touch, in order to honour his promise. King Midas, immensely delighted by his new powers, started immediately touching things in order to transform them into gold and increase his riches. His golden touch made him feel extremely fortunate and pleased with all the precious gold surrounding him. But his joy was not meant to last too long. After a while, the king's clothes, friends, food, water, his precious daughter and the whole palace was transformed into gold. As he nearly starved to death, King Midas realised his error and begged Dionysus to grant him release of his glittering destructive powers. Dionysus took pity on the king and granted his request by having him bathed in the Pactolus River.

The story is reminiscent of the disappointing economic performance of resource-rich countries observed over the last decades. Resource-rich countries experience an increase in income at the time of the resource discovery and thus the economy benefits in the short run. This is the "golden touch" gift that mother nature provided to a few regions around the world. Resource wealth, however, may be nothing more than a momentary bliss for the economy and the overall level of welfare. Often, natural resources create a false sense of security and make people lose sight of the need for prudent and growth-promoting strategies. Governments misuse the resource revenues and do not exercise care when planning economic policies. They succumb to greed and cannot foresee that an intense exploitation of the resource base leads to stagnation and a deterioration in living standards. For several reasons, that will become apparent as the analysis proceeds, resource-rich economies often find themselves much worse-off in terms of income growth in the long run. King Midas begged Dionysus to relieve him of the power of golden touch, as soon as he realised that such a gift was a threat to his welfare. King Faisal of Saudi Arabia said once of his country that the way resource rents are being wasted, they would soon end up riding camels again instead of Cadillacs. Plentiful fertile valleys, rich fishing stocks, diamond mines, and vast oil reserves do not necessarily guarantee a high level of economic prosperity, on the contrary they may inhibit it.

Recent empirical evidence and theoretical work provides strong support to a resource curse hypothesis; i.e. natural resource wealth tends to impede rather than promote economic growth (Auty 1994, Gylfason 2000, 2001a, 2001b, Leite and Weidmann 1999, Rodriguez and Sachs 1999, Papyrakis and Gerlagh 2004a, Sachs and Warner 1995, 1997, 1999a, 1999b). One of the most striking manifestations of the hypothesis is undoubtedly the disappointing performance of the oil cartel countries. As Gylfason (2001b) notes, the significant injections of petrodollars into their local economies from the oil extractive industries did not prevent them from experiencing a negative rate of income growth over the last four decades. In a similar context, Argentina ranked among the ten wealthiest nations at the beginning of last century but its vast resource base did not prevent its continuous downgrade to a developing country (Diaz-Alejandro 1970). Oil rich Venezuela had the second highest GDP per capita in Latin America before the first oil boom but sustained an average income growth rate of –3% thereafter. Papyrakis and Gerlagh (2004b) note that Alaska is the only U.S. state with a negative growth rate over the last two decades despite its extensive oil reserves and fishing industry.

The expectations of many early development economists (such as Nurkse 1953, Rostow 1960, and Watkins 1963) that resource endowments could support economic expansion and improve living standards proved to be wrong in most cases. In general, resource-dependent economies did not prosper by extracting and exporting their resource wealth, as long as their primary sector rents were not channelled into productive investments in order to build local infrastructure. Saying that, one should acknowledge that the resource curse hypothesis is though by no means an economic law without exceptions. Wright (1990) argues that the industrial expansion of the U.S. at the beginning of the 20th century was supported to a large extent by the discoveries of minerals. He stated on the conditional role of natural resources on economic development that “there is no iron law associating natural resource abundance with national industrial strength”. Sachs and Warner (1999a) argue, for instance, that Ecuador benefited from its oil boom between 1972-1986. The same authors (1995) point out that the vast deposits of iron ore and coal supported the industrial revolution in Great Britain and Germany. Wright (1990) associated the origins of rapid industrial expansion and technological transformation in the U.S. with the exploitation of mineral resources. More recently, Norway (the world’s second largest oil exporter) manages to convert its resource wealth into economic prosperity showing no symptoms of stagnation (see Gylfason and Zoega 2001). This naturally raises the question of what determines whether or not a country escapes the resource curse. Why does the majority of resource-dependent countries fail to capitalise on the resource blessing and lag behind in terms of income growth and welfare compared to their resource-poor counterparts?

The aim of this thesis is to contribute to our understanding of the interplay between economic growth and resource abundance.[1] The thesis investigates novel intermediary mechanisms that shed light on the "resource curse" hypothesis. Additionally, much emphasis is also given on testing existing explanations of the hypothesis and evaluating their relative importance.

Section 1.2 presents an introduction to the resource curse and the different economic experiences of resource-dependent economies. Section 1.3 reviews existing explanations of the negative association between resource income and economic growth. Section 1.4 briefly describes the relationship between the "resource curse" hypothesis and sustainability. Finally, the set up of the remainder of the thesis and the related research questions is presented in Section 1.5.

1.2. Natural Resources and Economic Prosperity

As discussed briefly in the introduction, most resource-abundant countries tend to be examples of development failures in terms of economic growth. Regions around the world with immense reserves of natural resources do not succeed in escaping crushing poverty. On the contrary, there seems to be a negative linkage between the two variables, implying that resource abundance impedes the efforts to increase per capita income and improve living

[1] We notice that there is much confusion about the exact meaning of the concept "resource abundance". The meaning may easily differ between sciences, and even between different areas of economics (for an extensive analysis of the confusion regarding precise terminologies of natural resources see Laroui and Van der Zwaan 2002). For natural scientists or environmental economists, resource abundance typically refers to a large amount of potentially exploitable natural resources. For economists that study the Dutch Disease, resource abundance typically refers to the amount of already exploited natural resources and reserves proven to be economically exploitable. The proportion of potential resources that, in the end, becomes economically exploitable depends on many economic, political and technological factors. To provide an example, Foster and Rosenzweig (2003) show that there is a strong positive correlation between economic growth and (potential) resource wealth (forest cover) for a sample of 23 closed developing economies. They argue that forest-dependent communities tend to renew forest cover once they realise their economic dependence on forest products and the related long-term implications of deforestation. In this context, resource affluence refers to the exploitable resource stock rather than the exploited amount of resources. Sachs and Warner (1995), in contrast, find a strong negative correlation between economic growth and (already exploited) resource wealth (the share of primary exports in GDP) for their cross-sectional analysis of 95 countries. To use Patten's own words (1889), in economics we often "really need new words more than we do new thoughts". In our analysis, we focus on the already exploited natural resources.

standards. As Figure 1.1 illustrates, there is a clear negative correlation between the average annual growth of GDP per capita between 1975–1996 and the share of mineral production in GDP in 1971 for a sample of 103 countries. Data on income and mineral production are provided by the Penn World Tables 6.0 from the Center for International Comparisons at the University of Pennsylvania and by the Sachs and Warner database at the Center for International Development (CID) at Harvard University respectively. Most countries with a mineral production accounting for more than 20% of total production experience negative rates of income growth. King Midas almost died of starvation due to his golden touch, and the population in many resource-rich regions do not seem to suffer less.

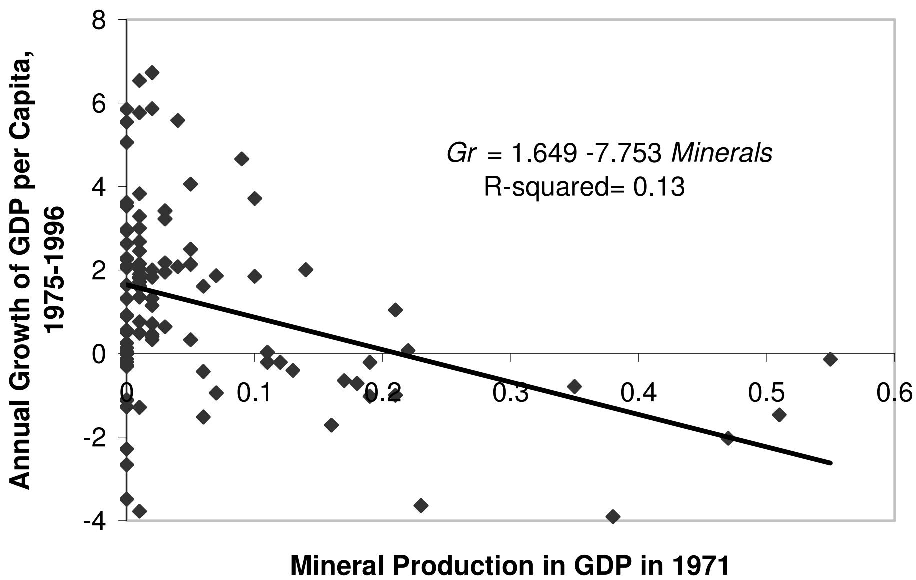

FIGURE 1.1. *Resource abundance and economic growth*

Resource-abundant countries seem to embark on a different development path compared to resource-scarce ones, due to the fact that their governments often lose sight of the need for growth-supporting policies and efficient management of available resources. Resource exploitation damages the sound fundamentals of the economy and results in a lower or even negative rate of income growth. This is graphically represented in Figure 1.2, where we depict the different development paths an economy may experience over time. We assume that before exploiting its resource base, the representative economy grows at a constant and positive rate along the development path AD. At a certain point in time, resource revenues enter the economy causing an abrupt increase in total income. This is represented by a sudden shift from a point A to B, indicating a positive income shock in the short term.[2] After that point in time, different scenarios may evolve. Empirical evidence[3] suggests that most resource-abundant countries shift to a different development path of lower income growth. Most of them either grow at a lower rate of economic growth, as suggested by the development path BE, or experience a negative growth rate, as depicted by the BF path.[4] In the first case, growth simply slows down and the economy is better off for a short period of time (the time implied by the intersection of the lines AD and BE). In the latter case, economic contraction starts immediately and the resource curse is more acute. There is not only a relative loss of welfare and income, but also an absolute loss. As mentioned earlier, however, the resource curse is by no means an economic law and a few countries manage to escape from it. This is illustrated by the development path BC, corresponding to unaffected growth performance after the resource exploitation. It is also possible that resource wealth boosts income growth, and in this case, the slope of BC is larger compared to AD.[5]

In Table 1.1, we present representative examples of resource-dependent countries following each distinctive development path between 1975-1996. Next to each country, we present the average growth rate of GDP per capita over the 1975-1996 period. All countries have a share of mineral production and primary exports in GDP in 1971 above 10%. The first set of countries includes Zambia, Mauritania and Venezuela, that followed a development path, similar to BF in Figure 1.2. These countries, with a negative growth rate, represent regions where the manifestation of the resource curse is most acute. The second set of countries includes Algeria, Zimbabwe and Barbados that followed a development path similar to BE. These countries experienced moderate rates of income growth, but smaller than the sample average (1.3%). In that case, the resource curse results in downgrading the relative position of a resource-abundant country in welfare distribution at a global scale. Finally, the last set of countries includes resource-dependent nations such as the Netherlands, Norway and Botswana that outperformed many of their resource-scarce counterparts. These countries belong to the few exceptional cases of countries escaping the resource curse. Below, we discuss briefly the divergent experiences of some of these resource-dependent countries in terms of their resource management and resulting growth performance.

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[2] A constant rate of income growth implies that the economy is at a steady-state and we abstract from any transitional dynamics.

[3] See, Papyrakis and Gerlagh (2004a) and Sachs and Warner (1995, 2001a, 2001b).

[4] Gylfason (2000 and 2001b) provides a similar figure analysing the first case, depicted by the BE scenario.

[5] We do not distinguish between the two cases, assuming that the BC development path characterises all those countries escaping the resource curse.

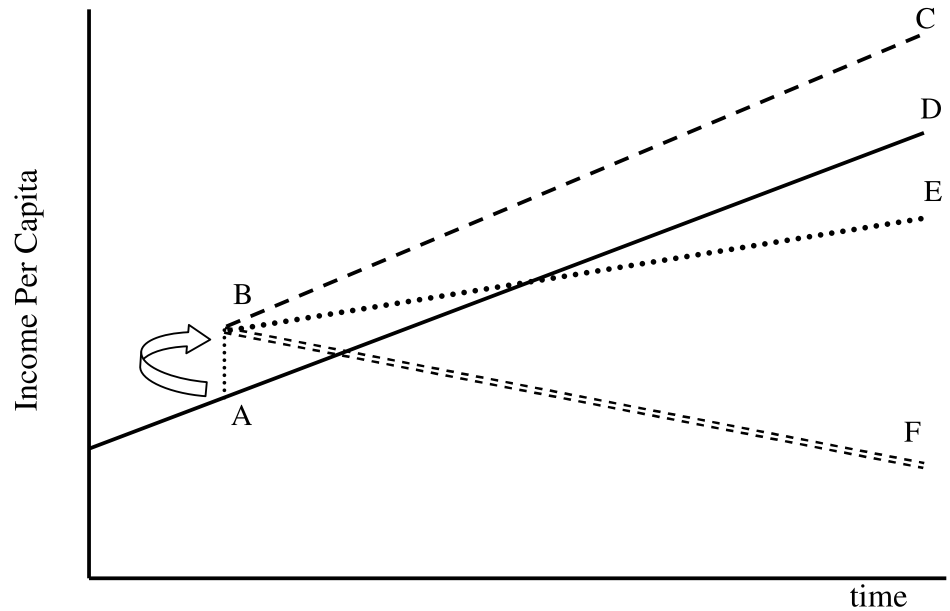

FIGURE 1.2. *Resource abundance and development paths*

TABLE 1.1. *Different cases of resource abundance and economic development*

Country	*GDP per capita Growth*	*Primary Exports in GDP*	*Development Path*
Zambia	–3.91	0.54	BF
Mauritania	–2.03	0.41	BF
Venezuela	–0.79	0.24	BF
Algeria	0.07	0.19	BE
Zimbabwe	0.33	0.17	BE
Barbados	1.15	0.17	BE
Netherlands	1.80	0.15	BC
Norway	3.00	0.10	BC
Botswana	4.06	0.10	BC

Norway

Norway is probably the most famous example of a country that turned its abundant natural resources into an unambiguous blessing. As Røed Larsen (2005) notices, Norway's economic growth accelerated after the discovery of oil in the late sixties and after catching-up with its neighbours Denmark and Sweden in the mid eighties, Norway maintained a higher pace of economic growth. During the seventies and eighties, Norway directed its resource revenues to debt repayments. As Norway shifted from being a net debtor to a net creditor in the nineties, the government established the Norwegian Petroleum Fund in order to shield the domestic economy from excessive spending. The fund invests the revenues from oil in foreign securities in order to prevent an overheated economy and achieve an equal distribution of resource rents across generations. A complementary policy, known as the "Spending Rule" requires that oil-funded public spending originates mainly from the financial returns of the fund's assets (Røed Larsen 2005). In the years following its oil discovery, Norway invested heavily in high-tech industries and services complementary to the oil sector. Nowadays, Norway has developed great expertise in off-shore drilling and exploration techniques and becomes largely involved in establishing drilling platforms and identifying new reserves outside its territories (Wright 2001).

The Netherlands

After the discovery of extensive gas fields in 1959 in the province of Groningen, the Netherlands became one of the largest gas exporters globally. The consecutive appreciation of the Dutch guilder and decrease in the volume of non-resource exports spurred interest among economists in the negative implications of resource income shocks on currency rate movements and prompted the formation of the Dutch disease literature. Although, nowadays, the gas revenues accruing to the Dutch state are not as large as in the past, they still accounted for almost 4.5 billion Euros in 1999 (Huitema and Kuks 2004). In an attempt to improve the management of gas revenues, the Dutch government deposits the majority of gas rents into the Economic Structure Enhancing Fund (Fonds Economische Structuurversterking). The main idea behind this is that Dutch ministries can finance through the fund's resources projects that support the main economic structure of the economy and increase productivity. Investments in know-how, education, environmental improvements and transportation belong to the category of such financed activities (as stated at the website of the Dutch government (www.government.nl)). Additionally, before commencing gas drilling in any Dutch provinces, it is legally required to discuss and address beforehand issues of after care and pollution of ground and surface water in order to minimise environmental damage (Huitema and Kuks 2004).

Venezuela

Venezuela is often referred to as the complete antithesis of Norway, due to its failure to transform its oil-rich endowments into sustained economic growth (Karl 1997). It is a prominent "resource curse" example of a previously relatively rich country that downgraded itself over time in terms of relative income per capita. So, what went so wrong? Venezuela used in the sixties and seventies its oil reserves as collateral to borrow internationally, which resulted in large accumulated debts and a massive rise in interest rates. The peak of the iceberg came with its 1983 default, but Venezuela's position with respect to its debt burden did not improve much ever since (for a discussion see Hausman 2003). Venezuela also established an oil fund to improve revenue spending, but widespread corruption has obstructed plans for a prudent spending of oil rents (Birdsall and Subramanian 2004). There has been a recurring change of the fund's rules stipulating the oil revenues spending. As a result the fund's resources have practically dried up rather than successfully insulate the Venezuelan economy from excessive spending. Furthermore, especially after the nationalisation of the oil industry in 1976, oil revenues were largely seen by government officials as a means to substitute direct income taxes in public finances and help prolong their stay in power (Karl 1997).

Botswana

Botswana is an exceptional case of a poor country that managed to benefit from its mineral endowments (diamonds) and substantially improve the living standards of its population. Botswana with its highest rate of income per capita growth in Africa the last three decades (and one of the highest in the world) reveals that not only developed economies such as Norway and the Netherlands are capable of escaping the "resource curse". So, what explains Botswana's successful economic performance when compared to the dismal economic experience of other resource-rich African countries, such as Angola, Zaire, Sierra Leone, and Nigeria? Botswana emerged from British rule in 1966 as an independent country with strong institutions, based on pre-existing local traditions that encouraged broad political participation and placed restrictions on the political power of the elites. Colonial administration did not penetrate deeply into Botswana's political system and therefore these pre-colonial institutions survived in the independence era (Acemoglu *et al*. 2003). The diamond rents were broadly distributed to all societal layers and no interest group was eager to incur the opportunity cost of undermining the good institutional framework in order to expand its share in the minerals rents at the expense of potentially destabilising the country. Good institutions of private ownership, an efficient bureaucracy and prudent investment of resource rents in infrastructure, health, and education made Botswana the "economic diamond" of the African continent.

Zambia

Zambia is one of the most famous economic failures of mineral-based development and visibly contrasts the succesful example of Botswana. Nowadays, the average Zambian has almost half the income level he or she relished back in the 1960s. This immediately poses questions on what went wrong in terms of economic development planning. Zambia's disappointing economic performance over the last four decades is largely attributed to its past economic reliance on the mineral sector (mainly copper) and respective lack of diversification. The overwhelming dependence of the state structure on the mining industry implied that any sustained fall in copper production or in the world price of copper consequently reduced government revenues, affected several development plans and resulted in widespread unemployment (Gupta 1974). The dominance of mining without a parallel effort to increase diversification inevitably made the Zambian political system extremely vulnerable and dependent on that sector. In that respect, mine workers often disturbed the production process having knowledge of their vital role in the Zambian economy and went repeatedly on strikes in order to demand wage increases. As a result, there was a widening of the wage gap with other sectors and soaring labour costs for the economy as a whole. Finally, while copper price fluctuations should signal officials to reduce dependence on copper, more wasteful resources were pumped into the mining industry rather than being directed into alternative sectors of production as a result of succumbing to the mining industry demands (Jones 1971).

1.3. Explanations of the "Resource Curse"

It is hard to believe that any contracting effect of resource rents on either welfare levels or economic growth rates can be directly attributed to the resource revenues themselves. As Sachs and Warner (2001) argue, the resource curse is most possibly associated with the crowding-out effects of natural resources on several growth determinants. The remainder of this section provides a concise overview of leading explanations as to why resource dependency has resulted in sluggish economic performance. These explanations will be analysed within four categories: (i) Dutch disease, (ii) Institutions, (iii) Investment, and (iv) Policy Failures, although many existing theories could well belong to more than one of the aforementioned classes.

(i). Dutch disease

Many of the trade-related explanations are combined under the label "Dutch disease", originally referring to the adverse effects of natural gas discoveries in the late 1950s on Dutch manufacturing through the appreciation of the Dutch guilder. Resource revenues often create a demand shock that triggers inflationary pressures and results in an overvaluation of the local currency (see Corden 1984, Neary and van Wijnbergen 1986). Increased income raises the prices of non-tradeable goods (which are not determined by international markets), the terms of trade deteriorate and the resulting loss of competitiveness reduces the level of exports (Fardmanesh 1991). If the magnitude of exports and openness are conducive to economic growth, as suggested by Frankel and Romer (1999), resource wealth will indirectly inhibit income growth.

Apart from a decrease in the volume of exports, their composition often becomes skewed away from manufacturing goods and towards primary goods. Corden and Neary (1982) decomposed the impact of resource abundance into a resource movement and a spending effect. The resource movement effect focuses on the shift of man-made capital and labour into the primary sector due to a higher marginal productivity. This was the case, for instance, for the Faroes and Greenland, both of which offered wage premia within their fishing industries (Paldam 1997).[6] The spending effect focuses on the relative increase of prices in non-export goods and the consequent shift of resources away from export production. In case the export sector consists mainly of manufacturing, the spending effect will lead to its contraction.[7] Linnemann *et al.* (1987), for instance, provide empirical evidence on the negative effect of resource abundance (in terms of arable land per person) on the export orientation of the manufacturing sector.

The contraction of the export sector and manufacturing in particular is a matter of concern due to the learning-by-doing externalities it offers. Matsuyama (1992) argues that a shift of labour from manufacturing deprives the economy from the growth-enhancing learning-by-doing externalities found in that sector. Krugman (1987) claims that an increase in resource income may create a loss in comparative advantage for many manufacturing industries, which may be permanent in the case that resource exploitation lasts too long. Furthermore, Herberttson *et al.* (1999) relate resource revenue fluctuations to exchange rate volatility and increased risk for investors. To the extent that resource booms and busts are recurrent (due to the excessive price fluctuation of primary commodities), exchange price volatility can become an inherent element of the economy. Additionally, since natural resources often weaken the manufacturing sector, policy makers may also adopt a protectionist response and impose quotas and tariffs in order to protect domestic producers.

It is needless to say that the extent of any Dutch disease implications closely depends on the degree to which resource rents enter the local economies. In most cases, the majority of resource revenues generated in the primary sector increase domestic consumption and to a lesser extent investment. In only a few cases, such as Norway, governments shield the economy from abrupt income shocks through establishing investment funds that channel domestic rents into portfolios of foreign assets. Similarly, nowadays, the Netherlands deposits

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[6] This also implies that the Dutch disease is not confined to currency-related issues, since both countries use the Danish krone for their international transactions.

[7] Torvik (2001) argued that the tradeable sector may consist of either manufacturing or primary goods depending on the country examined. Therefore, the spending effect does not always result in a contraction of manufacturing activities.

part of the gas revenues in an investment fund, from which ministries draw resources to finance infrastructure projects (Scholtens 2004).

(ii). Institutions

There is an extensive literature on the beneficial role of institutions in economic development (see, for example, Knack and Keefer 1995, Mauro 1995, and Murphy *et al*. 1993). Good standards in terms of rule of law, bureaucratic efficiency, corruption constraints, political stability, democratic liberties and transaction transparency are strongly associated with economic prosperity. Nobel laureate Douglas North (1981) emphasised the importance of intellectual property rights and contract enforceability in modern economic growth. This implies that any negative direct effect of natural resources on institutions will indirectly frustrate economic growth.

Many scholars have claimed that resource rents tend to erode the sound institutional base of the economy. Resource rents may tempt individuals to engage in rent-seeking competition rather than productive activities (see Baland and Francois 2000, Krueger 1974, Tornell and Lane 1999, and Torvik 2002). This is much related to the nature of natural resources themselves, especially in the case of minerals. In most cases, there is limited access to resource usage rights due to their limited physical availability, granted to a few public or private companies or even individuals. Such sector conditions that restrain intense competition create excessive profits accruing to a few agents in the economy. The larger the amount of resource rents (or the stricter the access to them), the fiercer is expected to be the rent-seeking competition. In a similar context, Sachs and Warner (2001) claim that wage premia in the natural resource sector are likely to crowd out entrepreneurial activities in the economy.

As detrimental to economic development as it may be, rent-seeking is not an illegal activity. Resource revenues also tend to increase unlawful informal activities that generate wealth for a few economic actors. For instance, resource rents often induce agents to bribe the administration in order to gain access to them (Leite and Weidmann 1999). In most cases, even in market economies, resource management is not granted through an open-access auction but through the intervention of public officials.

Another institutional aspect of the “resource curse” lies in the manner in which resource rents are utilised in the economy. A large share (if not all) of the resource revenues remains property of the government. Government officials are likely to utilise rents to reward either the electorate belonging to their party or interest groups that favour it. For instance, as Auty (1994) and Ross (1999) point out, domestic firms often achieve protection against international competition in the means of import substitution supported by resource transfers. In the case that resource revenues favour particular groups within the society, a widespread feeling of inequality may result in continuous disputes between different groups and inhibit income growth.[8] Furthermore, there is empirical evidence that resource dependence hinders democratic reforms. Ross (2001a) argues that oil and mineral revenues make governments less accountable to society by relieving social pressure in the means of increased public spending (which consecutively increases public satisfaction). Robinson and Torvik (2005) argue that rents can be channelled into "white elephant" projects of low social return as a politically appealing way of canvassing votes.

Collier and Hoeffler (1998) argue that resource abundance is also harmful to political stability. Since resource wealth is often geographically concentrated, it may trigger ethnic or regional conflicts or exacerbate existing tensions. De Soysa (2000) finds, for instance, that resource wealth increases statistically the probability of a civil war.

(iii). Investment

The positive role of investment in economic development has been well documented in recent literature (see Barro 1991, Grier and Tullock 1989, Kormendi and Meguire 1985, Sachs and Warner 1997). Levine and Renelt (1992) found investment in their regression analysis to be one of the few robust determinants of economic growth independent of the conditioning set of explanatory variables. Furthermore, recent empirical research has identified the crowding out impact of resource abundance on investment rates and consequently on economic growth.[9] Papyrakis and Gerlagh (2004a) estimated that 40% of the total negative impact of mineral income on economic growth is attributed to the investment channel.

Several explanations justify the negative relationship between resource abundance and investment. World prices for primary commodities tend to be more volatile than world prices for other goods. Therefore, an economy based on primary production will shift relatively often from booms to recessions creating uncertainty for investors (see Herbertsson *et al*. 2000). This argument may provide substance to the strong negative correlation between resource abundance and foreign investment rates over the last three decades (Gylfason 2001b). Additionally, natural resource wealth decreases the need for savings and investment, since natural resources provide a continuous stream of income wealth that makes future welfare less dependent on capital accumulation (Papyrakis and Gerlagh 2004c). Gylfason and Zoega (2001) argue that resource rents may decrease the need for financial intermediation and the development of related financial institutions that foster investment. Furthermore, as mentioned above, resource abundance often leads to a contraction of the manufacturing sector, which is mainly responsible for the accumulation of capital goods. Often, complementarities in investment or positive externalities in manufacturing result in a further

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[8] Aghion *et al*. (1999) and Alesina and Rodrik (1994) give an extensive overview on the role of inequality in impeding economic growth.

[9] See Sachs and Warner (1995) and Gylfason and Zoega (2001).

decrease in the profitability and productivity of investment (Milgrom *et al*. 1991). Last, even if the level of investment in physical capital is of similar magnitude between resource-abundant and scarce regions, there are differences in its quality and the efficiency of investment use. Investments often fail to reach the productive base of the economy (Usui 1997). Resource transfers often provide protection to many infant manufacturing industries that subsequently fail to mature (Bell *et al*. 1984). Instead, resource-abundant governments often invest in military and internal security sectors or engage in prestigious and popular projects with very low rates of return (Ascher 1999 and Robinson and Torvik 2005).

(iv). Policy Failures

Acknowledging that the demarcation line for categorising "resource curse" explanations is somewhat abstract, we incorporate as policy failures those explanations closely related to economic policy planning that do not belong to the other three groupings. The common theme of such explanations lies in the fact that resource wealth often creates a false sense of economic euphoria and overconfidence. Governments lose sight of the need for cautious planning and prudent policies (see Gylfason 2001a).

Resource-abundant countries tend to be myopic, have irrationally optimistic expectations on future resource revenues, and accumulate foreign debt to a greater degree than resource-scarce countries. Manzano and Rigobon (2003), for instance, argue that the "resource curse" may be related to excessive debt, accumulated using natural resources as collateral. Any volatile or falling primary commodity prices would then lead to a debt crisis, as many resource-dependent countries would face severe constraints in repaying their debts.

It is also likely that easy riches lead to sloth, both for individuals and governments. Natural wealth may enhance idleness, bureaucracy and discourage people from innovation and efficiency improvements (Papyrakis and Gerlagh 2004d). This might be because resource wealth leads people to believe they have a larger margin of error when planning ahead. As already mentioned, governments also tend to use resource rents through subsidies and transfers to support uncompetitive established industries rather than promote further diversification (see Auty 1994).

Educational policies often seem to be neglected in resource-dependent countries. This is largely due to the fact that the primary sector generally demands a less-skilled and educated labour force (Gylfason 2001a). Therefore, the need to accumulate human capital may appear less urgent in a resource-dependent economy. This would also imply that workers released from the primary sector are likely to experience greater difficulties in seeking employment elsewhere.

Auty (2001) and Auty and Mikesell (1998) argue that since resource revenues often accrue to governments, the decision making of their management lies in a few hands. A limited number of people involved in resource management implies less accountability and control of the ways resource rents are utilised.

We should acknowledge at this point that similar arguments are found in the literature on the impact of aid on economic growth. This is unsurprising, since both aid and natural resources distort economic incentives by creating positive income shocks. Younger (1992), for instance, states that abundant foreign exchange loans can result in overvalued currencies of the recipient countries. Boone (1996) argues that aid tends to augment consumption rather than investment in developing countries. Finally, Knack (2001) claims that conflict over the control of aid funds encourages rent-seeking and corruption in the economy.

1.4. Sustainability under the Resource Curse Perspective

Since the launch of the United Nations Environment Programme (UNEP) in 1972 and the United nations Earth Summit in Rio de Janeiro in 1992, the notion of sustainable development emerged as an essential part of policy analysis and a challenging field of environmental and growth economics. Although it is beyond the scope of this thesis to probe into issues of sustainability in depth, we believe that a brief comment on sustainability under the resource curse perspective deserves our attention due to the close association between resource management and sustainable development.

One of the most well-known definitions of sustainability is described in the report of the World Commission on Environment and Development, popularly known as the Brundtland report:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987).

Many economists adopted and adapted the above concept, formulating a number of criteria for sustainable development. There is, however, no universally agreed criterion of sustainability and there is a vast array of different interpretations (Pezzey 1997a, 1997b), although some concepts of sustainability have become more popular and have distinguished themselves from others. Pezzey's sustainability criterion, requiring utility (welfare) to be non-declining over time, is one of them (Pezzey 1992). Hartwick (1977) is an advocate of this sustainability notion, interpreting, though, utility strictly in terms of consumption.[10] Solow (1974), espousing the ideas of Rawls on intergenerational equity, interpreted

[10] In the case that utility depends solely on consumption, Pezzey's and Hartwick's sustainability criteria are identical.

sustainability even more strictly in terms of constant intertemporal utility. In his later work, Solow (1986) also defined sustainability as a way of distributing natural resources over time by maintaining production opportunities for the future. All these different sustainability notions are compatible with the depletion of the resource base, as far as certain compensation rules exist to sustain human welfare over time. In that respect, exploiting natural resources is sustainable, provided that future generations do not find themselves worse off in the long run. This sustainability view is also known as the "weak sustainability" notion, since it assumes there is no inherent difference between natural and man-made capital in determining human welfare (see Atkinson *et al*. 1997). As long as we replace exhausted natural resources with physical, human or social capital so that we can sustain our level of welfare, we find ourselves on a sustainable development path.

Figure 1.2 can be useful in identifying unsustainable development paths based on resource exploitation.[11] Both the BC and BE paths are considered sustainable according to the weak sustainability criterion. This certainly does not imply that both paths are equally desirable. The BC development path offers a strictly higher level of income compared to BE at each point in time. Provided that the economy does not experience decreases in income, both development paths satisfy the weak sustainability criterion. Thus, countries such as Trinidad and Tobago and Zimbabwe that are on the BE-type path, being examples of the more gentle manifestation of the resource curse, cannot be deemed unsustainable.

Nevertheless, one should keep in mind that income is an imperfect approximation for welfare. Economists often use income levels as a proxy for welfare standards, simply for reasons of convenience. The welfare of a population is undoubtedly not strictly determined in monetary terms. The availability of material goods, as captured by income indices, certainly contributes to a large extent to our welfare levels. We also, though, value largely intangible goods and services, such as the quality of education, social equality, political stability, and diversity in choices. In that direction, we also value ecological services and become discontent with environmental degradation. Therefore, paths such as the BC and BE may be less sustainable when we interpret utility more broadly to account for the detrimental impact of resource exploitation.

An aspect of sustainability, though often ignored in the literature, lies in its intragenerational rather than intergenerational dimension (see Rao 2000). Although the Brundtland report explicitly addresses the intragenerational aspect of resource distribution, this issue often seems to be neglected.

[11] This analysis makes most sense in the case of an exhaustible resource base (e.g. oil and mineral production). In case of agriculture, forestry and fishery, there is always the possibility there is enough time for the resource base to replenish itself.

> It [Sustainable development] contains within it two key concepts; the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs (World Commission on Environment and Development, 1987).

Addressing the intragenerational dimension of sustainability provides some additional insights into identifying unsustainable development paths. Countries on the BE-type path, (the so called examples of the gentle manifestation of the resource curse) do not experience income decreases over time. In that respect, they are intergenerational-wise on a sustainable path. In terms of relative income and poverty, however, they continuously downgrade themselves with respect either to most of their resource-scarce counterparts (on the AD development path) or the few resource-rich countries that escaped the resource curse (on the BC development path). In that case, all resource-rich countries being either on the BE path (the gentle resource curse) or the BF path (the acute resource curse) will shift over time to the lower end of the world income distribution. For the second set of countries, the increase in relative poverty will obviously be more intense. Therefore, from an intragenerational point of view both the BE and BF paths can be thought of as unsustainable. In such a context, sustainability can be broadly interpreted in terms of missed opportunities, where economies on unsustainable paths do not necessarily contract but rather miss the chance to follow the example of front-runner countries.

To imagine the distinction between two different development paths in practical terms, we can think of the following hypothetical example. Between the year 2000 and 2020, a country on the AD or BC path (with high rates of income growth) may shift from a standard word-processing software (such as the Microsoft Word 2000) to a word-processing software with voice recognition. By 2050 the same country uses a technologically advanced word-processing software with voice recognition and characteristics of artificial intelligence that automatically correct syntactical and grammatical errors of the person dictating. The country following the BE path simply shifts from a standard word-processing software to a better version of it by 2050 that does not allow voice recognition (e.g. from Microsoft Word 2000 to Microsoft Word 2003 software). On the other hand, a country on the BF path may reverse from using the standard word-processing software to using early electric typewriters by 2020 (such as the IBM Electromatic of the 1930s) and then manual typewriters by 2050. Perhaps, individuals in the BE-type economy will be able to produce and earn more by shifting from Microsoft Word 2000 to Microsoft Word 2003 software. But individuals of an AD-type country will be able to produce and earn much more thanks to their noteworthy technological advancements. Comoros in Africa, for instance increased its GDP per capita level from 560 dollars in 1950 (1990 international prices) to 574 dollars by 2001. Spain increased its GDP per capita level from 2189 to 15659 dollars in the same period. The income ratio between the two countries fell from 1/4 in 1950 to 1/30 by 2001.[12] Taking account of the intragenerational aspects of sustainability implies that Comoros' development path was unsustainable in terms of relative poverty.

Another notion of sustainability, known broadly as the "strong sustainability" criterion, assumes that increases in the stock of man-made capital cannot fully compensate for decreases in the stock of natural capital. In other words, this sustainability criterion assumes the existence of complementarities to some extent between the two types of capital. In that case, it is not only the level of the total capital stock that is important in terms of welfare, but also its composition. A non-declining stock of natural capital becomes a prerequisite of a sustainable development path.[13]

The preservation of natural capital may be important for two reasons. First, there may be valuable and non-substitutable environmental services to the economic process. Secondly, a declining natural capital may reduce welfare by upsetting ecosystem stability and resilience (see Arrow *et al.* 1995). According to the strong sustainability criterion, none of the three resource-dependent development paths are sustainable in the long term. In this case, resource-based development is simply unsustainable, independent of whether it achieves its goal of increasing income levels.

1.5. Outline of the Thesis

The study aims at enhancing our understanding of the "resource curse" phenomenon and the transmission mechanisms through which this occurs. The focal point of investigation can be formulated as follows:

> Which crowding-out mechanisms of resource abundance can substantiate the poor performance of resource-dependent countries and regions in terms of economic growth?

The thesis explores the issue both theoretically and empirically. The first part of the analysis focuses on developing novel theoretical explanations of the resource curse. The theoretical part makes extensive use of insights found in the endogenous growth literature. The second part evaluates empirically the relative importance of different transmission channels in explaining the paradoxical negative association between resource affluence and economic

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[12] For historical data see Maddison (2003).

[13] It is likely that certain components of natural capital are important in maintaining future levels of consumption and welfare and others are not. In that case, the strong sustainability criterion refers to the former kind of natural capital, also known as critical natural capital. See Atkinson *et al.* (1997).

growth. At the same time, it aims at justifying the theoretical mechanisms exposed before. In that respect, the formal and empirical parts complement each other in terms of findings. The specific research question addressed in each chapter is as follows:

> Is there a tendency for resource revenues to induce reductions in savings for future consumption? How likely is it that resource rents can compensate for the consecutive loss in investment and manufactured output?

Chapter 2 deals analytically with this research question. We develop an OverLapping-Generations (OLG) model, to show how savings adjust downwards to income from natural resources. This is a natural consequence of the tendency of resource income to reduce the necessity to save. Successively, a decrease in savings ultimately reduces investment and manufactured output. The reduction in income from manufacturing is exacerbated when labour productivity (through technology or education) depends on the level of physical capital. We show that any positive short-term impact of natural resources on income is likely to be outweighed by its contracting indirect effect on physical capital in the presence of strong knowledge spillovers. To a large extent, the distribution of resource rents over generations determines their effect on savings. The reduction in savings (and thus manufactured output) is larger, when resources are considered public property and the rents are used to pay for public expenditures such as social security. Savings adjust to a smaller extent when resources are considered common property and the rents are equally distributed over all consumers.

> Do resource rents crowd-out innovation and entrepreneurship in the economy ultimately frustrating the most decisive determinants of long-term growth?

In Chapter 3 we develop a variation of the Ramsey-Cass-Koopmans model with endogenous growth features in order to provide insights into the impact of resource booms on innovation activities. The potential crowding-out effect of resource abundance on innovation is much neglected in the literature and for that reason a study of this nature becomes particularly promising and appealing. Many scholars have explored formally the negative relationship between resource affluence and economic growth, focusing on learning-by-doing activities and positive externalities across sectors (e.g. Elíasson and Turnovsky 2004, Matsuyama 1992, and Torvik 2001). In contrast to these studies, we do not consider innovation as a by-product of any economic activity and we explicitly model an R&D sector. We assume individuals trade-off consumption and leisure in terms of utility and show how an increase in resource wealth induces a reduction in the steady-state labour supply. This is a consequence of the fact that resource revenues allow agents to pay for extra consumption without additional work effort. Furthermore, we illustrate how resource rents induce a smaller proportion of the labour force to engage in innovation. Both the impacts on work effort and the R&D labour base can decrease the growth potential of the economy.

> Is there any direct effect of resource abundance on economic growth across countries? Which indirect mechanisms can account for the negative impact of resource rents on growth as implied by the resource curse hypothesis?

In Chapter 4 we examine empirically the direct and indirect impact of resource abundance on economic growth between 1975-1996. As suggested by recent findings in the resource curse literature, we explore the contracting effect of resource rents on a number of growth determinants, namely on institutional quality, investment, openness, terms of trade, and education. We estimate cross-country growth regressions as in Barro (1991) incorporating initial income and a vector of these resource-related growth variables. We find that the negative impact of resource affluence on growth disappears when we account for the aforementioned indirect channels. This implies that natural resources are not bad for economic growth *per se*. The analysis allows us to calculate the relative importance of each transmission channel in explaining the negative correlation between resources and growth. We find investment to be the most significant intermediate mechanism through which the resource curse takes place, followed by openness and terms of trade.

> Is the resource curse relevant in regional economics; namely do resource-dependent regions within the same country underperform in terms of economic growth?

Chapter 5 contains an empirical analysis of regional economic growth utilising a novel U.S. state-disaggregated database. A merit of the analysis lies in the fact that regional economies are likely to be more homogeneous than sovereign countries in dimensions such as language, the quality of institutions, and cultural characteristics that are difficult to control for in growth regressions. Such an advantage is likely to be reflected on the precision of our estimations. Our approach challenges the absolute convergence hypothesis that focuses on initial income levels as the sole determinant of growth rate variation across regions. We investigate whether a number of growth-relevant variables including resource abundance have a significant impact on growth rates, as found across sovereign countries. We verify the existence of a U.S. state resource curse and confirm that several crowding-out mechanisms identified in our cross-country analysis apply across regions. Similarly to our cross-country analysis, our findings reveal that the U.S. regional resource curse is mainly attributed to intermediate channels. Contrary to our prior results, though, we find that the knowledge-based channels of schooling and R&D play a much larger role than investment in elucidating the resource curse. This implies that even if the resource curse exists at a regional level, it is likely to be of a different nature.

> Has the resource impact always been of a negative nature? Are there indications pointing to a beneficial role of resource abundance on sustaining higher income levels in the past?

In Chapter 6 we examine the impact of natural resources on income levels from a long-term historical perspective. Our approach extends the analysis by Acemoglu *et al*. (2001, 2002) on the relationship between current income levels, institutions, and colonisation policies. In places where Europeans settled in large numbers, they imported the investment-conducive institutional framework found in their countries of origin, largely based on the protection of private property rights. Acemoglu *et al*. (2001, 2002) investigated the endogenous character of settlement decisions and found that Europeans had a preference for areas with a mild disease environment and low urbanisation. We build on the same framework and investigate whether primary commodities influenced the settlement planning of Europeans. We find regions rich in precious metals (gold and silver) to be prominent settlement destinations and in addition to be fortunate enough to inherit better institutions. On the other hand, we find the production of agricultural commodities exported to Europe at the time of colonisation (coffee, tea, cocoa, and sugar), to discourage European immigration, but nonetheless, to be positively correlated to better institutions. This finding suggests that, even though current resource abundance has a contracting growth impact as suggested by the resource curse hypothesis, in the past natural resources have been beneficial for income improvements.

In Chapter 7 we elaborate upon the main conclusions and draw policy recommendations and suggestions for future extensions.

Part II

Theoretical Models

2. NATURAL CAPITAL, PHYSICAL CAPITAL, AND THE RESOURCE CURSE [*]

This chapter focuses on the savings-investment transmission channel through which resource rents affect income, and develops an OverLapping-Generations (OLG) model with features from endogenous growth theory to study this mechanism. In this model, savings adjust downwards to income from natural resources, investments adjust to savings, and subsequently the level of overall productivity falls. Natural resources have two counteracting effects on income. In the short term, resource wealth augments income, but in the long term, it decreases income through a crowding-out effect on knowledge creation.

2.1. Introduction

There has been a large interest recently in the failure of resource-based strategies to foster the economic development process (Gylfason 2000, 2001a, 2001b, Leite and Weidmann 1999, Papyrakis and Gerlagh 2004a, Rodriquez and Sachs 1999, Sachs and Warner 1995, 1997, 1999a, 1999b, 2001). Resource rents do not seem to translate into higher levels of income for the majority of resource-dependent countries. The first regression of Table 2.1 illustrates the negative relationship between natural resources and income for a sample of 82 countries. The dependent variable is the natural logarithm of GDP per capita in 2002 (LnY_{2002}), while we use the share of natural capital in total wealth in 1994 (*NatK*) as a proxy for resource abundance.[14] Data on natural capital and GDP per capita are provided by the World Bank (WB 1997 and 2004, respectively). There is a significant negative statistical association between the two variables. A one percentage increase in the share of natural resources in the total capital stock is associated with a 7% lower income level. An increase in the natural capital share by a standard deviation (0.11) is associated with a decrease in the natural log of income by 0.84, which implies a decrease in income by 57%.

As we discussed in Chapter 1, explanations of the tendency of resource-affluent regions to fail in generating high income levels are associated with extensive corruption, unfavourable

[*] This chapter is a slightly revised version of Papyrakis and Gerlagh (2004c).

[14] 1994 is the first year for which data on natural capital are available from the World Bank Database. Gylfason (2001) argues that the share of natural capital is a good proxy for resource abundance, since resource abundance is not varying substantially over time. Indeed, the results in all tables can be reproduced by using alternative measures of resource abundance, such as the Sachs and Warner (1995) measure of the share of primary exports in GDP in 1971 or the share of agricultural production in GDP for the same year.

terms of trade, low educational attainments, and policy failures among others. As an alternative mechanism this chapter is concerned with the role of resource abundance in reducing investment in physical capital. Papyrakis and Gerlagh (2004a, Table 4) argue that the investment channel is probably the most important channel in terms of its contribution to the resource curse. Usui (1997) claims that Mexico's underperformance after its oil boom was related to a large extent to the policy bias towards current spending rather than capital investment. Similarly, Trinidad and Tobago utilised their oil rents extensively (especially after the 1970s oil price shocks) as subsidies to consumers and unprofitable firms (see Velculescu and Rizavi 2005).

There are various mechanisms that can explain the crowding out of investment. In the Dutch disease literature (see Corden 1984, Neary and van Wijnbergen 1986), positive resource shocks and consecutive factor relocations result in a contraction of the manufacturing sector, mainly responsible for the production of capital goods. Volatile primary commodity prices provide a disincentive to foreign investors to direct their funds to resource-related projects. As another mechanism, Atkinson and Hamilton (2003) show that governments often spend resource rents on public consumption. The few countries that use resource rents to finance investment projects are those that have avoided the resource curse.

Our analysis combines the insights from the various studies mentioned above. We develop an overlapping-generations model to demonstrate how public spending of resource rents decreases national savings. Figure 2.1 depicts the strong negative correlation between savings in GDP in 1994 and natural capital for the same year (data on savings are provided by the World Bank (WB 2004). We show that the decrease in the level of investment following the decline in savings is exacerbated when, in turn, labour productivity (through technology or education) depends on the level of investment. The decline in income may more than offset the increase in resource revenues, when we take account of the decrease in savings and the responsiveness of technology to investment.

Our analysis provides a theoretical justification for the empirical observation that resource-dependent countries generally do not reinvest resource rents in other forms of capital. Lange (2004), for example, claims that Namibia – and the majority of resource-abundant countries – liquidate rather than reinvest their resource revenues and therefore find themselves on a development path of declining welfare. On the other hand, in a few cases where a prudent investment of resource revenues takes place (as in the case of Botswana), people relish a higher level of wealth over time (Lange and Wright 2004). In that respect, our analytical framework provides an explanation of the reasons that lead most resource-dependent countries not to direct resource rents into capital accumulation.

Table 2.1 reveals the contracting impact of natural capital both on savings and investment in physical capital. Regression (2.2) depicts the strong negative correlation between natural capital and savings. Regression (2.5) extends the correlation to investments (data on investment in GDP for 1994 are provided by the World Bank (WB 2004). Furthermore, countries that save less tend to invest less, as regression (2.8) demonstrates (although the coefficient on savings (smaller than unity) suggests substantial capital mobility, contrary to the findings by Feldstein and Horioka 1980).

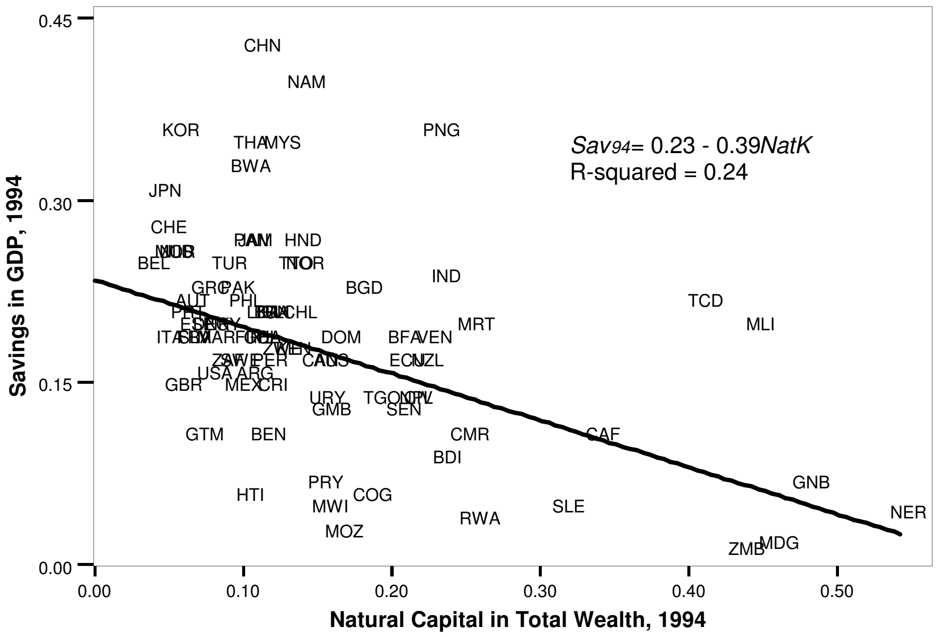

FIGURE 2.1. *Resource abundance and savings*

We notice that the growth-impeding crowding-out logic is not restricted to natural resource income. There is a resemblance observed with aid as income (Baland and Francois 2000, Dalmazzo and de Blasio 2003, Stevens 2003). Aid has a similar significant contracting effect on savings as shown in regression (2.3), though it has no negative impact on investment, shown in regression (2.6) (data on aid in GDP for 1994 provided by the World Bank (WB 2003). The difference with the effect of aid on savings and investment may be due to the fact that aid is often provided and monitored by international agencies with the condition that is utilised for investment projects. In that respect, conditional aid may indeed support capital accumulation, or – what seems more probable given the insignificant coefficient – decrease the need for domestic savings. Finally, in regressions (2.4) and (2.7), we test the negative correlation between natural capital and savings and investment, and show that it is robust when we control for aid as an additional regressor.

The chapter is organised as follows. Section 2.2 presents the OLG model, and explains how resource abundance crowds-out savings and investment. Section 2.3 compares the steady states of the OLG model under different parameter scenarios and provides numerical examples of the resource curse hypothesis under alternative assumptions. Section 2.4 concludes.

TABLE 2.1. *Savings and investment*

Dependent variable:	LnY_{2002}	Savings (Sav_{94})			Investment (Inv_{94})			
	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)	(2.6)	(2.7)	(2.8)
Constant	9.30	0.23	0.21	0.24	0.24	0.24	0.26	0.14
NatK	–7.61***	–0.39***		–0.22**	–0.23***		–0.25***	
(0.11)	(0.01)	(0.08)		(0.10)	(0.07)		(0.09)	
Aid_{94}			–0.20***	–0.23***		–0.06	–0.07	
(0.17, 0.18, 0.17, 0.18)			(0.08)	(0.06)		(0.06)	(0.06)	
Sav_{94}								0.43***
(0.09)								(0.06)
R^2 adjusted	0.43	0.24	0.05	0.33	0.12	0	0.18	0.27
N	82	83	111	63	83	117	63	134

Note: Standard deviations for independent variables in parentheses. For Aid_{94}, standard deviations refer to regressions (2.3), (2.4), (2.6), and (2.7) respectively; robust standard errors for coefficients in parentheses. Superscripts ** and *** correspond to a 5 and 1% level of significance.

2.2. A Model on Natural Capital, Savings and Investment

The model employed in this chapter extends the usual OLG models with discrete time steps, $t=1,\ldots,\infty$, by containing reference to a primary sector that provides the consumers with pure resource rents. As a second extension of the standard OLG model, we include a technology spill-over from the capital stock to a labour productivity variable. This second extension is essential to our analysis. As we will show in Section (iv), Proposition 2.2, capital-knowledge spillovers increase the crowding out effect of natural capital on man-made capital. In Section 2.3, we show that in a standard OLG model with a narrow definition of capital (excluding knowledge as part of the broad capital stock) and in the absence of spillovers from investment to labour productivity, resource-dependent countries can escape the resource curse. With capital-knowledge spillovers, however, as captured in our extended model, resource dependence is prone to lead to a substantial reduction in overall income levels.

(i). Demography

We assume that in every interval two generations exist, an old and a young generation. At the beginning of a period, a new generation enters the model and the previously old generation leaves the model, so that there is a turnover in population. Each generation is indexed by their date of entering the model t (as a subscript). Each individual's lifetime consists of two periods. The generations work when young and live from savings when old. We thus only examine the adult part of the life-cycle, i.e. from the age of 20 onwards, and each interval consists of a period of about 30 years. Population grows exponentially at a rate n:

$$L_t = (1+n)L_{t-1}, \tag{2.1}$$

where L_t stands for the population size. Each individual provides inelastically one unit of labour during her youth and retires at the second period of her lifetime. Therefore L_t also measures the supply of labour.

(ii). Producers

There is a simple production sector for a man-made consumer good Y_t, where physical capital K_t, technology h_t, and labour L_t are combined to produce output Y_t. We assume a constant returns to scale Cobb-Douglas production function for the economy:

$$Y_t = K_t^{\alpha} (h_t L_t)^{1-\alpha}, \ 0<\alpha<1. \tag{2.2}$$

Setting $y_t=Y_t/L_t$ and $k_t=K_t/L_t$ we can rewrite the production process in its intensive form:

$$y_t = k_t^{\alpha} h_t^{1-\alpha}. \tag{2.3}$$

We assume a simple form of learning-by-doing based on the endogenous growth models developed by Romer (1990) and Aghion and Howitt (1992), where human capital or technology h_t is a by-product of physical capital production. The rate of knowledge or technological accumulation depends directly on the rate of physical capital accumulation. We assume the following specification for the level of technology or knowledge:

$$h_t = k_t^{\pi},\ 0<\pi<1. \tag{2.4}$$

In that respect, the model is essentially a semi-endogenous growth model, where the long-run growth rate depends on exogenous parameters (as in Jones 1995a, Jones 1995b, Jones and Williams 2000, and Young 1998).[15] Since each period covers about 30 years, we assume that the capital of the previous period fully depreciates, and we set the capital stock equal to the level of investment of the previous period,

$$k_t = i_{t-1}/(1+n). \tag{2.5}$$

Markets for labour and capital are competitive so that the interest rate and labour wage per labour unit are given by:

$$r_t = \alpha k_t^{\alpha-1} h_t^{1-\alpha} - 1, \text{ and} \tag{2.6}$$

$$w_t = (1-\alpha) k_t^{\alpha} h_t^{1-\alpha}, \tag{2.7}$$

respectively. Taking account of the endogenous channel for human capital (eq.(2.4)) the output, interest, and wage equations become:

$$y_t = k_t^{\alpha+(1-\alpha)\pi}, \tag{2.8}$$

$$r_t = \alpha k_t^{(1-\alpha)(\pi-1)} - 1, \tag{2.9}$$

$$w_t = (1-\alpha) k_t^{\alpha+\pi(1-\alpha)}. \tag{2.10}$$

(iii). Consumers

Each generation maximises its lifetime utility derived from its two-period consumption scheme. Its utility function $U(c_t^t, c_{t+1}^t(1+n))$ only depends on consumption per capita in the two periods c_t^t and $c_{t+1}^t(1+n)$ and is assumed to be logarithmic, which implies a unitary inter-temporal elasticity of consumption. The variable c_{t+1}^t denotes the consumption of the old in

[15] The long-run growth rate of income is equal to $n(\alpha+\pi(1-\alpha))$.

period t+1, divided by L_{t+1}, whereas c_t^t is defined as the consumption of the young in period t divided by L_t; the multiplication with (1+n) corrects for this change in unit of measurement. Thus:

$$U_t = \ln c_t^t + [1/(1+\rho)] \ln [c_{t+1}^t(1+n)], \tag{2.11}$$

where $\rho>-1$ is the pure rate of time preference. Higher values of ρ represent a larger preference for current compared to future consumption. The restriction $\rho>-1$ rules out a negative weight on second-period consumption. Notice that the utility function is differentiable, concave, and strictly increasing in its arguments.

Each generation divides its labour income (wages) in the first period between its first-period consumption and savings, s_t. These savings are used to finance their second period consumption.

$$c_t^t + s_t = w_t , \tag{2.12}$$

$$c_{t+1}^t = [(1+r_{t+1})/(1+n)]s_t . \tag{2.13}$$

where w_t, r_{t+1} , c_t^t, and c_{t+1}^t indicate the first-period wage, the interest rate between the first and second period, and the level of consumption per capita during her two lifetime periods. Notice that when writing variables in intensive form, we correct for population growth. Over the two periods, the present value of an individual's consumption stream is equal to labour income:

$$c_t^t + c_{t+1}^t (1+n)/(1+r_{t+1}) = w_t . \tag{2.14}$$

Now, we extend the economy with a natural-resource base (e.g. oil reserves) that generates resource rents G_t, or g_t per person at period t. For convenience, these rents are assumed to be a proportion q of that period's total income Y_t. In the appendix, we show that results do not change much when resource rents are assumed independent of the income level Y_t. The distribution of resource rents over generations will determine their effect on savings. We distinguish two resource policies. First, resources are considered public property and the rents are used to pay for public expenditures such as social security. Second, resources are considered common property and the rents are equally distributed over all consumers. The analysis focuses on the first resource policy, when resource rents are used for public expenditures. In the appendix, we briefly analyse the second case.

We assume that the resource rents are used for social security; i.e. in every period, resource rents are paid to the retired generation. The second-period budget constraint becomes:

$$c_{t+1}^t = [(1+r_{t+1})/(1+n)]s_t + qy_{t+1}. \tag{2.15}$$

The inter-temporal budget constraint adjusts to:

$$c^t_t + c^t_{t+1}\,(1+n)/(1+r_{t+1}) = w_t + qy_{t+1}(1+n)/(1+r_{t+1}). \tag{2.16}$$

Each generation maximises utility subject to the budget constraint. The first order conditions with respect to consumption provide us with the Euler equation for the inter-temporal consumption allocation:

$$c^t_{t+1} = c^t_t\,[(1+r_{t+1})/(1+n)(1+\rho)]\,. \tag{2.17}$$

The distribution of consumption over time does not depend on resource-income or labour income. It only depends on the interest rate, population growth, and the pure rate of time preference.

Substitution of the Euler equation in the budget constraint (eq.(2.16)) gives consumption c^t_t as a function of the interest rate, the rate of time preference, population growth, and labour and resource income. Thus:

$$c^t_t = [(1+\rho)/(2+\rho)][(w_t + qy_{t+1}(1+n)/(1+r_{t+1})]. \tag{2.18}$$

Savings, s_t, will be given by:

$$s_t = w_t - c^t_t = [1/(2+\rho)]\,w_t - [(1+n)(1+\rho)/(2+\rho)(1+r_{t+1})]\,qy_{t+1}. \tag{2.19}$$

The savings curve is upwards-sloping with respect to the interest rate. An increase in the interest rate lowers the net present value of the resource revenues and increases the need for savings. When substituting for y_t, r_t, and w_t from equations (2.8), (2.9), and (2.10), the savings equation becomes:

$$s_t = [(1-\alpha)/(2+\rho)]\;k_t^{\alpha+\pi(1-\alpha)} - [(1+n)(1+\rho)/(2+\rho)\alpha]\;qk_{t+1}. \tag{2.20}$$

(iv). Equilibrium

The commodity balance is given by:

$$c^{t-1}_t + c^t_t + i_t = (1+q)y_t, \tag{2.21}$$

where c^{t-1}_t, c^t_t, and i_t stand for total consumption of the older and younger generation and total investment, respectively. Equation (2.21) indicates that total production inclusive of resource rents can be used for either consumption or investment. The value of consumption of the older generation is equal to the value of capital rents, αy_t, plus resource rents, qy_t. Thus, (2.15) can be restated as:

$$c_t^{t-1} = (\alpha+q)y_t. \tag{2.22}$$

The remainder of the manufactured income $(1-\alpha)y_t$ is used by the younger generation to both consume and save. Thus, equation (2.12) becomes:

$$c_t^{t} + s_t = (1-\alpha)y_t. \tag{2.23}$$

Equations (2.21)-(2.23) combined reveal the saving-investment balance:

$$i_t = s_t. \tag{2.24}$$

The savings-investment balance, together with the capital identity (2.5) and the savings equation (2.20), enables us to write the equilibrium as a recursive dynamic equation for k_t:

$$(1+n)k_{t+1} = [(1-\alpha)/(2+\rho)]\ k_t^{\alpha+\pi(1-\alpha)} - [(1+n)(1+\rho)/(2+\rho)\alpha]qk_{t+1}. \tag{2.25}$$

Rearranging terms provides k_{t+1} as a function of k_t:

$$k_{t+1} = \psi(k_t) = \frac{\alpha(1-\alpha)}{(1+n)\left[(2+\rho)\alpha+(1+\rho)q\right]} k_t^{\alpha+\pi(1-\alpha)}, \qquad (2.26),$$

where $\psi'>0$, $\psi''<0$, $\psi(0)=0$, $\psi'(0)=\infty$, $\psi'(\infty)=0$. This implies that the sequence k_t is convergent, and there is a unique non-trivial equilibrium level of capital per person denoted by k^*. We set $k_{t+1} = k_t$ in equation (2.26) in order to calculate the steady-state value of capital per capita. This provides us with:

$$k^* = \left[\frac{\alpha(1-\alpha)}{(2+\rho)(1+n)\alpha+(1+\rho)(1+n)q}\right]^{1/(1-\alpha)(1-\pi)}. \tag{2.27}$$

Similarly, the steady-state value of man-made output per capita is given by:

$$y^* = \left[\frac{\alpha(1-\alpha)}{(2+\rho)(1+n)\alpha+(1+\rho)(1+n)q}\right]^{\frac{\alpha+\pi(1-\alpha)}{(1-\alpha)(1-\pi)}}. \tag{2.28}$$

As the parameter q positively enters the denominator and the power coefficients are positive, it follows immediately from these equations that both the capital stock and output are decreasing in the resource wealth parameter q, as stated in the next proposition.

PROPOSITION 2.1. *An increase in the share q of resource rents in income results in a decrease in the steady-state levels of capital and output.*

The responsiveness of output to resource rents depends, to a large part, on the spill-over effects of capital on technology, π. From equation (2.28), we derive the relative change of steady-state output y^* with respect to the resource share q, that is the semi-elasticity:

$$\frac{dy^*}{dq}\frac{1}{y^*} = -\frac{\alpha + \pi(1-\alpha)}{(1-\pi)(1-\alpha)}\frac{(1+\rho)}{(2+\rho)\alpha + (1+\rho)q} < 0. \quad (2.29)$$

[16]

In turn, taking the derivative of (dy^*/dq)/y^* with respect to π, we find,

$$\frac{d\{(dy^*/dq)/y^*\}}{d\pi} < 0. \quad (2.30)$$

That is, a larger value for π intensifies the negative effect of resource revenues on the steady state levels of capital and man-made income. This result is stated in the next proposition.

PROPOSITION 2.2. *A large responsiveness of technology to capital accumulation, as captured by π, enhances the negative impact of resource wealth on the steady-state levels of capital and man-made income per person.*

Furthermore, as we can see from (2.29), the impact of resource rents on long-term output is independent of population growth.

2.3. Resource Curse Scenarios

For the resource curse to take effect, the decrease in output should exceed the increase in income brought by the resource rents. In order to investigate the effect of resource rents on total income, $(1+q)y^*$, we compare an initial situation, denoted with subscript '0', in which resource rents constitute a negligible proportion of man-made income $q_0 = 0$, with an alternative situation after a resource boom, denoted with subscript '1', when a resource base is discovered and resource revenues account for 10% of man-made income, $q_1 = 0.1$.

We use a set of parameter values to test the dependence of the resource curse thereon. In the baseline, we set the discount factor ρ equal to one, which implies that individuals value their first period consumption twice as much as their second period consumption. In terms of pure time preference, for periods of 30 years, this assumption is equivalent to a pure rate of time preference of 2.3 % annually. We assume an annual population growth rate of 1%, which is approximately equivalent to a rate of 35% for a period of thirty years.[17] We consider ranges

[16] The level of steady-state consumption c^* can either increase or decrease depending on the parameters of the model.

[17] This is the population growth rate for Canada and the U.S. in 1999 (World Bank (WB), 2003).

for both parameters as the analysis proceeds. We allow the capital share α to vary between 0.30 and 0.70. The lower value is a reasonable approximation for a narrow concept of physical capital (see, e.g. Romer 1996 ch.3), while the latter parameter value is reasonable if we interpret capital k_t broadly to consist of human capital as well (e.g. see Mankiw, Romer and Weil 1992 and Romer 1996 p.134).[18] In the first case, h_t can be thought of as a measure of both technological and educational improvements induced by capital investments. In the latter case, h_t stands for technological advancement rather than educational quality.

As the occurrence of a resource curse depends to a large extent on the value for the technological parameter π, we investigate which is a plausible range of values for it. Linearising equation (2.20) around k^* shows that the economy converges to its balanced growth path at a rate $\alpha+\pi(1-\alpha)$:

$$k_{t+1} - k^* \simeq [\alpha+\pi(1-\alpha)](k_t - k^*). \tag{2.31}$$

Most econometric studies find an annual convergence speed in the range between 0.005 and 0.025, depending on the set of additional variables included and the time span under investigation (e.g. Gylfason 2001a p.856, Barro and Sala-i-Martin 1992a p.242, Kormendi and Meguire 1985 p.149, Mo 2000 p.72, Sachs and Warner 1995 p.24).[19] For a 30-year period, we calculate that the factor $\alpha+\pi(1-\alpha)$ should lie in the range [0.47,0.85]. For α = 0.3, this range is consistent with $\pi\in$[0.24,0.79]. For α = 0.7, this range is consistent with $\pi\in$[0.0,0.46]. For all possible pairs (α,π) that produce a rate of convergence in the abovementioned range, the resource curse is minimal for the pair α = 0.30, π = 0.24, when it has the value 0.078. It is maximal for the pair α = 0.3, π = 0.79, when it has the value 0.657. The numerical calculations confirm the presence of a resource curse for the plausible range of parameters. Therefore, we let the technological parameter π of the endogenous technological channel vary between 0 and 0.8.

We evaluate the steady-state values for total income $(1+q)y^*$ before and after the resource boom, assuming the above parameter values. We calculate the steady-state income differential created by the resource exploitation. The resource curse is defined as the negative relative income change,

$$RC = 1 - \frac{y_1^*(1+q_1)}{y_0^*(1+q_0)}. \tag{2.32}$$

The results are depicted in Figure 2.2. The vertical axis presents the steady-state income differential defined by (2.32). Positive values imply that resource exploitation results in a

[18] Barro and Sala-i-Martin (1992 p.226) set α equal to 0.80 for an augmented measure of capital.

[19] See Abreu *et al*. (2005) for an extensive survey of studies of convergence and a meta-analysis approach to estimating it.

lower steady-state income per capita. The legend on the right hand side of the figure divides the figure area according to the magnitude of the resource curse.

As Figure 2.2 depicts, for almost all parameter values, the steady-state income per capita decreases when resource rents enter the economy. For example, for $\alpha = 0.3$ and $\pi = 0.5$, we find total income (including resource rents) to decrease by about 25% when the resource windfall accounts for 10% of man-made income. Only for the lowest values of π and α, assuming a narrow concept of capital and the absence of capital spill-over effects, the economy benefits from the resource rents. For $\alpha = 0.3$ and $\pi = 0$, total income increases by just 1%.

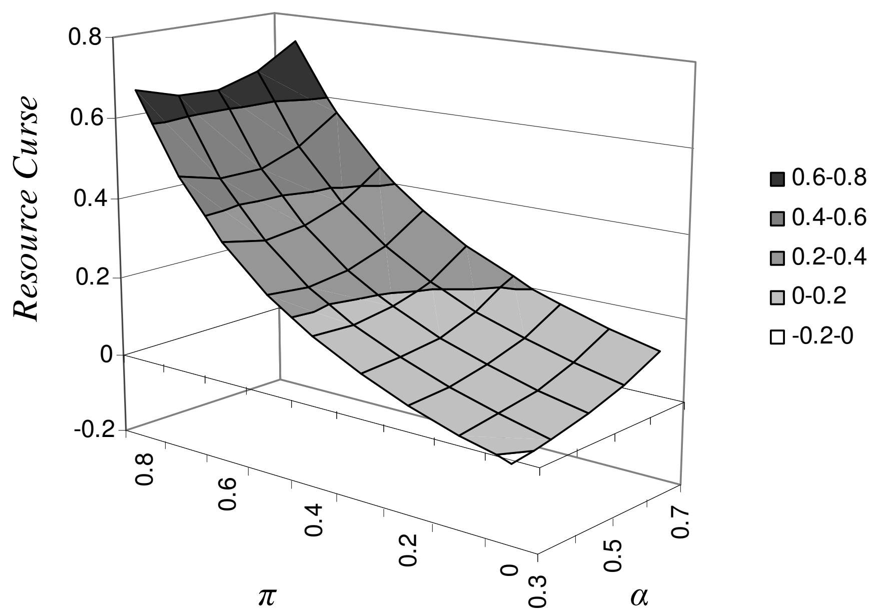

FIGURE 2.2. *Decrease in income following a 10% increase in resource revenues, dependence on the technology spillover (π) and the capital share (α)*

As a further check of our results, we also investigate how changes in the discount factor ρ affect the resource curse effect. An increased value of ρ enhances the resource curse, as can be calculated by equation (2.29):

$$\frac{d\{(dy^*/dq)(1/y^*)\}}{d\rho} = \frac{\alpha + \pi(1-\alpha)}{(1-\pi)(1-\alpha)} \frac{q\alpha}{(2+\rho)\alpha + (1+\rho)q} < 0. \tag{2.33}$$

Barro and Sala-i-Martin (1992a p.226) assume a rate of pure time preference of 0.05 per year for their calibrations for the U.S. This approximates a parameter value ρ of 3.35 for a period of 30 years. One could claim that for a developing country this parameter value could be even higher, since consumers in the developing world tend to value current consumption more compared to uncertain future consumption. Kotlikoff and Summers (1981) assume a range of (0.02, 0.07) for their yearly discount factor for their calibrations, which implies that the parameter value ρ lies approximately in the (0.8, 6.6) range for a 30-year period. For our robustness check, we set the capital share α and the population growth rate n equal to 0.3 and 0.35, respectively, and let the technological parameter π vary as aforementioned. We allow the discount factor ρ to vary between 1 and 6, so that the values remain in the range adopted by Kotlikoff and Summers (1981). We calculate the resource curse effect and present our results in Figure 2.3. For increased values of ρ, the resource curse becomes more acute. For instance, for a π value of 0.5, an increase of the discount rate from 1 to 6 amplifies the resource curse from 0.242 to 0.316.

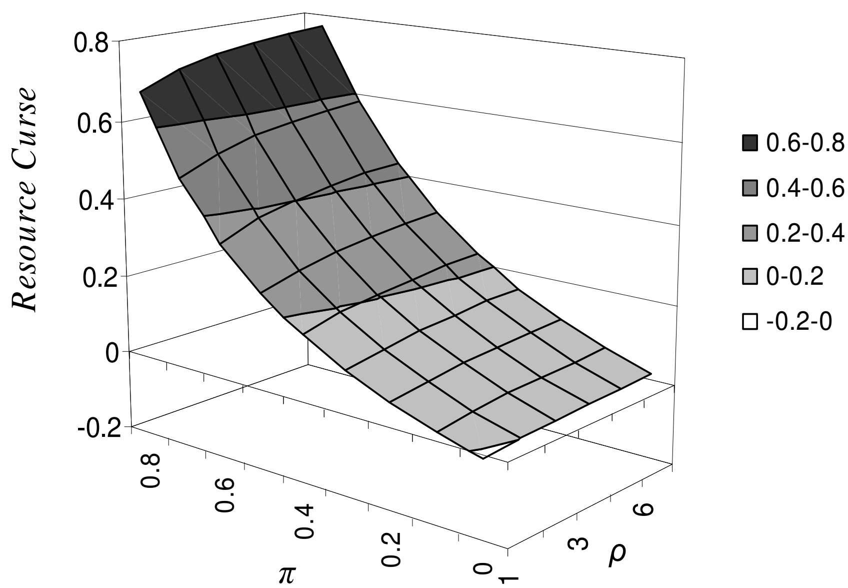

FIGURE 2.3. *Decrease in income following a 10% increase in resource revenues, dependence on the technology spillover (π) and the rate of time preference (ρ)*

Finally, it is of interest to explore whether our measurements in Figures 2.2 and 2.3 conform with empirical findings on resource revenues and income behaviour. Table 2.1 confirms the contracting impact of resource rents on income, savings, and investment. In Chapter 4, we specifically estimate the resource curse effect for revenues from mineral production, for the 1975-96 period, for a sample of 39 countries. We conclude that an increase in resource income of 10% decreases long-term income per capita by 60%, about half of which (30%) is due to a drop in investment in capital and education. The 30% decrease can be reproduced by our model for a set of parameters; e.g. for (α, π, ρ) = (0.3,0.5,4), or (0.5,0.6,1), or (0.7,0.4,1).

2.4. Conclusions

Resource-rich countries tend to neglect the necessity to save and direct their resource windfalls into productive investment. There is ample evidence of policy failures across developing countries related to underinvestment of resource revenues. Mexico, Trinidad and Tobago, and Venezuela, among others, are notorious examples of countries mismanaging their resource rents in order to relieve internal pressure from domestic interest groups. Motivated by such evidence, we exposed in this chapter a theoretical mechanism explicating the tendency of resource income to decrease incentives to save and invest. The main intuition lies in the potential of resource revenues to reduce the urgency to save for future consumption to the extent that future income levels may be supported by accrued resource rents.

In this context, we developed a stylised model in which technology (or education) depends endogenously on the level of investment. In this setting, increasing resource rents lead to a decrease in savings and investment that multiply over time, and long-term income substantially diminishes. For most of the reasonable parameter values, the effect of the decline in investment more than offsets the increase in income through resource revenues. Our analysis also reveals that the resource curse worsens with an increasing elasticity of output to capital and with a larger inter-temporal pure rate of time preference.

The mechanism described here provides an explanation of the resource curse hypothesis that is an alternative to the mechanisms described in earlier literature. From the literature, we know that resource-rich countries tend to suffer from currency overvaluations and loss of competitivess (Corden 1984), enhanced corruption and rent-seeking (Krueger 1974, Torvik 2002), bad-decision making (Sachs and Warner 1999b, Auty 2001), political instability (Collier and Hoeffler, 1998), low levels of educational quality (Gylfason 2001a), and low capital investment (Atkinson and Hamilton, 2003). In Chapter 4, we claim that the last-mentioned channel is the most important in explaining the resource curse phenomenon across countries. In this chapter, we describe a mechanism to explain this transmission channel, focusing on the role of resource abundance in crowding-out savings by enhancing future income for which no savings are required. The assumption that labour productivity depends endogenously on the level of investment is critical in the model. Under this presupposition, the decrease in savings and investment leads to a decline in output that exceeds the increase in resource income, thus producing the resource curse. Such a mechanism can provide a formal explanation of why resource-abundant countries are characterised by smaller shares of savings and investment in their GDP and lag behind in terms of long-run income.

APPENDIX 2.1. EXOGENOUS VERSUS ENDOGENOUS RESOURCE RENTS

The dynamics of our analysis are much simplified by assuming a constant share of resource rents in man-made income over time, $G = qY$, for constant q. It can be the case, however, that resource revenues are an either increasing or decreasing proportion of man-made income y as time evolves. Figure 2.4 depicts the relationship between the share of primary exports in GDP in 1990 and 2001. Data are compiled from the United Nations (UN, 2003) Database of Human Development Indicators. As the figure shows, the share of primary exports remained fairly stable over a period of eleven years. For instance, the share of primary exports in GDP fell from 30 to 29% for Panama and rose from 42 to 44% for Kuwait.

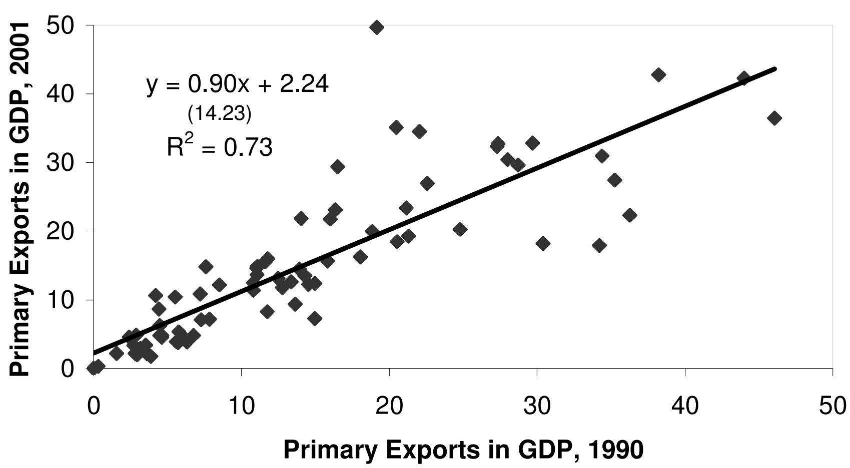

FIGURE 2.4. *Stability of the share of primary exports in GDP over time*

Still, the objective of this appendix is to show that our steady state model results carry over to an economy where total resource rents G are exogenous with an adjusting share in total income q, instead of the opposed assumption made in the main text. Figure 2.5 is helpful in this respect; as it depicts the relation between q, y^*, and g. It shows the steady state levels of man-made income y^*, resource income g, and total income $y^* + g = (1+q)y^*$, as functions of q. We adopt the following values for the capital share, $\alpha = 0.4$, the discount factor, $\rho = 2$, the population growth rate, $n=1$ and the technological externality, $\pi = 0.5$. The figure shows that, as q increases, the steady-state man-made income y^* decreases (Proposition 2.1). Furthermore, steady-state income per capita $y^*+g^*=(1+q)y^*$ strictly decreases in q. Resource rents g^* (equal to qy^*) increase initially, and then decrease after a certain value of q, that is, when the decrease in output y^* more than offsets the increase in q.

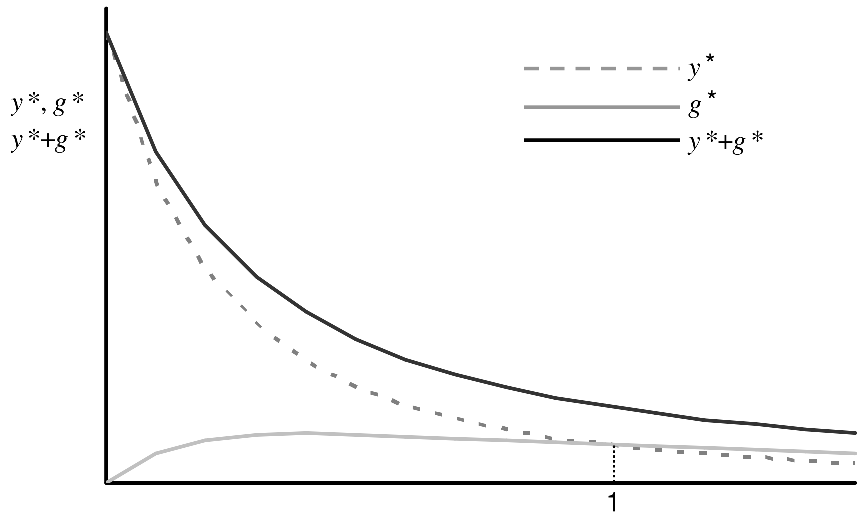

FIGURE 2.5. *Resource income g, man-made income y*, and total income y*+g*
Graph based on α=0.4, π=0.5, ρ=2, n=1.

Consider the case that a resource starts to be exploited and revenues *G* are constant and independent of other income sources *y*. The steady-state per capita income level y^* decreases due to the resource revenues, and as the economy shifts to the new equilibrium, the share of resource revenues in total income *q* will gradually increase over time. Consequently, for fixed total resource revenues *G*, the resource curse will turn out worse when compared to a situation where *q* is constant.

Appendix 2.2: The Case of Intergenerational Distribution of Resource Rents

As an alternative scenario of distribution of the resource rents G_t, we assume that the rents are equally distributed between the young and the old generation. Since population increases at an exogenous growth rate n, this implies that $(1+n)/(2+n)$ share of the resource rents accrues to the younger generation and the rest $1/(2+n)$ to the older one. The commodity balance for the consumer good is the same as in equation (2.21). The older generation consumes in period t the resource rents $[1/(2+n)]G_t$ and the savings from period t–1, which is a share α of manufactured income. Thus, equation (2.22) becomes:

$$c_t^{t-1} = (\alpha + q/(2+n))y_t. \tag{2.34}$$

The remainder of manufactured income $(1-\alpha)y_t$ and resource rents $[(1+n)/(2+n)]G_t$ are used by the younger generation to both consume and save. Thus, equation (2.23) becomes

$$c_t^t + s_t = (1-\alpha+q(1+n)/(2+n))y_t. \tag{2.35}$$

Equations (2.21), (2.34) and (2.35) combined reveal that the saving-investment balance (2.24) is maintained. By considering the intertemporal budget constraint for each generation, as in equation (2.12)-(2.19), we can adjust the savings equation (2.20), and reproduce the recursive dynamic equation for k_t as in (2.25):

$$(1+n)k_{t+1} = [(1-\alpha)/(2+\rho)\ ) + (1+n)q/(2+\rho)(2+n)]k_t^{\alpha+\pi(1-\alpha)}$$

$$- [(1+n)(1+\rho)/(2+\rho)(2+n)\alpha]qk_{t+1}. \tag{2.36}$$

We set $k_{t+1} = k_t$ in order to calculate the steady-state value of capital per capita. This provides us with the equivalent of (2.27):

$$k^* = \left[\frac{(1-\alpha)(2+n)\alpha + (1+n)\alpha q}{(2+\rho)(1+n)\alpha(2+n) + (1+\rho)(1+n)q}\right]^{1/(1-\alpha)(1-\pi)}. \tag{2.37}$$

For q=0, the two equations (2.27) and (2.37) produce the same steady state capital stock k^*. Under the scenario of equal distribution of resource rents, however, the steady-state level of capital is larger compared to the social security scenario in the presence of resource rents. Resource revenues may even have a beneficial impact for specific parameter values (for lower values of physical capital share α for instance). Thus, an equal distribution of resource rents is less harmful to investment when compared to an allocation under a social security scheme.

Figure 2.6 replicates Figure 2.2 for the case of an equal distribution of resource rents among generations. The resource curse now takes effect only for the highest values of technological spillovers π and lowest values of the capital share α.

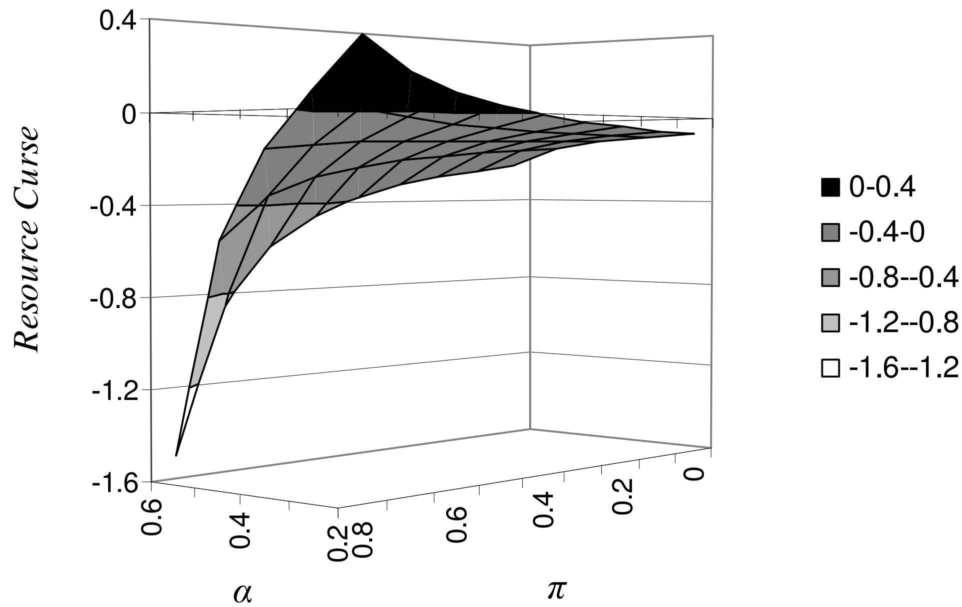

FIGURE 2.6. *Change in income following a 10% increase in resource revenues, under the scenario of equal intergenerational distribution, dependence on the technology spillover (π) and the capital share (α)*

3. Natural Resources, Innovation, and Growth *

This chapter investigates the connection between resource abundance and innovation as a transmission mechanism that can elucidate part of the resource curse hypothesis. We develop a variation of the Ramsey-Cass-Koopmans model with endogenous growth to explain the phenomenon. In this model, consumers trade off leisure versus consumption, and firms trade off innovation efforts versus manufacturing. We show that an increase in resource income frustrates economic growth in two ways: directly by reducing work effort and indirectly by inducing a smaller proportion of the labour force to engage in innovation.

3.1. Introduction

Directing work effort towards entrepreneurial activities is an important driving force of economic development. To some extent and in parallel, technological progress and improvements in labour productivity come as a by-product of other economic activities, such as investment in educational quality or physical capital. In that respect, in the trade literature in particular, the link between learning-by-doing and the Dutch disease has been exploited in a number of papers. The main motivating idea (going back to Arrow, 1962) is that as firms produce goods, they inevitably think of ways to improve their production techniques. Krugman (1987) assumes in his model that learning-by-doing (as a side effect of capital) occurs only in the export sector. A discovery of tradeable natural resources will lead to an appreciation of the real exchange rate and a crowding out of other export sectors. Such a shift in the production of tradeable sectors from a home country to abroad will result in declining relative domestic productivity. Similarly, Sachs and Warner (1995, 1999b) assume that learning-by-doing (as a side effect of employment) takes place only in the export sector. A resource boom in their model will drive labour away from the traded sector to the non-traded one and reduce the steady-state growth rate in the economy. Torvik (2001) develops a model of learning-by-doing and the Dutch disease, in which it is assumed that learning-by-doing (as a side effect of labour) can occur in both the traded and the non-traded sectors and that positive spillover effects between the two sectors may also take place (although weaker than the direct effects). In this way, the occurrence of the Dutch disease phenomena depends on the relative magnitude of learning-by-doing effects among sectors.

To a large extent, however, we learn to produce more efficiently by taking active steps in that direction. Booming primary sectors are likely to distort innovative activities in the

* This chapter is a slightly revised version of Papyrakis and Gerlagh (2004d).

economy and relocate entrepreneurial talent elsewhere. Individuals may prefer to become engaged in rent-seeking rather than productive activities, as described in Lane and Tornell (1996), Tornell and Lane (1999), Baland and Francois (2000), and Torvik (2001). They may even direct their skills and talent into parasitic activities such as warfare and robbery in order to improve their rent appropriation techniques (see Mehlum *et al*. 2003). In that respect, the crowding out of innovation or entrepreneurship is often neglected in the resource curse literature. Sachs and Warner (2001) point out that wage premia in the resource sector may encourage innovators to engage in the primary rather than the R&D sector, but they do not further develop this idea. They claim that average weekly earnings in the oil industry may be more than twice the size of those in other manufacturing sectors in oil-producing countries such as Trinidad and Tobago. In Zambia, a labour aristocracy backed up by powerful trade unions preserved higher wages in the copper industry in the 1960s and 1970s (Burger 1974 and Gupta 1974). The European Bank for Reconstruction and Development (EBRD) claims that the potential rent on Russian fossil fuels averaged 26% of GDP during 1992-2000, one third of which is estimated to have accrued to exporters (European Bank for Reconstruction and Development (EBRD) 2001). Figure 3.1 depicts the strong negative correlation between R&D expenditure in GDP in 1994 and natural capital for the same year (data on R&D are provided by the World Bank (WB 2004).

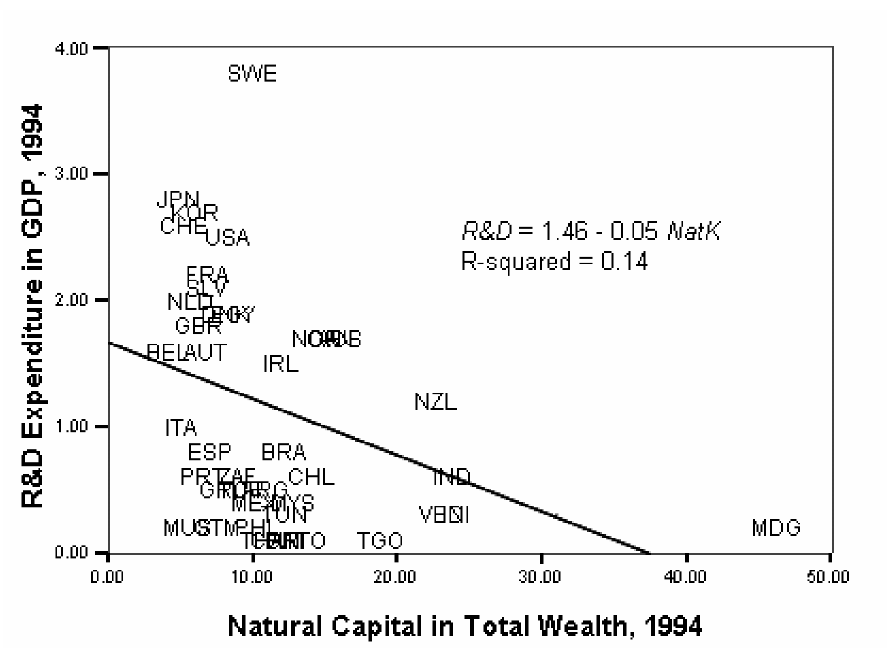

FIGURE 3.1. *Resource abundance and R&D Expenditure*

In our model, the crowding-out effect of resource wealth on innovation and entrepreneurial activity is not an outcome of informal or illegal rent-seeking competition. It simply stems from formal possibilities of skilled employees to direct their work effort between alternative sectors. Furthermore, resource affluence does not only affect innovative activities by distorting the distribution of the labour force among sectors, but also by encouraging individuals to work less intensively. Resource transfers reduce the need for labour income and increase the demand for leisure. For instance, it is highly likely that resource transfers in the form of unemployment benefits will discourage participation in the labour market. This rationale is consistent with the general tendency of resource-dependent countries to underutilise their factors of production (Gylfason 2001a).

In Section 3.2, we develop a variation of the Ramsey-Cass-Koopmans model with endogenous growth, where individuals trade off consumption and leisure in terms of utility. Contrary to previous approaches (Krugman 1987, Sachs and Warner 1995, Torvik 2001), technological progress does not come as a side-effect (learning-by-doing) without resources being devoted to R&D activities. Innovation is the outcome of intentional actions rather than the by-product of other activities. The analysis is novel in that respect, since it attempts to elucidate how resource abundance may distort the incentives to engage in R&D production. Section 3.3 derives the dynamic equilibrium and main propositions linking resource abundance to innovation and economic performance. We show that an increase in the resource base of the economy induces a reduction in the steady-state labour supply. Resource rents allow individuals to reduce their work effort (and related disutility) and use the resource revenues to pay for extra consumption. Furthermore, we show that resource abundance affects growth indirectly by inducing a smaller proportion of the labour force to engage in innovation. Finally, Section 3.4 concludes.

Our formal analysis bears resemblance to recent work by Elíasson and Turnovsky (2004), who also examine the resource curse within an endogenous growth model. In both their and our approach, labour movements between sectors play an important role, but our study differs from their analysis with respect to the underlying mechanisms of economic growth. In their model, economic growth is based on increasing returns to scale in the manufacturing sector, due to capital spillover effects on labour productivity. A shift of labour and capital away from manufacturing towards the resource sector reduces the spillover effect and restricts economic expansion. In our model, we specify R&D explicitly through a third sector that produces innovations, and this works as the engine of economic growth. The negative relationship between resource affluence and economic growth arises due to both a decrease in labour supply and a shift of labour away from R&D.

3.2. A Model on Resources and R&D

(i). Consumers

In this section we analyse a Ramsey-Cass-Koopmans type of model, where infinitely-living households choose both the level of consumption and the share of time devoted to leisure over time in order to maximise their intertemporal utility. We also incorporate in our analysis an endogenous growth channel, where returns to technology investments (which can alternatively be conceived as knowledge or labour quality) depend positively on the level of labour input in the economy. The intuition is straightforward; innovation and education become more productive when work effort increases. In other words, the harder we work, the more efficient, innovative and knowledgeable we become.

We assume that the economy consists of identical infinitely-lived agents. Population $N(t)$ remains constant at each point in time. Thus,

$$N(t) = N. \tag{3.1}$$

For the type of model we employ, a stable population level is a convenient assumption that precludes an ever-increasing growth rate for income per capita and allows the economy to converge to a balanced growth path.

Individuals divide their available time between work and leisure. A proportion $l(t)$ of their time is devoted to work and the rest to leisure activities. Therefore, the level of labour input $L(t)$ in the economy is determined respectively by:

$$L(t) = l(t)N. \tag{3.2}$$

Each representative household maximises the following intertemporal utility function:

$$U = \int_0^\infty u[c(t), l(t)]e^{-\rho t}dt \ , \tag{3.3}$$

where $c(t)=C(t)/N$ denotes consumption per person at time t, $C(t)$ stands for total consumption and ρ is the rate of time preference, which is assumed to be time-invariant and positive, implying that agents value future utility less comparatively to current utility. Thus, $U(t)$ is a weighted sum of all future discounted utility flows u$[c(t),l(t)]$, where u$[c(t),l(t)]$ represents the instantaneous utility function (also referred to as the felicity function) of each agent at a given time.

We assume that the instantaneous utility function u$[c(t),l(t)]$ is separable with respect to its two arguments and depends positively on the consumption level $c(t)$ and negatively on work intensity $l(t)$. Thus, we assume that there is a disutility of work effort, or in other words, that agents obtain satisfaction from leisure activities. For convenience, we assume a logarithmic consumption utility function and a labour disutility function with constant elasticity σ. Furthermore, we omit time references for the rest of the analysis, unless there is need for clarification. Utility's functional form is now:

$$u(c,l) = \ln c - l^{1+\sigma}. \tag{3.4}$$

Each household faces the following budget constraint when maximizing utility:

$$\dot{v} = wl + \frac{Q}{N} + rv - c\,, \tag{3.5}$$

where $v=V/N$ stands for the total value of assets held per person, the dot denotes the derivative over time, wl and Q/N stand for wage and resource income per person, and r for the real interest rate obtained per unit of asset value. Each household, thus, maximises utility subject to the budget constraint of equation (3.5). Therefore, we set up the following Hamiltonian:

$$H = \int_0^\infty (\ln c - l^{1+\sigma})e^{-\rho t} + \mu[wl + \frac{Q}{N} + rv - c]\,. \tag{3.6}$$

The first order conditions with respect to the control variables c and l, and the dual variable μ lead to the Ramsey Rule (3.7) and equation (3.8), which describe the evolution of consumption over time and the substitution possibilities between consumption and leisure respectively:

$$\frac{\dot{c}}{c} = r - \rho\,, \tag{3.7}$$

$$(1+\sigma)l^{\sigma}/c = w. \tag{3.8}$$

(ii). Producers

It is assumed that there are four sectors in our economy. First, there is a manufacturing sector with constant returns to scale with respect to its inputs; labour and intermediates. The price of the final good produced in the manufacturing sector is normalised to unity. Following Romer (1990), we adopt the conventional specification of a continuum of intermediate capital goods, indexed by $i \in [0,A]$. Each intermediate capital good i represents a distinctive design, and the number of designs, A, measures the total stock of knowledge. All designs are imperfect substitutes, whose level of substitution is captured by a parameter $0<\alpha<1$. Together, this leads to the following Cobb-Douglas production function for the manufacturing sector:

$$Y_M = (\gamma L)^{1-\alpha} \int_0^A x_i^{\alpha} di\,, \tag{3.9}$$

where $0<\gamma<1$ is the share of workers employed in the manufacturing sector, and x_i is the input of capital of type i.

Firms in the manufacturing sector produce competitively and choose the level of labour and intermediate capital goods that maximise their profits:

$$\max_{\gamma L, x_i} (\gamma L)^{1-\alpha} \int_0^A x_i^\alpha di - w\gamma L - \int_0^A p_i x_i di \,, \tag{3.10}$$

where w and p_i denote the labour wage (in the manufacturing sector) and the price of the durable good i, respectively. The first order conditions imply that each firm in the manufacturing sector faces the following demand equations for labour and durable goods:

$$w = (1-\alpha)(\gamma L)^{-\alpha} \int_0^A x_i^\alpha di = \frac{(1-\alpha)Y_M}{\gamma L} \,, \tag{3.11}$$

$$p_i = \alpha(\gamma L)^{1-\alpha} x_i^{\alpha-1} \,. \tag{3.12}$$

The first order conditions, given by equations (3.11) and (3.12), illustrate that firms pay labour and capital the value of their marginal products.

Secondly, there is a capital goods sector, where all capital intermediates are produced. Every durable good x_i is produced by a unique firm using a distinct patent (idea). This implies that all manufacturers of intermediate goods can exert monopolistic power, since their goods are imperfect substitutes, whose characteristics are determined by a specific design. Patent and copyright laws allow the specific firm that purchases and owns the design to use exclusively the corresponding idea and produce the related intermediate good. After incurring the fixed cost of innovation or the design purchase, each firm in the intermediate sector produces each durable good proportional to its capital input. In this way, intermediates can also be understood as durables, implying that $K = \int_0^A x_i di$, where K is a measure of the total capital stock.

Firms producing in the intermediate-goods sector buy the ownership for a design at price P_A, and after incurring the fixed cost of the design purchase, maximise profits π:

$$\max_{x_i} \pi_i = p_i(x_i)x_i - rx_i \,, \tag{3.13}$$

where $p_i(x_i)$ is the demand function for each durable good from the side of the manufacturing sector firms, as shown in equation (3.12). Therefore, $p_i(x_i)x_i$ equals the revenues of each firm operating in the intermediate-goods sector. The second part of the maximisation represents the interest cost firms face when producing each durable good x_i. As stated above, each firm in the intermediate sector transforms one unit of raw capital into one unit of intermediate good.

The first order condition with respect to x_i provides us with:

$$\frac{dp_i(x_i)}{dx_i}x_i + p_i(x_i) = r,$$

and after taking account of the demand function for durables (3.12), we can see that the monopolistic price of each durable good is a mark up over marginal cost that is equal for every design:

$$p_i = p = r/\alpha . \tag{3.14}$$

As equation (3.14) reveals, all intermediate capital goods sell at the same price. Since the demand function (3.12) refers to each individual intermediate good produced, equation (3.14) implies that each durable good is purchased and employed by the manufacturing sector by the same amount x. Therefore, we have:

$$K = \int_0^A x_i di = Ax . \tag{3.15}$$

The profits make the ownership of a design a valuable asset with price P_A, and, as such, they constitute a return to this asset value:

$$rP_A = \pi + \dot{P}_A . \tag{3.16}$$

On a balanced growth path, equation (3.16) simplifies to $rP_A = \pi$.

Third, we assume an R&D sector where designs for new intermediate goods are produced as in Romer (1990). This sector adds to the knowledge base. It employs a fraction $1-\gamma$ of the labour input, which is the remainder of the labour force not employed in the manufacturing sector. The production function of knowledge has constant returns to scale with respect to labour. This specification abstracts from duplication of effort; nor is there a positive spillover between researchers in the R&D sector. Furthermore, the production of designs depends positively on the stock of knowledge already discovered on a one-to-one basis. This implies that the growth rate of innovation (the rate of design accumulation) is independent of the level of knowledge. The stock of knowledge is freely available to all researchers in the R&D sector as a public good, and this fosters innovation. This specification suggests that there is endogenous growth with a scale and a composition effect (as in Smulders and van de Klundert 1995, and Peretto 1996). The larger the labour force and its share employed in the R&D sector, the faster the accumulation of new ideas. Thus, designs evolve according to:

$$\dot{A} = A(1-\gamma)L . \tag{3.17}$$

Knowledge is produced in the innovation sector, where labour earns its marginal value. Every design invented is sold to a firm in the intermediate goods sector for a price P_A. Marginal productivity of labour in the innovation sector thus becomes:

$$w = AP_A. \tag{3.18}$$

Last, we assume there is a resource sector exploiting the natural resource endowment of the economy (e.g. oil reserves, mines, fishing stocks, timber etc.). The production of the resource sector Q depends on the resource endowment available G (for instance the oil reserves discovered or the stock of fish) and the stock of physical capital K. The first component is apparent. The larger the resource base available, the larger is the potential to process and exploit the resource endowment. Resource booms make a larger amount of natural resources available for the resource sector to be exploited. The second component assumes that as a side effect of capital accumulation, natural resources are exploited more effectively. We take the simple proportional production function,

$$Q(K, G) = GK. \tag{3.19}$$

(iii). Closure

The production function for the manufacturing sector, after taking account of the capital-intermediate identity (3.15), becomes:

$$Y_M = (\gamma L)^{1-\alpha} \, Ax^{\alpha} = (A\gamma L)^{1-\alpha} K^{\alpha}. \tag{3.20}$$

Equation (3.20) reveals that production in manufacturing resembles the neoclassical Solow model. The commodity flows are closed by setting total output, or income, Y, from the manufacturing and resource sectors, equal to consumption C plus capital accumulation $\dot{K}$:

$$Y = (A\gamma L)^{1-\alpha} K^{\alpha} + KG = C + \dot{K}. \tag{3.21}$$

3.3. Analysis

(i). Dynamic Equilibrium

In this sub-section, we determine the equations governing the dynamics of consumption, the capital stock, labour supply, and the share of labour involved in innovation.

First, we determine the share of labour employed in the manufacturing sector versus the innovation sector. We compare wages for labour employed in the innovation sector and manufacturing sector, and the rate of returns to the two assets, knowledge A and capital K. Labour arbitrage between the manufacturing and innovation sector ensures equal wages. Thus (3.11) and (3.18) make:

$$AP_A = \frac{(1-\alpha)Y_M}{\gamma L}. \tag{3.22}$$

Next, we determine the level of the interest rate r for capital K. From the demand function (3.14), we know that the interest rate is the product of the parameter α and the durables price p. After substituting for the price p from (3.12), the amount of each durable demanded and produced x from (3.15), and taking account of the production function in the manufacturing sector (3.9), we know that the level of interest rate r is proportional to the ratio of the manufactured output to capital:

$$r = \alpha^2 \frac{Y_M}{K}. \tag{3.23}$$

We then proceed to calculate the interest earned on knowledge.

The immediate profits of each firm in the intermediate-goods sector are calculated by incorporating equations (3.12), (3.14), and (3.15) into (3.13):

$$\pi_i = \pi = \alpha(1-\alpha)(\gamma L)^{1-\alpha} x^{\alpha} = \alpha(1-\alpha)\frac{Y_M}{A}. \tag{3.24}$$

Taking account of equations (3.24) and (3.16) determining the price of patents P_A and the level of monopolistic profits π, in balanced growth, equation (3.22) becomes:

$$r = \alpha\gamma L. \tag{3.25}$$

After incorporating equation (3.23) into (3.25), we can express the share of the labour input engaged in the manufacturing sector in terms of the ratio of the output (in manufacturing) to capital:

$$\gamma = \frac{\alpha}{L}\frac{Y_M}{K} = \frac{\alpha}{lN}\frac{Y_M}{K}. \tag{3.26}$$

For the analysis of dynamics, it is useful to write equations in intensive form. From equation (3.21), we can derive the intensive form of total income in the economy by dividing the left-hand-side by labour in effective terms AL :

$$\hat{y} = \gamma^{1-\alpha}\hat{k}^{1-\alpha} + G\hat{k}, \tag{3.27}$$

where lower letter variables with hats denote variables expressed relative to effective labour supply: $\hat{y} = Y/AL$, $\hat{k} = K/AL$, $\hat{c} = C/AL$.

Substituting for the output in the manufacturing sector from equation (3.20) into (3.23) allows us to express the interest rate in terms of capital per effective labour,

$$r = \alpha^2 \hat{k}^{\alpha-1}\gamma^{1-\alpha}, \tag{3.28}$$

and the share of labourers in the manufacturing sector from (3.26) as

$$\gamma = \left(\frac{\alpha}{lN}\right)^{\frac{1}{\alpha}} \hat{k}^{\frac{\alpha-1}{\alpha}} . \tag{3.29}$$

We rewrite equation (3.7) in its intensive form, and substitute (3.17) and (3.28):

$$\frac{\dot{\hat{c}}}{\hat{c}} = r - \rho - \frac{\dot{A}}{A} - \frac{\dot{l}}{l} = \alpha^2 \hat{k}^{\alpha-1} \gamma^{1-\alpha} - \rho - (1-\gamma) lN - \frac{\dot{l}}{l} . \tag{3.30}$$

Subsequently, we rewrite equation (3.21) in its intensive form substituting (3.27):

$$\frac{\dot{\hat{k}}}{\hat{k}} = \gamma^{1-\alpha} \hat{k}^{\alpha-1} + G - \frac{\hat{c}}{\hat{k}} - \frac{\dot{l}}{l} - (1-\gamma) lN . \tag{3.31}$$

These two equations show that consumption and capital dynamics depend on labour supply dynamics. To solve for $\dot{l}/l$, we first express the level of labour wage in terms of capital per labour k. From equation (3.11) and (3.20), we can calculate:

$$w = (1-\alpha) k^{\alpha} \gamma^{-\alpha} A^{1-\alpha}. \tag{3.32}$$

Combining equations (3.8) and (3.32) provides us with the following equation:

$$(1+\sigma) l^{\sigma} c = (1-\alpha) k^{\alpha} \gamma^{-\alpha} A^{1-\alpha} , \tag{3.33}$$

which can be expressed in terms of effective labour as:

$$(1+\sigma) l^{1+\sigma} \hat{c} = (1-\alpha) \hat{k}^{\alpha} \gamma^{-\alpha} . \tag{3.34}$$

Together, we have four equations that determine the dynamics of $\hat{c}$ (3.30), $\hat{k}$ (3.31), and the levels of γ (3.29) and l (3.34). For use in the steady state analysis, we also derive equations that describe the labour supply l and use γ dynamics. Equation (3.34) implies that l evolves according to:

$$\frac{\dot{l}}{l} = \frac{\alpha}{1+\sigma} \frac{\dot{\hat{k}}}{\hat{k}} - \frac{1}{1+\sigma} \frac{\dot{\hat{c}}}{\hat{c}} - \frac{\alpha}{1+\sigma} \frac{\dot{\gamma}}{\gamma} . \tag{3.35}$$

From equation (3.29) we see that γ evolves according to:

$$\frac{\dot{\gamma}}{\gamma} = \frac{\alpha-1}{\alpha} \frac{\dot{\hat{k}}}{\hat{k}} - \frac{1}{\alpha} \frac{\dot{l}}{l} . \tag{3.36}$$

Combining equations (3.35) and (3.36), we see that l evolves according to:

$$\frac{\dot{l}}{l} = \frac{1}{\sigma}\left(\frac{\dot{\hat{k}}}{\hat{k}} - \frac{\dot{\hat{c}}}{\hat{c}}\right). \tag{3.37}$$

(ii). Steady State

Along a balanced growth path, capital *K*, consumption *C*, output *Y*, and technology *A* grow at the same rate, which implies that the levels of $\hat{k}$, $\hat{c}$ and $\hat{y}$ remain constant along the path. It can be seen from equations (3.36) and (3.37) that the work intensity *l* and the labour input share γ remain constant as well. Therefore, along the balanced growth path equations (3.30) and (3.31) become:

$$\alpha^2 \hat{k}_{ss}^{\alpha-1} \gamma_{ss}^{1-\alpha} - \rho - (1-\gamma_{ss}) l_{ss} N = 0, \tag{3.38}$$

$$\gamma_{ss}^{1-\alpha} \hat{k}_{ss}^{\alpha-1} + G - \frac{\hat{c}_{ss}}{\hat{k}_{ss}} - (1-\gamma_{ss}) l_{ss} N = 0, \tag{3.39}$$

where the subscript *SS* denotes the steady-state value of each variable along the balanced growth path.

Equations (3.29) and (3.34) evaluated at the steady-state, give the following levels of labour supply *l* and the share of workers employed in innovation,

$$\gamma = \left(\frac{\alpha}{l_{ss} N}\right)^{\frac{1}{\alpha}} \hat{k}_{ss}^{\frac{\alpha-1}{\alpha}} = \left(\frac{\alpha}{N}\right)^{\frac{1}{\alpha}} l_{ss}^{-\frac{1}{\alpha}} \hat{k}_{ss}^{\frac{\alpha-1}{\alpha}}. \tag{3.40}$$

$$(1+\sigma) l_{ss}^{1+\sigma} \hat{c}_{ss} = (1-\alpha) \hat{k}_{ss}^{\alpha} \gamma_{ss}^{-\alpha}. \tag{3.41}$$

Along with equations (3.38) and (3.39), these two equations constitute a system of four equations depending on the four steady-state levels $\hat{k}_{ss}$, $\hat{c}_{ss}$, l_{ss} and γ_{ss}. Substitution of these four equations produces a single equation linking resource income to labour supply l_{ss}:

$$G = \rho \frac{1+\alpha}{1+\alpha N} \frac{N}{\alpha} + \frac{1-\alpha}{1+\sigma} \frac{N}{\alpha} l_{ss}^{-\sigma} - \frac{1+\alpha}{1+\alpha N} \frac{N^2}{\alpha} (1-\alpha) l_{ss}. \tag{3.42}$$

The right-hand-side of equation (3.42) is strictly decreasing in labour supply, l_{ss}, so that there is a unique steady-state value, and we can derive that

$$\frac{dl_{ss}}{dG} = \left[-\sigma \frac{1-\alpha}{1+\sigma} \frac{N}{\alpha} l_{ss}^{-1-\sigma} - \frac{1+\alpha}{1+\alpha N} \frac{N^2}{\alpha} (1-\alpha)\right]^{-1} < 0. \tag{3.43}$$

This shows that an increase in resource abundance as captured by G results in a decrease of labour intensity at the steady state. Individuals trade off consumption and leisure in terms of utility. An increased amount of resource wealth gives them the opportunity to enjoy the same level of utility for a reduced work effort. In other words, resource abundance increases leisure and reduces man-made output. We state this finding as the first proposition:

PROPOSITION 3.1. *The steady state level of labour supply l_{ss} is decreasing in the resource base G.*

The rate of knowledge accumulation at the steady-state is given by equation (3.17). We label the steady state rate of knowledge accumulation as $\chi_{ss} = (\dot{A}_{ss} / A_{ss})$,

$$\chi_{ss} = (1-\gamma_{ss}) l_{ss} N. \tag{3.44}$$

From equations (3.40) and (3.51), in the appendix, we derive the ratio of the labour force engaged in the R&D sector ($1-\gamma_{ss}$):

$$1-\gamma_{ss} = 1 - \frac{N + \rho l_{ss}^{-1}}{1+\alpha N} \tag{3.45}$$

Equation (3.45) implies that a decrease in labour intensity at the steady-state due to an increase in resource endowments, as indicated by equation (3.43), decreases the ratio of the labour force engaged in the R&D sector.[20] Therefore, the accumulation of knowledge decreases for two reasons. First, the reduction in labour intensity directly retards knowledge accumulation. Secondly, the decrease in labour intensity reduces the rate of knowledge accumulation indirectly by lowering the percentage of the labour force engaged in the R&D sector. From equation (3.44), we see that technological progress depends negatively on the level of resource endowment (both directly and indirectly):

$$\frac{d\chi_{ss}}{dG} = \left[(1-\gamma_{ss})N + \frac{\rho}{(1+\alpha N) l_{ss}} \right] \frac{dl_{ss}}{dG} < 0, \tag{3.46}$$

where the derivative $\frac{dl_{ss}}{dG}$ is negative from equation (3.43).

Therefore, a resource-abundant country with a large natural resource base G will experience a lower labour intensity l_{ss} at the steady state and a lower rate of knowledge accumulation χ_{ss}. The economy will grow at a slower pace. This is our major finding:

[20] The equalisation of wage levels in the manufacturing and R&D sectors requires a negative adjustment of γ_{ss} in response to an increase in l_{ss}.

PROPOSITION 3.2. *Steady state R&D effort and implied economic growth* χ_{ss} *is decreasing in the resource base G.*

3.4. Conclusions

Technological progress is one of the main driving forces behind economic growth, and as such it deserves particular attention. Countries grow faster over time as they invest in projects that improve their productivity of capital and labour. Directing work effort towards R&D activities is an obvious way to support productivity growth. In that direction, it is of particular interest to explore the resource curse hypothesis from an endogenous growth perspective.

In this chapter, we investigate a resource curse mechanism not extensively discussed in the literature: the relationship between resource abundance and innovation. The pursuit of new ideas and designs by innovators is motivated by their interest in profiting from them. In our model, natural resources reduce the incentives of innovators to engage in R&D. This happens for two reasons. First, the discovery of resource reserves reduces the need to support consumption through labour income and therefore increases leisure and reduces work effort. Secondly, resource wealth negatively affects the allocation of entrepreneurial activity between the manufacturing and the R&D sector in favour of the former. In Chapter 5 we claim that knowledge-based mechanisms such as education and innovation are the most relevant intermediate channels to explain the slow growth rates of resource-dependent regions within a developed country such as the U.S.

Extensions of the analysis should take into account the possibility that work effort may also be allocated to the primary sector, as suggested by Sachs and Warner (2001). In this case, the share of the labour force employed as researchers in the R&D sector will be directly affected by the amount of resource rents, rather than indirectly (through labour intensity) as happens in our model. Furthermore, a more extensive database should allow us to examine the effect of particular components of resource income on R&D activities. It is possible that specific categories of natural resources, such as minerals and ores have a stronger (or weaker) crowding-out effect on innovation than others. Additionally, we believe that as soon as there is a collection of reliable data on innovation for a large number of countries (especially developing ones), it would be particularly interesting to identify a similar growth-frustrating mechanism of resource abundance across countries.

Appendix 3.1: Derivation of Steady-State Dynamics

Incorporating equation (3.40) into equations (3.38), (3.39) and (3.41) yields:

$$l_{ss}^{\frac{\alpha-1}{\alpha}} \hat{k}_{ss}^{\frac{\alpha-1}{\alpha}} \left(\frac{\alpha}{N}\right)^{\frac{1}{\alpha}} (1+\alpha N) - \rho - l_{ss} N = 0 , \tag{3.47}$$

$$l_{ss}^{\frac{\alpha-1}{\alpha}} \hat{k}_{ss}^{\frac{\alpha-1}{\alpha}} \left(\frac{\alpha}{N}\right)^{\frac{1-\alpha}{\alpha}} (1+\alpha) + G - \frac{\hat{c}_{ss}}{\hat{k}_{ss}} - l_{ss} N = 0 \text{, and} \tag{3.48}$$

$$\hat{c}_{ss} = \frac{N(1-\alpha)}{\alpha(1+\sigma)} l_{ss}^{-\sigma} \hat{k}_{ss} . \tag{3.49}$$

Incorporating equation (3.49) into (3.48) yields:

$$l_{ss}^{\frac{\alpha-1}{\alpha}} \hat{k}_{ss}^{\frac{\alpha-1}{\alpha}} \left(\frac{\alpha}{N}\right)^{\frac{1-\alpha}{\alpha}} (1+\alpha) + G - \frac{1-\alpha}{1+\sigma} \left(\frac{\alpha}{N}\right)^{-1} l_{ss}^{-\sigma} - l_{ss} N = 0 . \tag{3.50}$$

Rearranging equation (3.47 yields:

$$\hat{k}_{ss}^{\frac{\alpha-1}{\alpha}} = (\rho + l_{ss} N) \left(\frac{\alpha}{N}\right)^{-\frac{1}{\alpha}} (1+\alpha N)^{-1} l_{ss}^{\frac{1-\alpha}{\alpha}} . \tag{3.51}$$

Incorporating equation (3.51) into (3.50) solves for the steady-state value of labour intensity in equation (3.42).

Part III
Empirical Analyses

4. Cross-Country Evidence and Explanations of the Resource Curse [*]

We examine empirically the direct and indirect effects of natural resource abundance on economic growth. Natural resources have a negative impact on growth if considered in isolation, but a positive direct impact on growth if other explanatory variables, such as corruption, investment, openness, terms of trade, and schooling, are included. We study the transmission channels, that is, the effect of natural resources on the other explanatory variables, and calculate the indirect effect of natural resources on growth for each transmission channel. The negative indirect effects of natural resources on growth are shown to outweigh the positive direct effect by a reasonable order of magnitude.

4.1. Introduction

Countries differ largely in terms of both their resource endowments as well as their economic performance. In recent years, there has been a great interest in the association between resource affluence and economic growth. Many scholars have expressed concerns over the potential negative impact of being a resource producer (Gylfason 2000, 2001a, 2001b, Leite and Weidmann 1999, Papyrakis and Gerlagh 2004a, Rodriquez and Sachs 1999, Sachs and Warner 1995, 1997, 1999a). Countries, such as Mexico, Nigeria, Venezuela, and the so-called Oil States in the Gulf became examples of development failures despite their extensive reserves of natural wealth. The World Bank recently set up an "Extractive industry Review" in order to assess the impact of its involvement in oil and mining projects in host countries.[21] Similarly, Oxfam America in its study "Extractive Sectors and the Poor" expresses concern over the impact of minerals on poverty levels (Ross 2001b). At the same time, a number of recent papers dispute the ferocity of a resource curse in economic development. Davis (1995) claims that mineral dependence did not deter developing nations from achieving improvements in a series of human development indicators. In a similar context, Manzano and Rigobon (2003) and Stijns (2001a) contest the significance of a statistical association between resource abundance and economic growth. Torvik (2001) also criticises how assumptions on endogenous productivity and learning spillovers across sectors can bias our understanding of the impact of resources on productivity growth.

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[*] This chapter is a slightly revised version of Papyrakis and Gerlagh (2004a).

[21] See http://www.worldbank.org/ogmc.

The main interest lies undoubtedly on the sign of the resource impact: are natural resources ultimately a blessing or a curse? The aim of this chapter is to investigate the effect of resource wealth on economic growth across countries for a period of 21 years and test for the presence of the resource curse. There is a large literature pointing to the frustrating impact of resource-riches on investment, competitiveness, trade openness, institutional quality, and schooling (see Stevens 2003 for a literature review). Sachs and Warner (2001) argue that the resource curse is an indirect effect of natural wealth: namely resources retard economic growth by crowding out the aforementioned growth-related activities. Economies that maintain growth-promoting activities may be less vulnerable to the resource curse. Norway, for instance, converts its rich oil reserves mostly into foreign securities and, thus, protects its economy from abrupt income increases (Gylfason 2001a). Diamond-rich Botswana (in contrast to the Democratic Republic of Congo and Sierra Leone) experienced high income growth during the last three decades supported by good institutions of private ownership, constraints on political elites, an efficient bureaucracy, and prudent investment of resource rents in infrastructure, health and education (Acemoglu *et al.* 2003). This provides an additional research question to investigate. We explore whether resources affect growth directly or solely through intermediate channels. It is of particular importance to evaluate the different transmission mechanisms exposed in the literature and their relevance in explaining the association between resource wealth and economic growth.

Our analysis follows the methodology set out by Mo (2000 and 2001), who investigates the transmission channels through which income inequality and corruption affect growth. We use cross-country regressions to show that, on average, natural resources are associated with phenomena that impede the economic process. Taking account of the relation between natural resources and other indices used for growth regressions, we highlight the curse of natural resources. Specifically, we find that, if the negative indirect effects are excluded, natural resources contribute positively to economic growth. However, if the negative indirect impacts are included, these outweigh the positive direct contribution of natural resources to economic growth. We emphasise that this is an empirical finding and not an economic theory. If the government were to succeed in preventing the occurrence of these indirect phenomena, the country would benefit from its natural wealth.

The next section is devoted to the basic growth regressions. We verify that, in general, natural resource abundance impedes economic development rather than stimulates it. We also find, however, that if other indices such as corruption, investment, openness, terms of trade, and schooling are taken into account as independent variables, resource abundance has a positive direct impact on growth. Section 4.3 studies empirically the transmission channels and compares their relative weights in the overall negative impact of natural resources on economic growth. Section 4.4 concludes.

4.2. Basic Cross-Country Regressions

To identify the dependence of growth on natural resource abundance, we estimate cross-country growth regressions following the empirical work of Kormendi and Meguire (1985), Grier and Tullock (1989), Barro (1991), and Sachs and Warner (1995 and 1997). We base our equations on the conditional convergence hypothesis, i.e., different growth rates between different countries are explained by various characteristics of these countries; however, high-income countries have lower growth rates than low-income countries, all things being equal. Thus, per capita economic growth from period 1975 (t_0) to 1996 (t_T), denoted by $G^i=(1/T)\ln(Y_T^{\,i}/Y_0^{\,i})$, depends negatively on initial per capita income $Y_0^{\,i}$. It also depends on natural resource abundance R^i, and on a vector of other explanatory variables Z^i. Hence, we have:

$$G^i = \alpha_0 + \alpha_1 \ln(Y_0^{\,i}) + \alpha_2 R^i + \alpha_3 Z^i + \varepsilon^i, \tag{4.1}$$

where i corresponds to each country in the sample. Our focus is on the sign of the coefficient for resource abundance, α_2, and its relation to the vector of other variables Z.[22]

Before we turn to the data, let us first assess the long-term income effects of a change in a country's resource income R^i, as described by growth equation (4.1). We consider two scenarios for this country: one scenario in which the current value of resource abundance R and other characteristics Z persist, labelled i and another one labelled j that assumes a permanent change in characteristics from R^i to R^j and from Z^i to Z^j. We denote the change in the levels of R^i or Z^i by $\Delta R=R^j-R^i$, and $\Delta Z=Z^j-Z^i$. As we show in Appendix 4.1, a permanent difference in R or Z has a long-term effect on expected income given by:

$$\mathrm{E}(\Delta\ln(Y_\infty)) = -(\alpha_2/\alpha_1)\Delta R - (\alpha_3/\alpha_1)\Delta Z, \tag{4.2}$$

where $\Delta\ln(Y_\infty)= \ln(Y_\infty)^j - \ln(Y_\infty)^i$.

Taking exponentials, we can rewrite equation (4.2) and calculate the relative long-term income effect as:

$$\mathrm{E}(\Delta Y_\infty/Y_\infty) = \exp[-(\alpha_2/\alpha_1)\Delta R - (\alpha_3/\alpha_1)\Delta Z]-1. \tag{4.3}$$

For small values of $(\alpha_2/\alpha_1)\Delta R$ and $(\alpha_3/\alpha_1)\Delta Z$, we can use the following approximation:

$$\mathrm{E}(\Delta Y_\infty/Y_\infty) \approx -(\alpha_2/\alpha_1)\Delta R - (\alpha_3/\alpha_1)\Delta Z. \tag{4.4}$$

[22] We should acknowledge at this point, that every econometric analysis suffers to a certain extent from endogeneity and omitted variable bias; for that reason all regression results should always be interpreted with some caution.

The ratio $-(\alpha_2/\alpha_1)$ captures the long-term income effect of changes in resource endowments. Similarly, the ratio $-(\alpha_3/\alpha_1)$ captures the long-term impact of changes in other explanatory variables. Assuming conditional convergence, i.e., $\alpha_1<0$, four different situations may arise. A ratio $-(\alpha_2/\alpha_1)=1$ indicates that an immediate one percent increase in current income based on natural resource exploitation, i.e., $\Delta R=0.01$, also raises the long-term income level by one percent, i.e., $\Delta Y_\infty/Y_\infty=0.01$. If $-(\alpha_2/\alpha_1)>1$, resource abundance is so beneficial to growth that a one percentage increase in current resource income raises long-term income by more than one per cent. On the other hand, if $-(\alpha_2/\alpha_1)<1$, a one per cent increase in resource income results in less than a one percentage raise in long-term income. In the latter situation, the economy benefits from resource expansion but the permanent income effect is smaller than the temporary resource income effect. Finally, if $\alpha_2<0$ and $\alpha_1<0$, resource expansion leads to only a short-lived increase in income because growth is affected negatively. Hence, in the long term, the level of permanent income is actually less than it would be without the increase in natural resources. This corresponds to the curse of natural resources[23].

We estimate growth equation (4.1) using ordinary least squares (OLS)[24] and increase gradually the set of variables Z^i. Appendix 4.2 lists all variables and data sources. As a starting point, we include only initial income per capita in year 1975 ($Ln Y_{75}$) and natural resource abundance, for which we take the share of mineral production in GDP in 1971 (*SNR*) as a proxy.[25] The results, presented in column (4.1) of Table 4.1, indicate a highly significant and negative relationship between economic growth and natural resources. A one percentage point increase in income from mineral resources relative to total income decreases growth by 0.075% per year. An increase in income from mineral resources of one standard deviation (0.07), decreases the growth rate by about half of one per cent per year. Hence, natural resources appear to be an impediment to economic growth.

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[23] The latter situation refers to development paths BE and BF of reduced economic growth in Figure 1.2 of Chapter 1.

[24] Alternatively, the method of seemingly unrelated regressions (SUR) can be used to estimate simultaneously the basic cross-country regression, given by equation (4.1), and the indirect transmission channels, given by equation (4.5) in the following section, as a system of equations. The specification of our system of equations allows us to use OLS because the OLS and SUR estimates coincide in this system. Incorporating all transmission channels into the basic growth regression and allowing all indirect transmission channels to have identical explanatory variables implies that no possible correlation among individual error terms is assumed. Hence, the correction in SUR is unnecessary.

[25] The value of mineral production is calculated in national accounts after subtracting the cost of intermediate inputs (e.g. extraction costs). Although beyond the scope of this thesis, it is worth mentioning that environmental national accounting attempts to correct national accounts for environmental externalities (see Perman *et al*. 2003).

We now turn to the possible crowding-out effects of natural resources (Sachs and Warner 2001). Let us assume that the vector Z^i in growth equation (4.1) captures a set of growth-promoting activities. If resource abundance (R^i) crowds-out the activities captured by Z^i, then natural resources will indirectly harm economic growth (G^i). In other words, a negative statistical relationship between R^i and Z^i may explain the negative correlation between R^i and G^i in the first regression of Table 4.1. Furthermore, when the vector Z^i is sufficiently rich to fully capture most of the indirect negative effects of resource abundance on growth, we expect that its inclusion in our regressions would eliminate the negative coefficient of resource abundance on growth. In other words, if resource abundance affects growth solely through the intermediate transmission channels captured by the vector Z^i, we expect the coefficient of resource abundance to drop to a value close to zero ($\alpha_2 \approx 0$). In the case that either natural resources frustrate economic growth directly or that not all intermediate transmission channels through which resource abundance affects growth are accounted for, the coefficient of resource abundance is expected to sustain its negative sign. As our next step, we thus extend the vector Z^i, by adding progressively variables commonly used to explain growth, such as corruption, investment, openness, terms of trade, and schooling, and we examine the magnitude and significance of the resource abundance coefficient α_2.[26]

In the next regression, we include a measure of corruption for the 1980 to 1985 period from Transparency International. Higher values of the index correspond both to higher levels of corruption and to lower levels of institutional quality. The period 1980-85 is the earliest for which the index is available. In our regressions, we try to choose variables that refer either to the beginning of the overall period or to average values for the entire period to avoid endogeneity problems that may arise between variables. Mo (2001) argues, however, that endogeneity is less likely for the corruption variable because institutions tend to evolve slowly. The second regression in column (4.2) shows a negative sign for the coefficient α_1, which supports the conditional convergence hypothesis. Furthermore, corruption affects economic growth negatively, as expected. An increase in the corruption level of one standard deviation decreases growth by 1.17 %, which is 2.68 multiplied by 0.44. In the long term, this leads to a permanent income decrease of 74 %,[27] indicating that corruption impedes growth considerably. The coefficient for natural resources is almost unaffected, although its significance is reduced substantially. An increase in resource income (as a share of GDP) by one percent decreases growth by 0.07% per year and reduces long-term total income by about 6.4 % from equation (4.4). This regression illustrates the point that, although natural resources

[26] Acemoglu *et al*. (2002) use the same argument to give substance to their claim that income levels around 1500 (proxied by measurements of urbanisation and population density) affected long-term income per capita solely through institutions.

[27] $\exp(-1.17/1.16) - 1 = -0.74$.

increase wealth in the short term, the economy loses more in long-term growth than it gains in the short run.

In the subsequent columns of the table, we include as independent variables the ratio of real gross domestic investment to real GDP averaged over the period from 1975 to 1996, an index of openness, measured by the percentage of years during the period 1970 to 1990 in which the country is considered to be an open economy by Sachs and Warner (1995), a terms of trade index measuring the average annual growth in the ratio of the export price index divided by the import price index over the period from 1970 to 1990, and a schooling index proposed by King and Levine (1993), measuring the log of the average number of years of secondary schooling from 1970 to 1989, as a proxy for educational quality. As we include more explanatory variables, the coefficient on natural resources decreases gradually and becomes less significant in columns (4.3) and (4.4). In columns (4.5) and (4.6), the coefficient becomes positive but remains insignificant. Hence, natural resources may not be harmful to growth *per se*. The final regression indicates the effects of natural resources, corruption, investment, trade policies, terms of trade, and schooling on economic growth. Hence, the indirect effects of all transmission channels are taken into account by the coefficients of these variables. The coefficient on natural resources measures the direct effect on growth; excluding the indirect effects, we find an almost one-to-one relation between natural resource income and long-term income, from the ratio of their coefficients. Hence, an increase in resource income is permanent, although the low statistical significance of the direct effect of natural resources on growth suggests a cautious interpretation. Nonetheless, since resource abundance does not have a significantly negative direct effect on economic development, the indirect effects must be responsible for the overall harmful impact of natural resources on economic growth. We investigate the transmission channels for the indirect effects in the next section.

The coefficient for corruption also decreases as more explanatory variables are added but it remains negative, although eventually insignificant. Mo (2001) shows that corruption affects growth negatively through several indirect channels and that the corruption coefficient loses significance as these channels are included in the regression. However, corruption has no direct positive effect on income, because its coefficient remains negative. Furthermore, the coefficients for investment, openness, terms of trade, and schooling do not vary much. Their signs accord with intuition and are similar in value to those found in the literature. An economy characterised by a high investment ratio, a higher openness index, a lower initial income per capita, a decrease in terms of trade, and high educational standards is expected to experience a relatively high growth rate (Sachs and Warner 1995, 1997 and 1999b, Sala-i-Martin 1997, and Mo, 2001). Finally, we run a series of growth regressions equivalent to those in Table 4.1 using only the 39 countries that are used to estimate column (4.6) and find that the coefficients do not change qualitatively, nor do they change in an appreciable quantitative manner. Appendix 4.3 provides a list of the whole sample of countries, as in column (4.1) of Table 4.1, as well as the ones that constitute the core sample of 39 countries used in the last regression. Appendix 4.4 replicates all results for the final sample of 39 observations.

TABLE 4.1. *Growth regressions as in equation (4.1)*

Dependent variable: $G_{75\text{-}96}$	(4.1)	(4.2)	(4.3)	(4.4)	(4.5)	(4.6)
Constant	–2.62	10.03	11.66	12.87	12.33	12.03
$\text{Ln}\,Y_{75}$ (0.89)	0.52*** (0.17)	–1.16*** (0.39)	–1.61*** (0.29)	–1.77*** (0.31)	–1.76*** (0.33)	–1.61*** (0.33)
SNR (0.07)	–7.57*** (1.50)	–7.39** (2.95)	–4.41** (1.95)	–3.11 (1.96)	0.93 (2.22)	1.59 (2.11)
Corruption (2.68)		–0.44*** (0.13)	–0.30*** (0.10)	–0.26*** (0.10)	–0.19* (0.11)	–0.09 (0.11)
Investments (8.06)			0.16*** (0.03)	0.13*** (0.02)	0.15*** (0.02)	0.16*** (0.02)
Openness (0.45)				1.26*** (0.45)	1.64*** (0.48)	1.26** (0.53)
Terms of Trade (1.90)					–0.27** (0.11)	–0.31*** (0.10)
Schooling (0.61)						0.58 (0.56)
R^2 adjusted	0.18	0.25	0.51	0.55	0.62	0.66
N	103	47	47	47	46	39

Notes: 1. The standard deviations for the independent variables are in parentheses, based on the sample of 39 core countries used in the regression in column (4.6). 2. Robust standard errors for coefficients in parentheses. 3. The superscripts *, **, *** represent 10%, 5%, and 1% levels of significance, respectively.

4.3. Transmission Channels

To analyse the magnitude and relative importance of the transmission channels, we estimate the effect of natural resources on corruption, investment, openness, terms of trade, and schooling to capture their indirect effects on economic growth. First, we estimate the dependence of these variables on resource income from the following:

$$Z^i = \beta_0 + \beta_1 R^i + \mu^i, \tag{4.5}$$

where Z^i, β_0, β_1, and μ^i are vectors of which each element is associated with the indices of corruption, investment, openness, terms of trade, and schooling. To avoid having different sample sizes due to data availability and the corresponding sample bias, we confine the transmission analysis to only those 39 countries used in the last regression of Table 4.1. As Table 4.2 indicates, most of these coefficients are not highly significant due to small sample size. In Appendix 4.5, we run the same sequence of regressions for the largest possible sample available for each transmission channel. We find significant coefficients at the 10% level for the terms of trade and openness indices and at the 1% level for the investment, openness and schooling indices. Additionally, using the larger sample increases the R^2 for each transmission channel.[28]

TABLE 4.2. *Indirect transmission channels as in equation (4.5)*

	Corruption (4.7)	Investments (4.8)	Openness (4.9)	Terms of Trade (4.10)	Schooling (4.11)
Constant	5.87	20.77	0.68	–0.74	–0.70
SNR (0.07)	7.21 (4.74)	–28.83* (17.38)	–1.82*** (0.59)	7.75 (6.36)	–2.16 (1.44)
R^2 adjusted	0.01	0.03	0.05	0.05	0.03
N	39	39	39	39	39

Notes: 1. Robust standard errors for coefficients in parentheses. 2. The superscripts * and *** represent 10% and 1% levels of significance, respectively.

Since natural resources explain part of the variation in investment and other variables, we compute the direct and indirect effects of natural resources on growth. Substituting equation (4.5) into equation (4.1) yields:

$$G^i = (\alpha_0+\alpha_3\beta_0) + \alpha_1 \ln(Y_0{}^i) + (\alpha_2+\alpha_3\beta_1)R^i + \alpha_3\mu^i + \varepsilon^i, \tag{4.6}$$

where $\alpha_2 R^i$ is the direct effect of natural resources on growth, $\alpha_3\beta_1 R^i$ is the indirect effect of natural resources on growth, and μ^i are the residuals of equation (4.5). The estimated values for the coefficients α_1, $\alpha_2+\alpha_3\beta_1$, and α_3 of equation (4.6) are given in Table 4.3. The coefficient of natural resources includes both direct and indirect effects. A one percent increase in natural resource income leads to a decrease in the growth rate of 0.096 percent,

[28] The values of the coefficients are generally robust against the sample size, as can be seen in Table 4.6. The coefficient on natural resources on investment decreases significantly for the largest sample, but as a counteracting effect the coefficient on investment in growth regression (4.3) also substantially increases when we abstract from corruption and thus increase the sample to 103 observations.

and a decrease in long-term income of about 6 percent from equation (4.4), which is consistent with column (2) of Table 4.1.[29] An increase in the share of mineral production in GDP of one standard deviation would directly and indirectly lead to a reduction in annual per capita growth of 0.67%, which is equal to 0.07 times –9.60, and a long-term income decrease of 33% from equation (4.3).

TABLE 4.3. *Growth regression, including indirect effects as in equation (4.6)*

Dependent variable: $G_{75\text{-}96}$	(4.12)
Constant	16.53
Ln Y_{75} (0.89)	–1.61*** (0.33)
SNR (0.07)	–9.61*** (1.34)
μ_1 (*Corruption*) (2.63)	–0.091 (0.11)
μ_2 (*Investments*) (7.82)	0.16*** (0.02)
μ_3 (*Openness*) (0.43)	1.26** (0.53)
μ_4 (*Terms of Trade*) (1.82)	–0.31*** (0.10)
μ_5 (*Schooling*) (0.59)	0.58 (0.56)
R^2 adjusted	0.66
N	39

Notes: 1. The standard deviations for the independent variables are in parentheses. 2. Robust standard errors for coefficients in parentheses. 3. The superscripts ** and *** represent 5% and 1% levels of significance, respectively.

In addition, we can estimate the relative importance of each transmission channel in explaining the indirect negative impact of natural resources on economic growth. The results are presented in Table 4.4. The effect of natural resources on corruption is depicted in the first

[29] This regression in Table 1 is, however, based on a larger sample.

column of Table 4.2.[30] Natural resources tend to increase the level of corruption, but the indirect effect on growth is relatively small compared to the other transmission channels. Yet, although the contribution of corruption to the overall negative impact of natural resources seems minor – only 7% – corruption is, nonetheless, a significant resource curse mechanism since it alone cancels out about 40 per cent of the positive direct effect of natural resources on economic growth (which is 0.65 from Table 4.4 divided by 1.59 from Table 4.1). This finding is consistent with recent empirical work by Sachs and Warner (1995) and Gylfason (2000). Explanations of the effect of natural resources on institutional quality and, more specifically on corruption, are found in the literature. Krueger (1974) argues that natural resources are associated with large amounts of appropriable rents, and therefore they tend to promote rent-seeking competition rather than productive activities. Moreover, rents induce economic agents to bribe the administration in order to gain access to them (Sachs and Warner 1995, Gray and Kaufmann 1998, Ascher 1999, Leite and Weidmann 1999, Sachs and Rondriguez 1999, Gylfason 2001a). Furthermore, Mauro (1998) claims that natural resource abundance is often associated with the emergence of politically powerful interest groups that attempt to influence politicians to adopt policies that may not favour the general public interest.

The second transmission channel, investment, is the most important as it accounts for 48% of the indirect negative impact of natural resources on growth. In Chapter 2, we argue that natural resource wealth decreases the need for savings and investment, since natural resources provide a continuous stream of wealth that enhances future income levels. Furthermore, world prices tend to be more volatile for primary commodities than for other goods. Therefore, an economy based on primary production will fluctuate from booms to recessions, which creates uncertainty for investors in these natural resource economies (Sachs and Warner, 1999b). Additionally, during a natural resource boom, increased rents in the primary sector cause a reallocation of factors of production from manufacturing towards the booming primary sector. Since the manufacturing sector is often characterised by increasing returns to scale and positive externalities, a decrease in scale of manufacturing decreases the productivity and profitability of investment, which further accelerates the decrease in investment (Sachs and Warner 1995 and 1999a Gillis *et al.* 1996, and Gylfason 2000 and 2001a). Finally, Gylfason and Zoega (2001) conclude that the rate of optimal savings and the maturity of the financial system are negatively related to the share of natural resources in national output.

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[30] An extensive literature considers the endogeneity of social capital and institutions and concludes that institutions are not affected by other factors in the short run, but they are in the long term. We link institutional quality to natural resource abundance. Acemoglu *et al.* (2001), Mauro (1995) and Hall *et al.* (1999) relate institutions to the mortality rate of settlers during colonisation, ethnolinguistic fragmentation, and geographical characteristics respectively. See also Chapter 6 for a more elaborate discussion.

The international transmission channel consists of the effects of natural resources on the degree of openness of the economy and its terms of trade. Taken together these two channels account for another 49% of the total impact of natural resources on growth. Natural resource abundance reduces openness and has negative effects on the terms of trade. Since natural resources weaken the manufacturing sector, policy makers may impose import quotas and tariffs that, in the short run, protect domestic producers (Auty 1994 and Sachs and Warner 1995). In the long run, however, such measures reduce the openness of the economy and retard its integration into the global economy. In addition, natural resource booms increase domestic income and, consequently, the demand for goods, which generates inflation and an overvaluation of the domestic currency. Hence, the relative prices of all non-traded goods increase and the terms of trade deteriorate, so that exports become expensive relative to world market prices and decline. This phenomenon is known as the Dutch disease (Sachs and Warner 1995, Torvik 2001, Gylfason 2000, 2001a and 2001b, and Rodriguez and Sachs 1999).

Finally, the schooling transmission channel is almost twice as important as the corruption channel. Natural resource booms lead to a decline in the manufacturing sector for which human capital is an important production factor. Hence, Gylfason (2001a) argues that the need for high-quality education declines and, with it, the returns to education. Sachs and Warner (1995) claim that natural resource abundance creates a false sense of confidence and that easy riches lead to sloth. An expanding primary sector does not need a high-skilled labour force, so that spending on education need not increase. Hence, the future expansion of other sectors that require educational quality is restricted (Gylfason 2000, 2001a and 2001b, and Sachs and Warner 1999b) and technological diffusion is retarded (Nelson and Phelps, 1966). Our result that schooling is a more important and more significant transmission channel than corruption contrasts with the empirical results in Sachs and Warner (1995 and 1999a).

TABLE 4.4. *Relative importance of transmission channels as in equation (4.5)*

Transmission channels	α_3 (Table 4.1)	β_1 (Table 4.2)	Contribution to $\alpha_2+\alpha_3\beta_1$	Relative Contribution
SNR			1.59	–17%
Corruption	–0.09	7.21	–0.65	7%
Investment	0.16	–28.83	–4.61	48%
Openness	1.26	–1.82	–2.29	24%
Terms of Trade	–0.31	7.75	–2.40	25%
Schooling	0.58	–2.16	–1.25	13%
Total			**–9.61**	**100%**

4.4. Conclusions

When used in a prudent manner, natural resources can be an important asset for governments and societies. For some countries resource wealth is a blessing, which has accelerated their economic growth rate. For most resource-dependent nations, however, resource affluence has become a curse of poor economic performance and underdevelopment. Our findings in this chapter suggest that a natural resource-based economy that suffers from corruption, low investment, protectionist measures, deteriorating terms of trade, and low educational standards will probably not benefit from its natural wealth due to these adverse indirect effects.

Our empirical analysis indicates that natural resource wealth increases growth, if negative indirect effects are excluded. However, if these transmission channels are included, the overall effect of natural resource abundance on economic growth is strongly negative. Moreover, the investment channel is shown to be the most important of these transmission channels, accounting for almost half of the negative correlation between resource income and economic growth. This substantiates our argument in Chapter 2 on the contracting role of resource rents on savings and investment. Furthermore, it suggests that such a crowding-out mechanism is highly relevant in explaining the resource curse, since we found the rest of the transmission channels to bear a smaller significance in explaining the phenomenon.

Extensions of this analysis can expand the sample used for the empirical analysis and identify additional transmission channels through which natural resources affect growth. It would be of interest to extend the vector of institutional proxies, in order to account for alternative institutional measures that capture the degree of rule of law or bureaucracy in the economy. Additionally, an appealing extension would be to account for variation in technological intensity across countries, although there is a lack of credible data for most of the developing countries. Furthermore, we should attempt as a next step to overcome the scarcity of data on institutional and protectionism measures and expand the dataset to perform panel data analysis for subperiods in order to reinforce our findings. In addition, the mechanisms behind the transmission channels can be investigated more thoroughly. The analysis is so far exploratory in nature and more elaborate transmission mechanisms can be tested. A better understanding of these mechanisms is essential for developing policy measures to reduce the negative impact of natural resources on economic growth.

APPENDIX 4.1: LONG-TERM INCOME EFFECTS

In this appendix, we derive the long-term income effects of equation (4.2), using the description of economic growth in equation (4.1). Since G^i represents income growth in country i over a period of T years, we rewrite equation (4.1) as:

$$(\ln(Y_T^i) - \ln(Y_0^i))/T = \alpha_0 + \alpha_1 \ln(Y_0^i) + \alpha_2 R^i + \alpha_3 Z^i + \varepsilon^i. \qquad (4.7)$$

After rearranging terms, we derive income for country i at the end of the period, i.e., in year T as:

$$\ln(Y_T^i) = \alpha_0 T + (\alpha_1 T+1)\ln(Y_0^i) + \alpha_2 T R^i + \alpha_3 T Z^i + T\varepsilon^i. \qquad (4.8)$$

We use this equation to calculate the difference in expected income from a permanent change in R and Z from R^i to R^j and from Z^i to Z^j, where i and j correspond to the value before and after the change correspondingly. We denote the change in the levels of R^i or Z^i by $\Delta R = R^j - R^i$, and $\Delta Z = Z^j - Z^i$. Since the level of initial income has not changed, we abstract from any convergence impacts on long-term growth $(\Delta\ln(Y_0) = \ln(Y_0^j) - \ln(Y_0^i) = 0)$. This allows us to focus on income differences generated either by the resource abundance factor or the vector of the other explanatory variables Z. Hence, we have:

$$E(\Delta\ln(Y_T)) = \alpha_2 T\,\Delta R + \alpha_3 T\,\Delta Z, \qquad (4.9)$$

where $\Delta\ln(Y_t) = \ln(Y_t^j) - \ln(Y_t^i)$. To assess the long-term effects of R and Z on income, we assume that ΔR and ΔZ are constant over time and study the propagation of income differences over time. After two periods of T years, income differences are equal to:

$$E(\Delta\ln(Y_{2T})) = (\alpha_1 T+2))(\alpha_2 T\Delta R + \alpha_3 T\Delta Z). \qquad (4.10)$$

After three periods, we have:

$$E(\Delta\ln(Y_{3T})) = (1+(\alpha_1 T+1)+ (\alpha_1 T+1)^2))(\alpha_2 T\Delta R + \alpha_3 T\Delta Z)\ . \qquad (4.11)$$

Since $0<\alpha_1 T+1<1$, as t goes to infinity, the first term on the right hand side reduces to:

$$(1 + (\alpha_1 T+1) + (\alpha_1 T+1)^2 + (\alpha_1 T+1)^3 + \ldots) = 1/(1-(\alpha_1 T+1)) = -1/(\alpha_1 T). \qquad (4.12)$$

Hence, equation (4.2) is derived.

APPENDIX 4.2: LIST OF VARIABLES

G	Average annual growth in real GDP per person from 1975 to 1996, calculated as $G=(\ln(Y_{1996}/Y_{1975})/21)\times 100\%$. Source: Center for International Comparisons at the University of Pennsylvania (CIC), 2002.
$\mathrm{Ln}\,Y_{75}$	The log of real GDP per capita in 1975 at 1985 international prices. Source: Center for International Comparisons at the University of Pennsylvania (CIC), 2002.
SNR	The share of mineral production in GDP for 1971. Source: Center for International Development at Harvard University (CID), 2002.
Corruption	The Corruption Perception Index from 1980 to 1985 from Transparency International. The index means the degree to which corruption is perceived to exist among public officials and politicians. Source: Center for Globalisation and Europeanisation of the Economy (CeGE) of the Georg-August-University of Goettingen and Transparency International Organisation (TI), 2002.
Investment	Average real gross domestic investment, private and public, at 1985 international prices, from 1975 to 1996. Source: Center for International Comparisons at the University of Pennsylvania (CIC), 2002.
Openness	The fraction of years from 1965 to 1990 in which the country is rated as an open economy according to the criteria imposed by Sachs and Warner. Source: Center for International Development at Harvard University (CID), 2002.
Terms of Trade	The average annual growth in the log of external terms of trade between 1970 and 1990, where the terms of trade is given by the ratio of an export price index to an import price index. Source: Center for International Development at Harvard University (CID), 2002.
Schooling	The log of average secondary schooling from 1970 to 1989, known as the King and Levine Index. Source: Center for International Development at Harvard University (CID), 2002.

APPENDIX 4.3: LIST OF COUNTRIES IN SAMPLES

1. Algeria
2. Angola
3. Argentina
4. Australia*
5. Austria*
6. Bangladesh
7. Belgium*
8. Benin
9. Bolivia*
10. Botswana
11. Brazil*
12. Burkina Faso
13. Burundi
14. Cameroon*
15. Canada*
16. Cape Verde
17. Central African Republic
18. Chad
19. Chile*
20. China
21. Colombia*
22. Comoros
23. Costa Rica
24. Cyprus
25. Denmark*
26. Dominican Republic
27. Ecuador*
28. Egypt*
29. El Salvador
30. Ethiopia
31. Fiji
32. Finland*
33. France*
34. Gabon
35. Gambia
36. Ghana
37. Greece*
38. Guatemala
39. Guinea-Bissau
40. Guyana
41. Haiti
42. Honduras
43. Hong Kong*
44. Iceland
45. India*
46. Iran
47. Ireland*
48. Israel*
49. Italy*
50. Jamaica
51. Japan*
52. Jordan
53. Kenya*
54. Korea
55. Lesotho
56. Madagascar
57. Malawi
58. Malaysia*
59. Mali
60. Mauritania
61. Mauritius
62. Mexico*
63. Morocco
64. Mozambique
65. Nepal
66. Netherlands*
67. New Zealand*
68. Nicaragua
69. Niger
70. Nigeria
71. Norway*
72. Pakistan*
73. Panama
74. Papua-New Guinea
75. Paraguay
76. Peru
77. Philippines*
78. Portugal*
79. Rwanda
80. Senegal
81. Seychelles
82. Sierra Leone
83. Singapore*
84. South Africa*
85. Spain*
86. Sri Lanka
87. Sweden*
88. Switzerland
89. Syria
90. Taiwan
91. Tanzania
92. Thailand*
93. Togo
94. Trinidad and Tobago
95. Tunisia
96. Turkey*
97. Uganda*
98. United Kingdom*
99. Uruguay
100. United States
101. Venezuela*
102. Zambia
103. Zimbabwe

* Base sample of 39 core countries.

APPENDIX 4.4: REPLICATION OF TABLE 4.1 WITH A FIXED SAMPLE OF 39 OBSERVATIONS

TABLE 4.5. *Growth regressions as in equation (4.1) with a fixed sample of 39 observations*

Dependent variable: $G_{75\text{-}96}$	(4.13)	(4.14)	(4.15)	(4.16)	(4.17)	(4.18)
Constant	–2.31	7.31	10.22	11.80	8.99	12.03
$\text{Ln}\,Y_{75}$	–0.03	–0.77	–1.40***	–1.61***	–1.31***	–1.61***
(0.89)	(0.45)	(0.48)	(0.37)	(0.33)	(0.33)	(0.33)
SNR	–8.98***	–7.05***	–3.52	–2.15	0.64	1.59
(0.07)	(2.46)	(2.68)	(2.27)	(2.05)	(2.09)	(2.11)
Corruption		–0.31**	–0.20*	–0.18*	–0.08	–0.09
(2.68)		(0.15)	(0.12)	(0.11)	(0.12)	(0.11)
Investments			0.16***	0.13***	0.16***	0.16***
(8.06)			(0.03)	(0.02)	(0.02)	(0.02)
Openness				1.27***	1.48***	1.26**
(0.45)				(0.44)	(0.45)	(0.53)
Terms of Trade					–0.31***	–0.31***
(1.90)					(0.10)	(0.10)
Schooling						0.58
(0.61)						(0.56)
R^2 adjusted	0.10	0.17	0.51	0.56	0.66	0.66
N	39	39	39	39	39	39

Note: Standard deviations for independent variables in parentheses, based on the sample $N = 39$ of regression (6); robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

APPENDIX 4.5: REPLICATION OF TABLE 4.2 FOR THE LARGEST POSSIBLE SAMPLE

TABLE 4.6. *Indirect transmission channels as in equation (4.5)*

	Corruption (4.19)	Investments (4.20)	Openness (4.21)	Terms of Trade (4.22)	Schooling (4.23)
Constant	5.81	15.80	0.68	–0.86	–1.17
SNR	8.78*	–15.24***	–1.11***	6.65*	–2.17***
(0.06, 0.11, 0.11, 0.11, 0.10)	(5.02)	(5.61)	(0.22)	(3.80)	(0.76)
R^2 adjusted	0.03	0.04	0.07	0.07	0.05
N	47	103	96	98	84

Notes: 1. The sequence of standard deviations for *SRN* for all regressions provided in parenthesis. 2. Robust standard errors for coefficients in parentheses. 3. Superscripts * and *** correspond to a 10 and 1% level of significance.

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5. Resource abundance and Economic Growth in the U.S. *

It is a common assumption that regions within the same country converge to approximately the same steady-state income levels. Empirical data seem to support the absolute convergence hypothesis for U.S. states, but the data also show that natural resource abundance is a significant negative determinant of growth. We find that natural resource abundance decreases investment, schooling, openness, and R&D expenditure, and increases corruption; and we show that these effects can fully explain the negative effect of natural resource abundance on growth. In particular, our findings point to a significant role of innovation in explaining growth differentials, once we account for spatial spillovers across states.

"Do we value this land and are we prepared to protect it, or are we going to desecrate it, diminish it, change it forever for a small amount of oil?"

Senator Joseph Lieberman speaking for Alaska, International Herald Tribune, March 21 2003.[31]

5.1. Introduction

The influx of economic data at a regional level in the 1990s stimulated the interest of economists to investigate empirically the behaviour of regions within countries. The regional empirical analyses by Barro and Sala-i-Martin (1992a, 1992b, 1995), Barro *et al.* (1991), and Johnson (2000) claimed that differences in growth rates at a regional level are fully driven by initial income. In other words, poorer regions tend to catch up with richer ones. But then an important issue remains unresolved. Do they fully catch up? Or do they simply cover part of the distance inbetween, as income differences are never fully eliminated due to diversity in steady-state levels? Are U.S. states, such as Maine and California fundamentally different in any socio-economic features apart from initial income that may influence their future income levels? Will Sicily and the poorer southern part of Italy's mainland catch up with the richer North? Eurostat statistics (www.europa.eu.int/comm/eurostat) reveal that even in relatively small countries, such as the Netherlands and Belgium, large income differentials are observed. For example, there is approximately a 10,000 dollars-equivalent difference between the GDP

* This chapter is an extension of Papyrakis and Gerlagh (2004b).

[31] The quote should not be perceived by any means as a political statement or an endorsement of the Senator's general political viewpoint.

per capita levels in the poorer region of Hainaut and the wealthier Antwerpen region in Belgium for the year 1999. Similarly the GDP per capita level in the province of Noord Holland in the Netherlands exceeded that of Friesland by approximately 50% for the same year. Are such income differentials permanent or do they reflect temporary deviations from a common steady state? There is undoubtedly no single answer to all the aforementioned questions. Some regions enjoy more political and economic autonomy than others, some are more populous than many independent countries (e.g. California has approximately the population of Spain or Poland), while others are larger in size compared to most sovereign states (Nunavut in Canada with a size of 2 million square metres is as large as Indonesia).

In this context, it is interesting to test whether variables that are considered to be important growth determinants at a cross-country level (such as resource abundance, investment, schooling, innovation, openness, and corruption) have an important explanatory power when addressing regional variation in economic growth performance. More importantly, within the context of this thesis, it is appealing to investigate whether resource curse type phenomena are relevant at a regional level; an issue that has received very little attention so far. Do resource-rich regions have a comparative disadvantage in economic development compared to their resource-scarce counterparts?

In this chapter, we contribute to this strand of the literature by studying the natural resource curse and its transmission channels on a U.S.-state level. As Figure 5.1 illustrates, there is substantial variation across U.S. states with respect to the importance of the primary sector within their local economies. To our knowledge, this is the first empirical analysis performed at a regional level focusing on the negative relationship between economic growth and resource abundance and the indirect mechanisms through which this occurs. A particular merit of our analysis is that whereas countries often differ in dimensions – such as language, the quality of institutions, and cultural characteristics – that are difficult to control for in growth regressions, these differences are likely to be smaller across regions within a country (Barro and Sala-i-Martin 1995). The U.S. is a relatively homogeneous country and therefore a regional U.S. analysis may provide more precise estimates (compared to cross-country studies) of the effect of resource wealth on growth and the indirect channels through which this takes place.

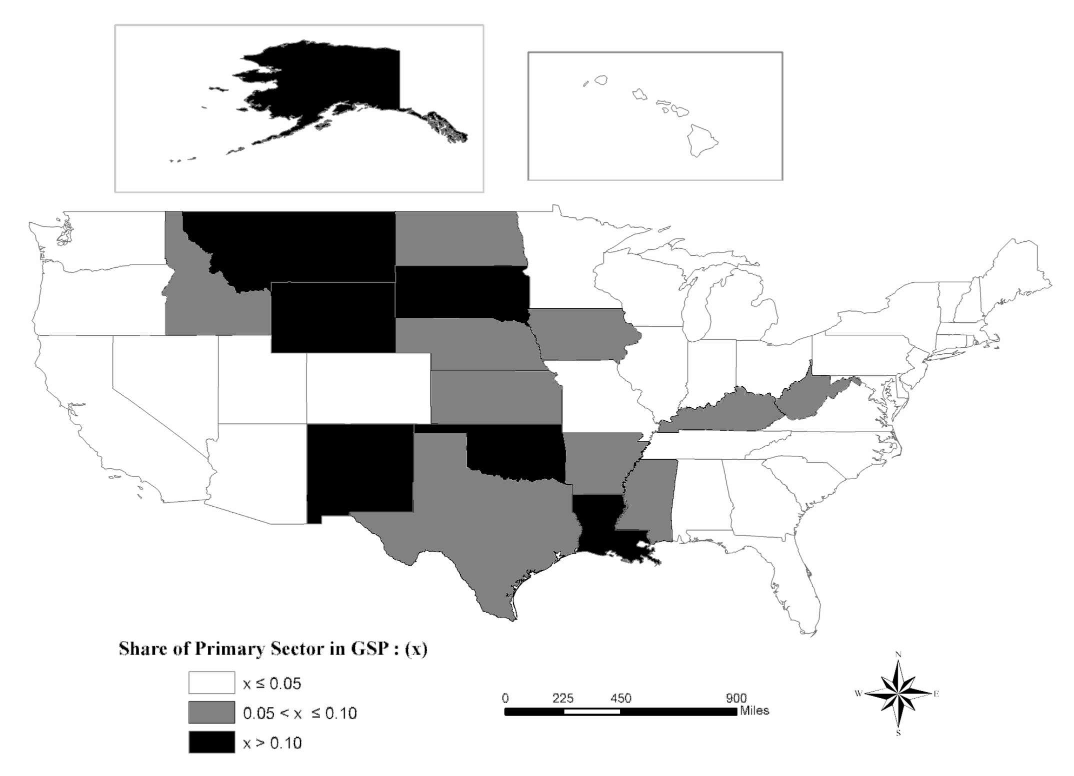

FIGURE 5.1. *Resource abundance in the U.S.*

Figure 5.2 depicts the negative correlation between resource abundance and economic growth over the period 1986-2001 for the 49 states for which data were available for all the variables of our analysis (all U.S. states excluding the District of Columbia and Delaware). The correlation is significant at the 1% level. Data are compiled from the Bureau of Economic Analysis of the U.S. Ministry of Commerce.

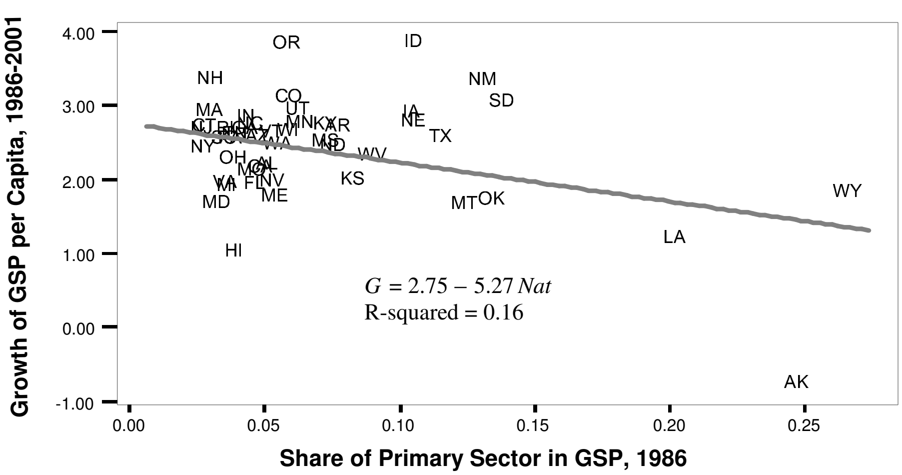

FIGURE 5.2. *Resource abundance and economic growth in the U.S.*

Our analysis contributes to growth theory in a wider perspective, as it examines the conditional convergence hypothesis for different regions (the U.S. states) within a country. As aforementioned, most empirical analyses on (intra-country) regional data sets (e.g. Barro and Sala-i-Martin (1992a, 1992b, 1995), Barro *et al*. (1991), and Johnson (2000)) focus on the absolute convergence hypothesis. In these studies, an implicit assumption is that different regions within the same country are characterised by the same fundamental economic features (tastes, technologies, institutions etc.) and therefore that they all must converge to the same steady state. Then, differences in growth across regions are fully driven by initial income differentials.[32] Figure 5.3 depicts the negative correlation between economic growth and initial income for our sample of 49 U.S. states. At a second stage, Barro and Sala-i-Martin (1992a) include education and immigration as regressors in their analysis, only to show that the convergence rate they calculate remains stable. We believe that more can be said about the role of these independent variables. Finding the coefficients significant implies that regions converge to different steady-state levels, or stated differently, that regions with the same initial income level but different education and immigration levels will experience different growth rates. Johnson and Takeyama (2001) claim, for instance, that the set of U.S. states with a higher density of capital stock experienced stronger convergence since 1950. Though differences in human capital, investment rates, resource abundance, openness, and institutions across regions are likely to be smaller than those across countries, in our analysis we find them to be non-negligible and significant in explaining economic growth.

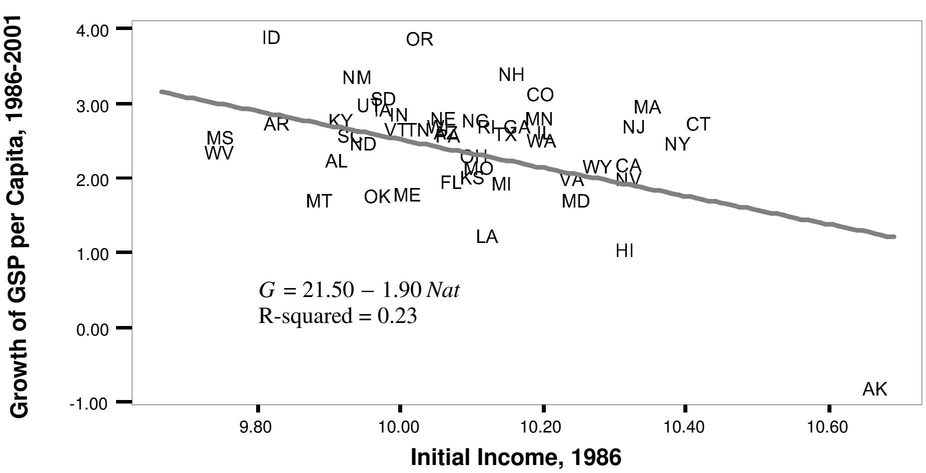

FIGURE 5.3. *Absolute convergence in the U.S.*

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[32] To give justice to the literature, there are studies that examine a series of growth determinants for regions within Europe. For an extensive survey, see Fingleton (2003).

Our analysis on the resource curse transmission channels follows the same methodology described in Chapter 4. Through cross-state regressions (for the United States), we investigate in a similar manner to the previous chapter the effect of natural resources on investment, schooling, openness, innovation (R&D), and institutional quality, and we estimate the share of each transmission channel in the overall negative effect of resource abundance on growth.

The next section is devoted to the empirical evidence on resource abundance and economic growth for the U.S. We verify our main proposition that natural resource abundance impedes economic development at a regional level. Section 5.3 focuses on other growth determinants (investment, schooling, openness, innovation, and corruption) and the existence of conditional convergence. Section 5.4 studies empirically the transmission channels and compares their relative weight in the overall negative impact of natural resources on economic growth. Section 5.5 pays special attention to the role of innovation and regional R&D spillovers in explaining the diverse economic performance across states. Section 5.6 analyses the differing growth experience of U.S. states individually and attributes their above (below)-average growth performance to their resource endowments and other specific characteristics of their economies. Section 5.7 summarises our main results and offers concluding remarks. Finally, as we have carried out an extensive set of robustness checks to test our findings, we do not report on all these throughout the text, but separately in Appendix 5.1.

5.2. Natural Resource Abundance and Growth

To identify the dependence of growth on natural resource abundance and other economic factors, we estimate cross-state growth regressions for the U.S. states in a similar analysis to Chapter 4. We include initial income per capita in our regressions to check for the conditional convergence hypothesis, which predicts higher growth in response to lower starting income per capita keeping the other explanatory variables constant. Thus, per capita economic growth from period t_0=1986 to t_T=2000, denoted by $G^i=(1/T)\ln(Y_T^i/Y_0^i)$, depends on initial per capita income Y_0^i, natural resource abundance, R^i (the sign of dependence is the subject of our analysis), and a vector of other explanatory variables Z^i:

$$G^i = \alpha_0 + \alpha_1 \ln(Y_0^i) + \alpha_2 R^i + \alpha_3 Z^i + \varepsilon^i, \qquad (5.1)$$

where i corresponds to each U.S. state.[33]

We now estimate growth equation (5.1) using OLS, gradually increasing the set of variables Z^i. As a starting point, we estimate growth dependent only on initial income per capita in 1986 (LnY_{86}). Data on income levels are provided by the Bureau of Economic Analysis of the U.S. Ministry of Commerce, and we use the real Gross State Product (GSP)

[33] Appendix 5.2 lists variables and data sources.

database, which is the state equivalent to GDP. As a second step we include natural resource abundance, for which we take the share of the primary sector's production (agriculture, forestry, fishing, and mining) in GSP in 1986 (*Natural Resources*) as a proxy (values in the range of 0 to 1). The results are listed in column entry (5.1) and (5.2) of Table 5.1. Our findings support the hypothesis that poorer regions tend to grow faster than richer regions (a result that still holds when conditioning on any other characteristics of the regions).[34] The second column reveals that there is a highly significant and negative relationship between economic growth and natural resources. It is apparent that regions within the U.S. differ substantially in economic features that are important for economic growth, apart from initial income levels. A one percentage point increase in income from the primary sector relative to total income decreases annual growth by 0.047%. An increase in income from natural resources of one standard deviation (0.06) decreases the annual growth rate by about 0.28%. This is an effect of substantial magnitude. As a comparison, we observe that a one percentage point increase in initial income, other than through the primary sector, decreases growth by 0.018% per year.

Our results can easily be misinterpreted as suggesting that resource-rich states are growing slower due to closer proximity to their steady-state levels after a positive resource income shock. But such convergence effects of income shocks are captured through the initial income variable, as we can see through the analysis of long-term income effects (see Appendix 4.1). When the negative effect of natural resources on growth persists, the long-term effect of an increase in natural resource income of one percent amounts to 4.77/1.77=3 per cent (see equation (4.4)). A persistent one standard deviation increase in natural resource income leads to a decrease in long-term income by about 16 percent. The numbers illustrate the argument that whereas in the short term natural resources may increase wealth, in the long term the economy can fall back more than it gained. This is consistent with Alaska's experience. It has vast oil reserves and fishing stocks, but it is the only region in the U.S. with a negative rate of income growth over the last two decades.

When using the natural logarithm of income per capita in 2000 as the dependent variable rather than the average growth rate over the period 1986-2000, we find the same

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[34] For our sample of 49 regions, we find an estimated convergence rate of 0.022 per year. In the final regression of Table 5.1, where we account for all explanatory variables captured in vector Z^i, we estimate a much higher rate of conditional convergence (close to 0.033). In that respect, our results contradict Barro and Sala-i-Martin' analysis, which predicts a common rate of absolute and conditional convergence. Furthermore, as expected, the estimated convergence rate for our cross-state analysis is larger than those estimated at a cross-sectional level for different countries (e.g. Barro 1991 and Barro and Sala-i-Martin 1992). At a cross-country level, the absolute convergence rate is usually close to zero and the conditional convergence rate close to 0.018. This implies that within a country, it is relatively easy for poorer regions to catch up.

evidence of a negative correlation.[35] Resource-abundant states tend to be poorer compared to their resource-scarce counterparts. Results are presented in Table 5.2. Our findings do not necessarily contradict but rather complement the findings by a number of recent studies that emphasise the positive role of resource endowments on income levels in the late 19th and early 20th centuries both across U.S. states and for the country as a whole (Mitchener and McLean 2003, Wright 1990, 2001, Wright and Czelusta 2003). Wright, in particular, (1990) associates the leading U.S. role in manufacturing at the turn of the twentieth century with technological progress and the learning potential within the American mining sector. Similarly, David and Wright (1997), Wright (2001), and Wright and Czelusta (2003) emphasise how, at the same historic period, mining promoted the establishment of prestigious educational institutions and diffused knowledge to other industrial sectors. In Chapter 6, we also argue that endowments in precious metals influenced the colonisation strategies of Europeans in the past and resulted in the institutional upgrade of resource-rich countries. It is not impossible that there has been a gradual reversal of the resource impact thereafter. Auty (2001), for instance, claims that the resource curse is a recent phenomenon of the last four decades. De Long and Williamson (1994) and Wright (2001) point out that past high transport costs for natural resources made their physical proximity essential for the introduction of new industries, technologies, and economic expansion. In a similar context, Matsuyama (1992) makes the point that natural resources are prone to become less beneficial to economic development over time as free trade and specialisation expands.

[35] The coefficient remains negative even when we do not account for initial income in 1986.

TABLE 5.1. *Growth regressions as in equation (5.1)*

Dependent variable: $G_{1986\text{-}2000}$	(5.1)	(5.2)	(5.3)	(5.4)	(5.5)	(5.6)	(5.7)
Constant	21.50	20.44	19.34	20.54	27.43	26.97	27.97
$Ln\,Y_{86}$	–1.90**	–1.77***	–1.69***	–1.83***	–2.57***	–2.53***	–2.59***
(0.19)	(0.93)	(0.64)	(0.61)	(0.62)	(0.73)	(0.69)	(0.66)
Natural Resources		–4.72**	–3.43	–2.66	–0.70	–0.34	–0.14
(0.06)		(2.38)	(2.44)	(2.46)	(2.36)	(2.31)	(2.16)
Investment			0.29***	0.26***	0.34***	0.31***	0.21**
(0.78)			(0.09)	(0.09)	(0.09)	(0.08)	(0.11)
Schooling				0.27**	0.35***	0.29*	0.34**
(0.44)				(0.13)	(0.13)	(0.16)	(0.16)
Openness					1.43**	1.17*	1.28**
(0.17)					(0.64)	(0.65)	(0.62)
R&D						0.15	0.10
(0.97)						(0.10)	(0.10)
Corruption							–0.11**
(1.65)							(0.05)
R^2 adjusted	0.22	0.33	0.40	0.41	0.46	0.48	0.52
N	49	49	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses, based on the sample *N*=49 of regression (7); robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.2. *Income levels and resource abundance*

Dependent variable: LnY_{00}	(5.8)	(5.9)
Constant	3.01	2.86
LnY_{86} (0.19)	0.73*** (0.13)	0.75*** (0.09)
Natural Resources (0.06)		–0.66** (0.33)
R^2 adjusted	0.69	0.73
N	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts ** and *** correspond to a 5 and 1% level of significance.

5.3. Conditional convergence

We now turn to the possible crowding-out effects of natural resources (Sachs and Warner 2001). Following the methodology in Chapter 4, we investigate whether resource abundance (R^i) affects economic growth (G^i) solely by crowding-out growth-related activities captured by Z^i. As we argued in Section 4.2, when this is indeed the case and the vector Z^i is sufficiently rich to fully capture most of the indirect negative effects of resource abundance on growth, we expect that its inclusion in our regressions would eliminate the negative coefficient of resource abundance on growth. As our next step, we thus extend the vector Z^i, by progressively adding variables commonly used to explain growth, such as investment, schooling, openness, R&D expenditure, and corruption, and we examine the magnitude and significance of the resource abundance coefficient α_2.

In column entry (5.3), we include the share of industrial machinery production in GDP in 1986 as a proxy for investment. Data are provided by the Bureau of Economic Analysis of the U.S. Ministry of Commerce. The variable refers to the beginning of the period 1986-2001 in order to avoid endogeneity problems. Of those investment measures available, we find industrial machinery production most likely to be favourable to economic growth (rather than constructions for instance). This is in line with recent empirical evidence on the much stronger association of equipment production with productivity growth compared to other components of investment across countries (De Long and Summers 1991, 1992, 1993, 1994, Jalilian and Odedokun 2000, and Temple 1998). Investment contributes positively and considerably to growth as expected. An increase in the investment level of one standard deviation increases growth by $0.78 \times 0.29 = 0.23$ percent. In the long term, this leads to a permanent income increase of 13 percent.[36] The coefficient for natural resources becomes smaller and less significant (the significance level falls to 17%).

In the subsequent column entry we include as independent variables, the contribution of educational services in GDP in 1986 (*Schooling*), which we consider a proxy for investment in human knowledge. Next, we include a proxy for *Openness*, for which we use the ratio of net international migration for the 1990-99 period for each state relative to the population of the state in 1990. We expect a more open economy to receive more foreigners compared to a closed economy. We observe that schooling and openness contribute positively to economic growth as expected, and when added as explanatory variables they strongly decrease the magnitude and significance of the coefficient on natural resources. In column (5.5) of Table 5.1, where we take account of the first three transmission channels (investment, schooling, and openness), the coefficient of resource abundance has been reduced by a factor seven compared to column entry (5.2) and has become totally insignificant. This suggests that a large part of the resource curse hypothesis is explained through these indirect transmission channels.

Finally, in column entries (5.6) and (5.7) we incorporate two more explanatory variables in our regression analysis. In column (5.6) we include the share of R&D expenditure in GSP for 1987 as a proxy for innovation and endogenous technological progress. In column (5.7) we include the number of prosecuted corrupt public officials over the period 1991-2000 per 100,000 citizens as a proxy of corruption in the economy. Data are provided by the Criminal Division of the United States Department of Justice. The coefficients on both variables have the expected sign. Innovation promotes growth and corruption inhibits it. The coefficient on R&D is, however, not highly significant and of small magnitude. This finding is in line with earlier work by Griliches *et al.* (1990), who argue that in accounting for labour productivity differentials between Japan and U.S. in the 1970s, the contribution of R&D has been minor. Recent research has also claimed that the contribution of R&D to U.S. productivity growth has declined substantially over time (Mairesse and Hall 1996). Similarly, in a calibrated stylised model with free entry to research and innovation embodiment, Comin (2004) finds that R&D accounts for only a tenth of total productivity growth in the U.S. in the post-war era. Yet we must keep in mind that spillover effects of R&D activities are not likely to be constrained by state boundaries. The coefficient on R&D will thus seriously underestimate the countrywide effect on growth. We come back to this in Section 5.5. Also, innovation may affect growth through some other indirect channels, such as investment, so that part of its positive effect is captured through this coefficient (their direct correlation is significant at the 5% level). We observe that the coefficient on resource abundance has approached zero in the last column entry and has become almost totally insignificant (84% insignificance level).

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[36] $0.78 \times (-0.29) / (-1.69) = 0.13$, see equation (4.4).

Overall, the sequence of regressions in Table 5.1 reveals that adding explanatory variables steadily reduces both the magnitude and significance of the coefficient on resource abundance. This leads to two conclusions. First, natural resources are not harmful to growth *per se*. They tend to frustrate economic growth mainly through indirect channels (investment, schooling, openness, innovation, and corruption). Second, the list of indirect channels is rich enough to capture all indirect effects since the remaining coefficient shows a negligible impact of resource abundance on growth insofar as this is not captured through the other variables.

5.4. Transmission Channels

In this section we further investigate the transmission channels, following the methodology set out in Section 4.3. Specifically, we estimate the impact of resource abundance on investment, schooling, openness, R&D, and corruption, and the indirect effect, thereof, on economic growth, and subsequently we calculate the relative importance of each transmission channel compared to one another.

Before turning to our empirical investigation, we briefly discuss the variables that entered the regression analysis and their probability to act as a transmission channel. In Section 4.3, we extensively commented on the crowding out effect of resource rents on investment, education, and corruption. A contraction of the manufacturing sector following a resource boom and volatility in the prices of primary commodities discourage investment to a large extent (e.g. see Sachs and Warner 1999b). Additionally, due to a higher level of non-wage income, private and public incentives to accumulate human capital are reduced in resource-affluent economies (Gylfason and Zoega 2001). Furthermore, natural resource rents entice individuals and interest groups into rent-seeking and corruption in order to gain access to them (e.g. Krueger 1974).

Another transmission channel that we consider is the impact of natural resources on the degree of openness in the economy, measured by the ratio of net immigrants during 1986-2000 to the population at the beginning of the period. We acknowledge the fact that our proxy of openness is not obvious. A better measure might have been the amount of exports and imports in GSP for each region, but this measure is not available. Economies that are open to trade tend also to be open in terms of accepting immigrants: a well-known example is the Netherlands during their Golden Age; Markusen (1983) and Schmitz and Helmberger (1970) argue that relaxing the unrealistic assumptions of identical technologies and production functions amongst trading partners in a Heckscher-Ohlin type of model gives rise to complementarity between trade in goods and factor mobility. More recently, Ethier (1985) and Rodrik (1997, ch.2) claimed that open economies have a more elastic labour demand and therefore are more eager to accept immigrants. This theme has also been examined empirically in the recent pioneering work by Collins et al. (1999), Kohli (1999), and Mundra (2005), who provide through data analysis support to a strong complementarity between trade openness and labour mobility (immigration).

Our data show that resource abundance is indeed negatively correlated with the degree of openness for our sample of U.S. regions. We recognise that the mechanisms that link resource abundance to openness must be different for the state level when compared to the country level. At a state level, resource abundance cannot lead to a raise in trade tariffs or to import quotas; a relation that is often found in cross-country analyses (Auty 1994, Sachs and Warner 1995). There is also no overvaluation of the local currency (Sachs and Warner 1995, Torvik 2001, Gylfason 2000, 2001a, 2001b, Rodriguez and Sachs 1999). Resource abundance may harm, however, the openness of regional economies within a country in a different manner. Resource-dependent sectors often suffer from uncertainty due to the high volatility of prices of primary commodities (following a negative trend over time, see Cashin *et al*. 2002). In order to protect regional employees working in these sectors, local governments may transfer funds to their support (or exert pressure to the central government to do so). If these funds were utilised for alternative purposes, this could create a temporary loss of jobs for the regional population (and voters). Local trade unions from the resource-based sectors may deter the development of an institutional and regulatory environment that fosters competition. If resource abundance is also related to rent-seeking and corruption, as it is often mentioned in the literature (Gray and Kaufmann 1998, Ascher 1999, Leite and Weidmann 1999, Gylfason 2001), then a climate of shirking and opportunism may increase the potential hazards of trade (North 1991). In the literature, people in the coal-rich Appalachia region (Virginia, West Virginia, and Kentucky) are described as being relatively antagonistic towards the government and foreigners (Santopietro 2002, Hansen 1966). Essentially, the arguments show a similarity between regional and national governments; both have an increased incentive to protect the perceived interests of domestic people when natural resource income grows.

Another mechanism through which natural resources may affect openness is through labour opportunities. In the past, resource-affluent U.S. regions have witnessed increased immigration, as exemplified by the gold rush experience in California (Mitchener and McLean 2003). In an era where manufacturing and services were not sufficiently developed to provide large employment opportunities to a work force characterised by large unemployment and a need to achieve some minimal living standards, workers fled to resource-dependent sectors. More recently, the primary sector with its dependence on volatile resource prices does not provide extra employment opportunities. On the contrary, we used data on unemployment rates across states in 1986 (from the Bureau of Labour Statistics of the U.S. Department of Labour) to confirm that indeed resource-dependent states tend to suffer from increased unemployment (correlation at the 1% level of significance).

As a next transmission channel we consider the effect of resource abundance on innovation (R&D). This linkage receives less attention in the "Dutch disease" literature, but our data unambiguously point to a link between natural resource abundance and R&D expenditures. Sachs and Warner (2001) suggest that resource abundance may crowd out entrepreneurial activity and innovation by encouraging potential innovators and entrepreneurs to engage in the primary sector. To the extent that entrepreneurial talent is limited, the crowding-out effect of innovation can be potentially large. Furthermore, as Murphy *et al.* (1991) point out, when talented individuals start firms, they innovate and foster growth. When they become rent seekers, they only redistribute wealth and reduce economic growth. In countries where rent-seeking activities give higher rewards to talent than entrepreneurship, innovation is likely to be crowded-out and the economy stagnates.

Now we turn to the data. Our basis specification of the dependence of the variables Z^i on resource income is given by:

$$Z^i = \beta_0 + \beta_1 R^i + \mu^i, \tag{5.2}$$

where Z^i, β_0, β_1, and μ^i are specified for investment, schooling, openness, R&D, and corruption. Table 5.3 lists the results for the estimated equation (5.2). Our results indicate that resource abundance leads to lower investment, schooling, openness, R&D expenditure, and higher levels of corruption. All coefficients are consistent with the negative correlation between resource abundance and economic performance. The schooling variable has the most significant relation to natural resource abundance at the 1% level, and resource abundance alone accounts for 17% of the variation in educational quality across different states. Interestingly, we also find a strongly significant coefficient on R&D, and natural resources by themselves explain more than 11% of variation in R&D expenditures. On the other hand, the corruption channel seems to be relatively weak, since it is only significant at the 10% level.

TABLE 5.3. *Indirect transmission channels as in equation (5.2)*

	Investment (5.10)	Schooling (5.11)	Openness (5.12)	R&D (5.13)	Corruption (5.14)
Constant	1.23	0.86	0.22	1.50	2.70
Natural Resources	–4.45***	–3.32***	–0.75***	–6.16***	5.96*
(0.06)	(1.14)	(0.76)	(0.30)	(1.62)	(3.57)
R^2 adjusted	0.09	0.17	0.04	0.11	0.02
N	49	49	49	49	49

Note: robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

To test the robustness of our results we use an alternative specification for the transmission channels by incorporating initial income, $\ln(Y_0^i)$, in equation (5.2). The specification describing the transmission variables becomes:

$$Z^i = \gamma_0 + \gamma_1 \ln(Y_0^i) + \gamma_2 R^i + \sigma^i. \quad (5.3)$$

Estimations of equation (5.3) for all five transmission channels are provided in Appendix 5.3. Two findings stand out. First, the coefficient for initial income is insignificant in all transmission channels except for the openness channel, and second, the coefficients for natural resource abundance remain almost unchanged. From this, we conclude that income is not a major determinant for most of the variables captured by the vector Z^i, and this reduces the probability of endogeneity for the same set of variables. It is more likely that the variables captured in the vector Z^i affect income levels rather than the other way round. We choose equation (5.2) as the basis for our further analysis.

Since openness, however, appears to depend on income levels, we test an alternative specification adopting a measurement of openness based on 1990 data (*Openness90*) as an instrument for our index of *Openness* over the whole period. The two measures are strongly correlated at the 95% level and the instrumental variable is uncorrelated with the error term ε^i of equation (5.1). In Appendix 5.4, we present a two-stage least-squares (2SLS) estimation of equation (5.1) including all explanatory variables and treating average *Openness* as endogenous. Panel A reports the 2SLS estimates of the coefficients on all growth-determining variables and Panel B gives the corresponding first stages. We find no major qualitative differences as compared to our previous results (reported in Table 5.1) but significance drops for most coefficients.

As resource abundance explains part of the variation in investment and other variables, by substitution of equation (5.2) into (5.1) we calculate the overall (direct and indirect) impact of natural resources on growth:

$$G^i = (\alpha_0 + \alpha_3\beta_0) + \alpha_1 \ln(Y_0^i) + (\alpha_2 + \alpha_3\beta_1)R^i + \alpha_3\mu^i + \varepsilon^i, \quad (5.4)$$

where $\alpha_2 R^i$ denotes the direct effect of natural resources on growth, $\alpha_3\beta_1 R^i$ indicates the indirect effect of natural resource abundance on growth,[37] and μ^i are the residuals of (5.2). The estimated values for the coefficients α_1, $\alpha_2+\alpha_3\beta_1$, and α_3 of equation (5.4) are listed in column (5.15) of Table 5.4. Alternatively, we adopt the specification provided by equation (5.3) for the openness channel (since openness is the only variable where initial income appears to be a significant factor) and maintain the transmission specification of equation (5.2) for the remaining variables. Results are provided in column (5.16) of Table 5.4. Finally, the last column of the table presents estimations when we substitute equation (5.3) into (5.1),

[37] Note that $\alpha_3\beta_1$ is an inproduct of two vectors of five elements.

in order to account for the possible impact of initial income on all transmission variables. Comparing the results presented in Table 5.4 reveals that the coefficient on initial income in equation (5.4) is likely to be slightly overestimated, when initial income is excluded as an explanatory factor for the various transmission variables. Additionally, the coefficient on natural resources is likely to be slightly underestimated, though the difference is small. Qualitatively, the conclusions derived from the second regression in Table 5.1 on the relative importance of initial income and natural resource abundance are consistent with the results of Table 5.4.

TABLE 5.4. *Growth regression, including indirect effects as in equation (5.4)*

Dependent variable: $G_{1986\text{-}2000}$	(5.15)	(5.16)	(5.17)
Constant	28.66	22.20	20.44
Ln Y_{86}	–2.59***	–1.94***	–1.77***
(0.19)	(0.66)	(0.50)	(0.47)
Natural Resources	–4.46**	–4.66**	–4.72**
(0.06)	(1.94)	(1.95)	(1.95)
Investment (μ_1; μ_1; σ_1)	0.21**	0.21**	0.21**
(0.74)	(0.11)	(0.11)	(0.11)
Schooling (μ_2; μ_2; σ_2)	0.34**	0.34**	0.34**
(0.40)	(0.16)	(0.16)	(0.16)
Openness (μ_3; σ_3; σ_3)	1.28**	1.28**	1.28**
(0.17)	(0.62)	(0.62)	(0.62)
R&D (μ_4; μ_4; σ_4)	0.10	0.10	0.10
(0.90)	(0.10)	(0.10)	(0.10)
Corruption (μ_5; μ_5; σ_5)	–0.11**	–0.11**	–0.11**
(1.62)	(0.05)	(0.05)	(0.05)
R^2 adjusted	0.52	0.52	0.52
N	49	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. The parentheses next to the variable names represent the sequence of residuals used in each regression. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

As in chapter 4, we quantify the relative importance of each transmission channel in explaining the overall negative impact of natural resources on economic growth. The direct effect is given by α_2 and the indirect effect by $\alpha_3\beta_1$, as can be seen from equation (5.4). Results are listed in Table 5.5.[38] Consistent with the drop in size and significance of the natural resource coefficient in Table 5.1, the largest part of the resource curse can be attributed to the indirect channels.

TABLE 5.5. *Relative importance of transmission channels as in equation (5.4)*

Transmission channels	α_3 (Table 5.1)	β_1 (Table 5.3)	Contribution to $\alpha_2+\alpha_3\beta_1$	Relative Contribution
Natural Resources			–0.14	3%
Investment	0.21	–4.45	–0.93	21%
Schooling	0.34	–3.32	–1.13	25%
Openness	1.28	–0.75	–0.96	22%
R&D	0.10	–6.16	–0.62	14%
Corruption	–0.11	5.96	–0.66	15%
Total			**–4.46**	**100%**

The knowledge-based channels of schooling and R&D appear to be the most important transmission mechanisms, accounting for almost 40% of the negative impact of resource abundance on growth for the U.S. states. This is a somewhat remarkable result, given the fact that resource affluence supported the establishment of prestigious educational institutions in the U.S. in the past and given the technological expansion in the field of oil drilling and exploration more recently in Norway (Wright 2001). It suggests that the crowding-out effect of natural resources on education is indeed related to policy failures rather than the resources themselves (e.g. Gylfason 2001a, p.851).

5.5. The Role of R&D

The insignificant correlation between GSP growth and innovation in Table 5.1 is somehow puzzling, since the rise in productivity growth after the mid 1990s is attributed to a large extent to technological improvements. For that reason, we substitute our innovation proxy (*R&D*) with a new variable taking account of regional spillovers. The new innovation variable we construct is an equally weighted sum of each region's share of R&D expenditure in GSP

[38] We also calculate the relative importance of each transmission channel for the alternative transmission specifications provided by equation (5.3). Appendix 5.5 lists the results. As illustrated in Tables 5.38 and 5.39, a slightly larger role for the openness channel is found when initial income is accounted for in the transmission specifications.

for 1987 and the average share of all neighbouring states, meaning $Innovation_i = \frac{1}{2} R\&D_i + \frac{1}{2}\left[\sum_{j=0}^{n}(R\&D_j)\right]/n$, where i represents the state of interest and n the number of neighbouring states. We keep in mind that this is an imperfect approximation of the regional R&D spillovers between the U.S. states. We assume an equal role for all neighbouring states in generating regional externalities to simplify the analysis. Alternatively, different weights could be applied for regional spillovers and domestic R&D. As seen in Table 5.6, innovation now becomes significant at the 10% level, implying that regional R&D spillovers tend to be important. The significance for the rest of the coefficients, however, decreases in general. An increase in innovation of one standard deviation increases growth by 0.25%, an effect twice as large as when compared with the innovation variable abstracting from regional spillovers. The new innovation proxy remains strongly and negatively correlated with natural resources (Table 5.7). When we reproduce Table 5.5 using the new innovation proxy, innovation becomes the most important transmission mechanism. The knowledge-based channels of schooling and innovation jointly rise in terms of explaining the resource curse to 53% (Table 5.8).

TABLE 5.6. *Growth regression as in equation (5.1) with R&D spillovers*

Dependent variable: $G_{1986\text{-}2000}$	(5.18)
Constant	27.17
$Ln Y_{86}$ (0.15)	–2.53*** (0.63)
Nat (0.06)	0.20 (2.05)
Investment (1.01)	0.20* (0.10)
Schooling (0.38)	0.27 (0.18)
Openness (0.09)	1.13** (0.58)
Innovation (0.60)	0.31* (0.17)
Corruption (1.34)	–0.09* (0.05)
R^2 adjusted	0.55
N	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.7. *Indirect transmission channel as in equation (5.2): Innovation*

	Innovation (5.19)
Constant	1.44
Natural Resources (0.06)	–4.82*** (1.22)
R^2 adjusted	0.19
N	49

Note: robust standard error for coefficients in parenthesis. Superscript ** corresponds to a 5 level of significance.

TABLE 5.8. *Relative importance of transmission channels as in equation (5.2) with regional R&D spillovers (Innovation)*

Transmission channels	α_3 (Table 5.6)	β_1 (Tables 5.3 and 5.7)	Contribution to $\alpha_2+\alpha_3\beta_1$	Relative Contribution
Natural Resources			0.20	–4%
Investment	0.20	–4.45	–0.89	20%
Schooling	0.27	–3.32	–0.90	20%
Openness	1.13	–0.75	–0.85	19%
Innovation	0.31	–4.82	–1.50	33%
Corruption	–0.09	5.96	–0.54	12%
Total			**–4.48**	**100%**

Our results in Tables 5.6–5.8 provide strong support to our findings in Chapter 3 on the contractionary effect of resource rents on innovation and thereof on growth. Our findings suggest that resource-rich U.S. states underinvest in R&D activities and do not sufficiently encourage their talented individuals to make full use of their potential. It is apparent that education and innovation are the most important reasons for the disappointing performance of resource-affluent U.S. states, accounting for the largest part of the negative association between resources and growth. Furthermore, our findings provide evidence that the role of R&D activities may not be confined within state borders but is likely to diffuse across neighbouring regions. This enhances the overall impact of innovation on the growth process of our U.S.-state sample.

5.6. Some Examples

Modifying the structural representation of equation (5.4) can further our understanding of the growth experience of particular states. Equation (5.5) attributes growth differences relative to the average growth rate (2.47%) to differences in resource abundance, investment, schooling and openness (the portion of them not explained by natural resources) from their mean values.

$$G^{i} - G^{a} = \alpha_1[\ln(Y_0)^{i} - \ln(Y_0)^{a}] + (\alpha_2 + \alpha_3\beta_1)(R^{i} - R^{a}) + \alpha_3\mu^{i} + \varepsilon^{i}, \qquad (5.5)$$

where the *i* superscript represents a single state, the *a* superscript represents the average state, μ are the residuals of equation (4.5) (which are basically the part of all explanatory variables *Z* not explained by resource abundance *R*) and ε is the error term of equation (5.4). In this way we can interpret relatively high and low growth rates over the 1986-2000 period in terms of each explanatory factor and an unexplained residual ε. To put it in other words, we can see whether a high or low growth level is due to convergence, resource abundance (including the indirect effect through the transmission channels), other explanatory variables (whose influence is captured by the vector μ^i), or finally some unexplained factors (namely the error term ε^{i}).

Making use of specification (5.5), Table 5.9 displays the divergent growth experience of U.S. states. We briefly comment on a few cases of resource-dependent states.[39] As can be seen, Alaska and Louisiana experienced disappointingly low growth rates over the period. The large contribution of the resource-abundant factor (third row entries) identifies them as typical examples of the resource curse. The direct and indirect effects of resource abundance on growth explain almost half of the negative growth differential for Louisiana, and one quarter of the negative growth differential for Alaska. On the other hand, New Mexico and Texas experienced above-average growth rates, despite the presence of an extensive resource base in their economies. Other things being equal, New Mexico and Texas would have experienced growth rates of –0.25 and –0.19 percentage points below the average, respectively, due to their resource abundance. New Mexico's remarkable growth performance is attributed mostly to convergence and the R&D sector (apart from the unexplained residuals).[40] Texas seems to have benefited from its openness.[41] The two last examples give substance to the argument that the natural resource curse is by no means an iron law.

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[39] We select states with a relatively large contribution of natural resources and small residual, that is, where the model has good predictive power.

[40] New Mexico is outdoing most U.S. states in terms of R&D expenditure in GSP and per capita (Fossum et al. 2000, American Association for the Advancement of Science (AAAS) 2002). Much of this research is undertaken within the minerals sector (e.g. at the Petroleum Recovery Research Center and the New Mexico Bureau of Mines and Mineral Resources) and natural resources in general (e.g. at the Center for Global Environmental Technologies and the Albuquerque Forestry Sciences Laboratory). This is indicative of the knowledge-intensive character of New Mexico's primary sector.

[41] Texas was, for instance, the first state in 2001 to enact legislation allowing undocumented aliens to attend taxpayer supported colleges and universities at in-state tuition fees.

TABLE 5.9. *Growth differentials from the average value among U.S. regions*

U.S. State		$G^i - G^a$	α_1* [$\ln(Y_0)^i - \ln(Y_0)^a$]	($\alpha_2 + \alpha_3\beta_1$)* ($R^i - R^a$)	$\alpha_3\mu^i$ - investment	$\alpha_3\mu^i$ - schooling	$\alpha_3\mu^i$ - openness	$\alpha_3\mu^i$ - R&D	$\alpha_3\mu^i$ - corruption	ε^i (error term)
ALABAMA	AL	–0.21	0.48	0.10	–0.05	–0.11	–0.21	0.07	–0.01	–0.48
ALASKA	AK	–3.33	–1.74	–0.85	–0.03	0.04	0.16	0.01	–0.12	–0.80
ARIZONA	AZ	0.17	0.09	0.11	0.00	–0.14	0.11	–0.02	0.08	–0.06
ARKANSAS	AR	0.30	0.71	–0.02	0.03	–0.12	–0.17	–0.08	0.13	–0.18
CALIFORNIA	CA	–0.25	–0.57	0.11	–0.06	–0.06	0.72	0.11	–0.04	–0.47
COLORADO	CO	0.69	–0.25	0.07	–0.06	–0.10	0.01	0.02	0.26	0.74
CONNECTICUT	CT	0.30	–0.83	0.20	0.06	0.12	0.01	0.07	0.06	0.60
FLORIDA	FL	–0.49	0.06	0.12	–0.15	–0.09	0.37	–0.05	–0.29	–0.46
GEORGIA	GA	0.26	–0.17	0.14	–0.14	–0.08	–0.05	–0.07	–0.10	0.73
HAWAAI	HI	–1.40	–0.57	0.15	–0.24	–0.02	0.36	–0.11	–0.13	–0.84
IDAHO	ID	1.45	0.71	–0.15	0.07	–0.03	0.03	0.18	–0.04	0.69
ILLINOIS	IL	0.18	–0.29	0.15	0.10	0.01	0.16	0.00	–0.29	0.32
INDIANA	IN	0.43	0.24	0.13	0.10	–0.04	–0.19	0.03	0.11	0.05
IOWA	IA	0.49	0.31	–0.14	0.39	0.07	–0.10	–0.04	0.22	–0.21
KANSAS	KS	–0.42	–0.01	–0.04	–0.05	–0.10	–0.08	–0.03	0.16	–0.27
KENTUCKY	KY	0.33	0.47	0.00	0.06	–0.08	–0.18	–0.08	–0.14	0.28
LOUISIANNA	LA	–1.21	–0.06	–0.57	–0.05	0.11	–0.03	–0.02	–0.29	–0.30
MAINE	ME	–0.65	0.23	0.09	–0.16	0.01	–0.21	–0.11	–0.07	–0.42
MARYLAND	MD	–0.73	–0.38	0.19	–0.17	0.01	0.08	–0.03	0.07	–0.50
MASSACHUSETTS	MA	0.52	–0.63	0.20	0.14	0.49	0.04	0.17	0.03	0.09
MICHIGAN	MI	–0.51	–0.12	0.16	0.14	–0.14	–0.13	0.19	0.12	–0.72
MINNESSOTA	MN	0.35	–0.24	0.05	0.32	–0.02	–0.08	0.08	0.20	0.04
MISSISSIPPI	MS	0.11	0.91	0.01	–0.06	–0.09	–0.20	–0.11	–0.49	0.14
MISSOURI	MO	–0.30	–0.02	0.13	–0.10	0.05	–0.16	0.03	–0.09	–0.14
MONTANA	MT	–0.74	0.55	–0.22	–0.15	–0.04	–0.14	–0.08	–0.05	–0.61

Note: Coefficients α_1, ($\alpha_2 + \alpha_3\beta_1$) and α_3's as in regression (13) of Table 3. Average values G^a, $\ln(Y_0)^a$, and R^a are equal to 2.47, 10.02, and 0.05 respectively.

TABLE 5.9 cntd. *Growth differentials from the average value among U.S. regions*

U.S. State		$G^i - G^a$	α_1* $[\ln(Y_0)^i - \ln(Y_0)^a]$	$(\alpha_2 + \alpha_3\beta_1)$* $(R^i - R^a)$	$\alpha_3\mu^i$ - investment	$\alpha_3\mu^i$ - schooling	$\alpha_3\mu^i$ - openness	$\alpha_3\mu^i$ - R&D	$\alpha_3\mu^i$ - corruption	ε^i (error term)
NEBRASKA	NE	0.36	0.10	–0.14	0.01	0.03	–0.08	–0.08	0.27	0.26
NEVADA	NV	–0.45	–0.57	0.09	–0.15	–0.21	0.33	–0.11	0.00	0.17
NEW HAMPSHIRE	NH	0.95	–0.15	0.19	0.47	0.18	–0.19	–0.11	0.21	0.34
NEW JERSEY	NJ	0.26	–0.60	0.21	–0.11	–0.07	0.35	0.13	–0.08	0.45
NEW MEXICO	NM	0.92	0.42	–0.25	–0.12	–0.06	0.14	0.26	0.15	0.38
NEW YORK	NY	0.02	–0.75	0.21	–0.09	0.17	0.51	–0.03	–0.22	0.23
NORTH CAROLINA	NC	0.33	–0.02	0.13	0.09	0.03	–0.15	–0.02	0.11	0.15
NORTH DAKOTA	ND	0.03	0.39	–0.01	–0.11	–0.10	–0.12	–0.07	–0.39	0.44
OHIO	OH	–0.14	–0.01	0.16	0.13	–0.04	–0.20	0.00	–0.19	0.01
OKLAHOMA	OK	–0.69	0.34	–0.27	0.10	–0.03	–0.06	–0.02	0.07	–0.82
OREGON	OR	1.43	0.19	0.07	–0.09	–0.07	0.05	–0.08	0.24	1.12
PENNSYLVANIA	PA	0.13	0.08	0.16	–0.02	0.24	–0.14	0.03	–0.07	–0.16
RHODE ISLAND	RI	0.26	–0.07	0.16	–0.12	0.32	–0.06	–0.04	–0.01	0.07
SOUTH CAROLINA	SC	0.14	0.44	0.17	0.00	–0.12	–0.20	–0.06	–0.07	–0.01
SOUTH DAKOTA	SD	0.63	0.32	–0.29	–0.03	0.04	–0.08	–0.07	–0.15	0.89
TENNESSEE	TN	0.21	0.19	0.15	0.00	–0.05	–0.19	–0.08	–0.07	0.25
TEXAS	TX	0.16	–0.13	–0.19	0.00	–0.03	0.34	0.01	0.08	0.08
UTAH	UT	0.54	0.37	0.05	0.13	0.13	–0.02	0.12	0.24	–0.47
VERMONT	VT	0.22	0.27	0.09	–0.07	0.30	–0.14	0.09	0.08	–0.41
VIRGINIA	VA	–0.46	–0.37	0.17	–0.19	–0.12	0.03	–0.06	–0.12	0.20
WASHINGTON	WA	0.06	–0.25	0.09	–0.14	–0.11	0.13	0.14	0.13	0.08
WEST VIRGINIA	WV	–0.10	0.92	–0.07	–0.11	–0.10	–0.19	–0.08	0.07	–0.54
WISCONSIN	WI	0.24	0.12	0.06	0.43	–0.03	–0.18	–0.01	0.31	–0.45
WYOMING	WY	–0.29	–0.45	–0.98	0.02	0.06	0.04	0.02	0.11	0.89

5.7. Conclusions

A number of recent studies argue that resource-affluent economies underperform in a series of economic fundamentals; they tend to underinvest in education and infrastructure; they suffer from rent seeking and corruption; they fail to diversify their economies; and neglect the necessity to constrain government ineffectiveness. As a consequence, many resource-rich countries suffer from crushing poverty and long-term stagnation. The natural resource curse, as described above, is often seen as a problem of developing countries that waste their wealth instead of managing it efficiently. In this chapter, we examined whether such phenomena are restricted to the international arena, or also hold across regions within the highly developed U.S. This is of particular interest, since resource endowments also supported the 19th and 20th century industrialisation process throughout the United States. We used U.S. state-level data to show that resource-scarce states tend to have a comparative advantage in development compared to resource-abundant states. The main mechanisms responsible for economic underperformance among resource-abundant countries are also found across resource-rich regions. We do not suggest that there runs a necessary causality from resource abundance to lower growth. New Mexico and Texas show that prudent economic policies and cautious planning can reverse the pattern for individual cases.

Our findings are important for two reasons. First, they challenge the common hypothesis that regions within a country converge to the same steady-state income level. There may be a substantial and persistent divergence between regions that deserves its own analysis. Second, it demonstrates that even in a relatively homogeneous sample, resource abundance can have a substantial negative impact through affecting various economic fundamentals such as investment levels, schooling rates, innovation, and openness. A better understanding of the indirect resource curse mechanisms is essential for adopting policy measures that can prevent the negative impact of natural resources on economic growth. The natural resource curse is not a problem of countries with weak institutions, but it is potentially a common threat to both developing and developed economies.

Empirical analysis at a regional level often suffers from data limitations, since data are often unavailable for extensive periods or at a disaggregated level. We expect future progress on data availability to contribute substantially to the investigation of regional economic growth and its determinants. Such an extension could also help us to test the hypothesis of a reversal of the resource impact on economic development over the past century. Furthermore, it would be of particular interest to investigate whether similar results can be obtained when examining the resource curse and its explanations within regions of a developing country.

APPENDIX 5.1: ROBUSTNESS CHECKS

(i). Alternative Specifications

We run a series of alternative specifications to check whether our results are robust. We estimated all regressions using the Bounded Influence Estimation technique, as analysed in Welsch (1980) and Krasker and Welsch (1982), which attaches smaller weights to observations with large residuals. The main results of our analysis remain the same, as can be seen in Tables 5.10 and 5.11. We also replicated the growth specifications by Benhabib and Spiegel (1997, 2000), discerning growth determinants into "primitives" and "ancillary" variables. We included as "primitives" the average value of our investment measurement over the whole 1986-2000 period and the average annual growth of the percentage of people (25 years old and over) that hold an advanced degree (master's, doctorate or professional) between 1990 and 2000 (data on advanced degree holders are provided by the U.S. Census Bureau (2003) from the 1990 Census of Population) as proxies for investment in physical and human capital respectively. Table 5.12 presents estimations of the Benhabib and Spiegel neoclassical growth specification. Following Benhabib and Spiegel (1997, 2000), we included in regressions (5.28)-(5.30) as ancillary variables a measure of *inequality* (the Gini coefficient in 1989, provided by the U.S. Census Bureau (2003)), a measure of *financial depth* (the value of total assets held by commercial banks with respect to GSP in 1986, provided by the U.S. Federal Deposit Insurance Corporation)[42] and interactive terms between financial depth, initial income and inequality. The ancillary variables perform poorly and the proxy for investment in human capital remains mostly insignificant. Our proxy for inequality is insignificant and of the wrong sign, as in Benhabib and Spiegel (1997, 2000). In column (5.31), we keep the primitive variables (*Inv HC*, *Inv PC*) and also include initial income ($Ln Y_{86}$), *Openness*, *Schooling*, *R&D*, and *Corruption* as in our main growth specification (regression (5.7) of Table 5.1). The coefficient on natural resources is now positive (reinforcing our argument that the resource curse takes place solely through indirect mechanisms). Since human capital accumulation (*Inv HC*) is insignificant and the two variables capturing physical and human capital accumulation are likely to be dependent on the growth rate over the same period, we treat these results with caution. Table 5.13 presents regression results based on the "reduced" specification, as in Benhabib and Spiegel (1997), where the level of human capital (rather than its accumulation) and initial income ($Ln Y_{86}$) enter the regressions in order to capture endogenous features and convergence. Finally, Table 5.14 presents results based on the

[42] The same measurement has been used as a proxy of financial depth by Abrams *et al*. (1999).

structured growth specification, as in Benhabib and Spiegel (1997, 2000), where a catch-up term (*BS-Catch-up*) calculated as *Schooling x* (Y_{max}/Y_{86}) replaces initial income ($Ln Y_{86}$) in the regression analysis. In regression (5.40) of Table 5.14, we incorporate all variables appearing in regression (5.7) of Table 5.1 apart from initial income ($Ln Y_{86}$), which is replaced by the Benhabib and Spiegel catch-up term. Although the Benhabib and Spiegel catch-up variable enters significantly, it does not perform as well as initial income as a convergence term.

TABLE 5.10. *Growth regressions as in equation (5.1) (Bounded Influence Estimation)*

Dependent variable: $G_{1986\text{-}2000}$	(5.20)	(5.21)
Constant	13.44	20.92
LnY_{86} (0.19)	–1.07** (0.51)	–1.89*** (0.54)
Natural Resources (0.06)	–3.66** (2.05)	–0.94 (1.68)
Investment (0.78)		0.26*** (0.10)
Schooling (0.44)		0.22 (0.17)
Openness (0.17)		1.04* (0.56)
R&D (0.97)		0.11 (0.08)
Corruption (1.65)		–0.07* (0.04)
R^2 adjusted	0.08	0.39
N	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.11. *Indirect transmission channels, as in equation (5.2) (Bounded Influence Estimation)*

	Investment (5.22)	Schooling (5.23)	Openness (5.24)	R&D (5.25)	Corruption (5.26)
Constant	1.18	0.82	0.21	1.48	2.71
Natural Resources (0.06)	–4.25** (1.75)	–3.05*** (0.95)	–0.72* (0.41)	–6.58*** (2.23)	4.74 (4.64)
R^2 adjusted	0.09	0.16	0.04	0.14	0.01
N	49	49	49	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.12. *Growth regressions (Neoclassical specification)*

Dependent variable: $G_{1986\text{-}2000}$	(5.27)	(5.28)	(5.29)	(5.30)	(5.31)
Constant	1.47	3.01	1.22	1.35	26.41
Natural Resources	–2.75	–2.86	–2.53	–3.40	0.93
(0.06)	(2.52)	(2.47)	(2.40)	(2.40)	(2.12)
Inv PK	0.19***	0.18**	0.17***	0.15**	0.15**
(1.22)	(0.07)	(0.07)	(0.06)	(0.07)	(0.07)
Inv HC	3.48*	3.10	3.62*	3.12	2.49
(0.05)	(2.04)	(1.99)	(2.07)	(1.92)	(1.67)
Inequality		–3.01			
(0.02)		(3.61)			
Financial Depth			0.38	16.59**	
(0.29)			(0.23)	(7.44)	
Financial Depth x Inequality				1.24	
(0.12)				(3.96)	
Financial Depth x LnY_{86}				–1.66**	
(2.88)				(0.82)	
LnY_{86}					–2.51***
(0.25)					(0.59)
Openness					1.60**
(0.17)					(0.69)
Schooling					0.33**
(0.44)					(0.15)
R&D					0.09
(0.97)					(0.10)
Corruption					–0.11**
(1.65)					(0.05)
R^2 adjusted	0.28	0.27	0.28	0.32	0.55
N	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.13. *Growth regressions (Reduced specification)*

Dependent variable: $G_{1986\text{-}2000}$	(5.32)	(5.33)	(5.34)	(5.35)
Constant	19.70	21.42	19.28	41.00
Ln Y_{86} (0.25)	–1.75*** (0.62)	–1.73*** (0.60)	–1.72*** (0.61)	–3.86*** (1.25)
Natural Resources (0.06)	–2.90 (2.48)	–2.96 (2.23)	–2.94 (2.45)	–1.66 (2.00)
Inv PK (1.22)	0.15** (0.06)	0.13* (0.07)	0.15** (0.06)	0.13* (0.07)
Schooling (0.44)	0.29** (0.14)	0.26* (0.14)	0.25** (0.14)	0.12** (0.15)
Inequality (0.02)		–4.40 (3.63)		
Financial Depth (0.29)			0.24 (0.16)	–36.63** (16.41)
Financial Depth x Inequality (0.12)				–12.92** (5.76)
Financial Depth x Ln Y_{86} (2.88)				4.21** (1.82)
R^2 adjusted	0.40	0.40	0.40	0.43
N	49	49	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.14. *Growth regressions (Structured specification)*

Dependent variable: $G_{1986\text{-}2000}$	(5.36)	(5.37)	(5.38)	(5.39)	(5.40)
Constant	2.18	3.69	2.01	2.03	2.23
BS-Catch-up	0.78**	0.71**	0.82**	0.01	1.00*
(0.36)	(0.39)	(0.40)	(0.41)	(0.34)	(0.51)
Natural Resources	–4.01	–4.03	–4.05	–4.21	–2.65
(0.06)	(3.38)	(3.23)	(3.33)	(3.39)	(3.28)
Inv PK	0.19***	0.17**	0.17***	0.15**	0.16**
(1.22)	(0.07)	(0.07)	(0.06)	(0.07)	(0.07)
Schooling	–1.25*	–1.15	–1.39*	0.18	–1.67*
(0.44)	(0.73)	(0.74)	(0.80)	(0.68)	(0.91)
Inequality		–3.41			
(0.02)		(4.03)			
Financial Depth			0.39*	20.03*	
(0.29)			(0.24)	(10.82)	
Financial Depth x Inequality				0.50	
(0.12)				(4.33)	
Financial Depth x $Ln Y_{86}$				–1.98*	
(2.88)				(1.16)	
Openness					0.40
(0.17)					(0.59)
R&D					0.13
(0.97)					(0.14)
Corruption					–0.10*
(1.65)					(0.06)
R^2 adjusted	0.26	0.26	0.27	0.27	0.32
N	49	49	49	49	49

Note: *BS-Catch-up* calculated as *Schooling* * (Y_{max}/Y_{86}) according to Benhabib and Spiegel (1997, 2000) Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

(ii). Data sample and control variables

We focus our analysis on the 49 states for which data are available for all variables of interest. Since there is a lack of data on R&D expenditures for the District of Columbia and Delaware, we exclude these states from the first regressions in order to avoid a sample bias when comparing coefficients. To check qualitatively our results, we repeat the (first five) regressions of Table 5.1 for the whole sample of 51 states in Table 5.15.

TABLE 5.15. *Growth regressions as in equation (5.1) for all 51 states*

Dependent variable: $G_{1986\text{-}2000}$	(5.41)	(5.42)	(5.43)	(5.44)	(5.45)
Constant	12.47	13.13	11.15	14.77	17.74
$Ln\,Y_{86}$	–1.00	–1.03*	–0.87**	–1.26**	–1.58**
(0.25)	(0.79)	(0.61)	(0.64)	(0.58)	(0.71)
Natural Resources		–5.28*	–4.29	–2.93	–1.94
(0.06)		(2.84)	(2.98)	(2.69)	(2.57)
Investment			0.25***	0.20**	0.24***
(0.78)			(0.09)	(0.09)	(0.09)
Schooling				0.43**	0.48***
(0.50)				(0.18)	(0.19)
Openness					0.83
(0.17)					(0.61)
R^2 adjusted	0.10	0.25	0.30	0.34	0.35
N	51	51	51	51	51

Note: Standard deviations for independent variables in parentheses, based on the sample N=51; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

Furthermore, we incorporated a vector of geographical variables in our estimations. When we included three regional dummy variables (south, midwest and west) as in Barro and Sala-i-Martin (1992), in most cases they were insignificant and unstable in sign when included in Table 5.1.[43] Additionally, it is of interest to investigate whether geographical control variables such as access to oceans or navigable rivers, latitude, and distance to the US capital have any impact on our findings. We incorporated in all regressions (see Tables 5.16 and 5.19) a variable measuring the *Latitude* of each state capital as well as a dummy variable measuring

[43] We also checked for spatial correlation of the error terms in our growth and transmission channel specifications, but we did not find any substantial evidence of it.

access to ocean, navigable rivers or the Great lakes (*Access to Water*).[44] Therefore, our growth and transmission channels specifications become:

$$G^i = \alpha_0 + \alpha_1 \ln(Y_0^i) + \alpha_2 R^i + \alpha_3 Z^i + \alpha_4 Geo^i + \chi^i, \tag{5.6}$$

$$Z^i = \beta_0 + \delta_1 R^i + \delta_2 Geo^i + \xi^i, \tag{5.7}$$

where *Geo* is a vector of geographical regressors. We do not find that access to a coast or a navigable waterway provides a growth advantage. Neither do we find latitude and thus more temperate climates to contribute significantly to economic growth. The coefficients on resource abundance in all transmission mechanisms remain rather stable in magnitude and significance. We still find education to be the most important transmission mechanism, although the overall explanatory power of the channels decreases (not shown here). Furthermore, in Tables 5.17, 5.18, 5.20, and 5.21 we additionally incorporate two variables measuring *Longitude* and distance from the nation's capital – Washington D.C. – (*Distance from W DC*).[45] In the growth regressions, the significance of many coefficients decreases, though the transmission channel estimates of resource abundance remain all significant. As the geographical control variables do not improve any of our results but instead add multicollinearity problems (due to the high correlation between Schooling and these two variables – Pearson correlation around –0.49) that make our growth estimations less reliable, we treat these results with caution.

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[44] Data on Latitude provided by the Department Division of the U.S. Census Bureau (2003). Data on access to ocean, navigable rivers and the Great Lakes as in Mitchener and McLean (2003). Using a dummy variable measuring solely access to ocean produces similar results.

[45] We did not incorporate the two variables jointly due to their high correlation.

TABLE 5.16. *Growth regressions as in equation (5.6) (Latitude, Access to Water)*

Dependent variable: $G_{1986\text{-}2000}$	(5.46)	(5.47)	(5.48)	(5.49)	(5.50)	(5.51)	(5.52)
Constant	21.46	20.00	17.93	18.95	26.46	26.29	27.46
LnY_{86} (0.19)	–1.92** (0.86)	–1.76*** (0.62)	–1.54*** (0.57)	–1.65*** (0.57)	–2.49*** (0.79)	–2.48*** (0.78)	–2.56*** (0.77)
Latitude (5.78)	0.01 (0.03)	0.02 (0.02)	0.01 (0.02)	0.003 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
Access to Water (0.41)	–0.15 (0.21)	–0.34 (0.24)	–0.47** (0.24)	–0.47** (0.24)	–0.36 (0.25)	–0.31 (0.24)	–0.25 (0.28)
Natural Resources (0.06)		–5.72** (2.33)	–4.30** (2.11)	–3.49 (2.13)	–1.77 (2.14)	–1.38 (2.16)	–0.98 (2.03)
Investment (0.78)			0.32*** (0.10)	0.29*** (0.10)	0.35*** (0.10)	0.33*** (0.09)	0.24** (0.11)
Schooling (0.44)				0.26 (0.17)	0.32** (0.16)	0.28 (0.17)	0.32* (0.17)
Openness (0.17)					1.40** (0.64)	1.24* (0.70)	1.34** (0.67)
R&D (0.97)						0.10 (0.09)	0.07 (0.10)
Corruption (1.65)							– 0.10* (0.05)
R^2 adjusted	0.19	0.36	0.44	0.45	0.49	0.49	0.52
N	49	49	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses, robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.17. *Growth regressions as in equation (5.6) (Latitude, Longitude, Access to Water)*

Dependent variable: $G_{1986\text{-}2000}$	(5.53)	(5.54)	(5.55)	(5.56)	(5.57)	(5.58)	(5.59)
Constant	20.16	19.53	17.71	18.88	26.74	26.55	27.78
LnY_{86}	–1.66**	–1.66***	–1.48**	–1.63***	–2.48***	–2.46***	–2.55***
(0.19)	(0.73)	(0.62)	(0.59)	(0.64)	(0.78)	(0.79)	(0.76)
Latitude	0.005	0.02	0.01	0.003	0.01	0.01	0.01
(5.78)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Longitude	–0.01	–0.005	–0.003	–0.001	–0.01	–0.01	–0.01
(18.66)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Access to Water	–0.34	–0.41	–0.50*	–0.48*	–0.41	–0.35	–0.30
(0.41)	(0.28)	(0.28)	(0.29)	(0.30)	(0.29)	(0.28)	(0.26)
Natural Resources		–5.22**	–4.04*	–3.47	–1.40	–1.05	–0.49
(0.06)		(2.24)	(2.20)	(2.20)	(2.22)	(2.26)	(1.96)
Investment			0.31***	0.29***	0.35***	0.33***	0.23**
(0.78)			(0.10)	(0.10)	(0.10)	(0.09)	(0.12)
Schooling				0.25**	0.25	0.22	0.23
(0.44)				(0.20)	(0.17)	(0.19)	(0.19)
Openness					1.58*	1.40*	1.61**
(0.17)					(0.63)	(0.65)	(0.61)
R&D						0.09	0.05
(0.97)						(0.09)	(0.09)
Corruption							– 0.11**
(1.65)							(0.05)
R^2 adjusted	0.24	0.36	0.44	0.44	0.49	0.49	0.52
N	49	49	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.18. *Growth regressions as in equation (5.6) (Distance from W DC, Access to Water)*

Dependent variable: $G_{1986\text{-}2000}$	(5.60)	(5.61)	(5.62)	(5.63)	(5.64)	(5.65)	(5.66)
Constant	19.91	18.80	17.46	18.74	25.18	26.97	26.80
LnY_{86}	–1.61**	–1.51***	–1.44***	–1.61***	–2.26***	–2.28***	–2.38***
(0.19)	(0.78)	(0.56)	(0.54)	(0.58)	(0.65)	(0.65)	(0.62)
Distance from W DC	–10.46	–5.77	–3.06	–0.56	–4.42	–4.02	–6.15
(0.02)	(7.11)	(7.15)	(6.55)	(8.04)	(8.27)	(7.87)	(6.71)
Access to Water	–0.35	–0.46*	–0.52**	–0.49*	–0.46*	–0.39	–0.34
(0.41)	(0.24)	(0.26)	(0.26)	(0.26)	(0.26)	(0.24)	(0.23)
Natural Resources		–4.88**	–3.92*	–2.66	–1.26	–0.90	–0.34
(0.06)		(2.14)	(2.12)	(2.46)	(2.14)	(2.16)	(1.89)
Investment			0.32***	0.30***	0.37***	0.34***	0.24**
(0.78)			(0.08)	(0.08)	(0.09)	(0.08)	(0.11)
Schooling				0.25	0.26	0.23	0.24
(0.44)				(0.20)	(0.19)	(0.20)	(0.20)
Openness					1.39**	1.23**	1.45***
(0.17)					(0.62)	(0.62)	(0.55)
R&D						0.10	0.06
(0.97)						(0.09)	(0.09)
Corruption							–0.11*
(1.65)							(0.06)
R^2 adjusted	0.25	0.36	0.45	0.45	0.49	0.49	0.53
N	49	49	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.19. *Indirect transmission channels as in equation* (5.7) *(Latitude, Access to Water)*

	Investment (5.67)	Schooling (5.68)	Openness (5.69)	R&D (5.70)	Corruption (5.71)
Constant	–0.29	0.07	0.42	0.86	4.23
Natural Resources (0.06)	–4.63*** (1.59)	–3.53*** (1.06)	–0.71* (0.37)	–7.69*** (1.57)	7.97** (4.07)
Latitude (5.78)	0.03* (0.02)	0.02 (0.01)	–0.004 (0.005)	0.03 (0.02)	–0.05 (0.04)
Access to Water (0.41)	0.33 (0.22)	0.11 (0.15)	–0.03 (0.05)	–0.50 (0.41)	0.47 (0.65)
R^2 adjusted	0.13	0.19	0.03	0.15	0.03
N	49	49	49	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.20. *Indirect transmission channels as in equation* (5.7) *(Latitude, Longitude, Access to Water)*

	Investment (5.72)	Schooling (5.73)	Openness (5.74)	R&D (5.75)	Corruption (5.76)
Constant	0.57	1.04	–0.06	0.96	5.14
Natural Resources (0.06)	–3.78*** (1.27)	–2.56*** (0.81)	–1.18*** (0.35)	–7.58*** (1.872)	8.80** (4.36)
Latitude (5.78)	0.03* (0.02)	0.01 (0.01)	–0.003 (0.003)	0.03 (0.02)	–0.05 (0.04)
Longitude (18.66)	–0.01 (0.01)	–0.01* (0.004)	–0.004*** (0.001)	–0.001 (0.01)	–0.01 (0.01)
Access to Water (0.41)	0.23 (0.22)	0.00 (0.14)	0.02 (0.04)	–0.51 (0.41)	0.38 (0.68)
R^2 adjusted	0.13	0.28	0.18	0.13	0.02
N	49	49	49	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.21. *Indirect transmission channels as in equation* (5.7) *(Distance from W DC, Access to Water)*

	Investment (5.77)	Schooling (5.78)	Openness (5.79)	R&D (5.80)	Corruption (5.81)
Constant	1.24	1.69	–0.18	2.19	2.69
Natural Resources	–3.18***	–2.21***	–1.24***	–6.90***	7.44*
(0.06)	(1.11)	(0.74)	(0.32)	(1.72)	(3.92)
Distance from W DC	–8.92*	–9.21**	4.30***	–2.19	–4.81
(0.02)	(5.02)	(4.20)	(1.33)	(8.69)	(11.47)
Access to Water	0.17	0.03	0.03	–0.57	0.49
(0.41)	(0.19)	(0.15)	(0.04)	(0.40)	(0.65)
R^2 adjusted	0.11	0.26	0.19	0.13	0.01
N	49	49	49	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

To overcome the possible endogeneity of openness, as discussed in Section 5.4, we reproduced all growth regressions of Table 5.1 for the 1994-2000 period, using an openness measure ($Openness_{90\text{-}94}$) referring to an earlier period (the preceding five years: 1990-1994). Prior to 1990, there are no data available on international immigration disaggregated at a state level. All main results hold and openness still appears to be an important contributor to economic growth, as can be seen from Table 5.22. We also reproduced (see Table 5.23) the openness transmission channel for the 1990-1994 period using initial income and the share of the primary sector in the economy in 1990 ($Natural\ Resources_{90}$). Finally, when including economic growth in the 1986-1990 period as a regressor of immigration between 1990-1994 (not shown), we found its coefficient to be insignificant. This suggests that the causality is likely to run from immigration (openness) to growth rather than the other way round.

TABLE 5.22. *Growth regressions as in equation (5.1) with Openness* $_{90\text{-}94}$

Dependent variable: $G_{1994\text{-}2000}$	(5.82)	(5.83)	(5.84)	(5.85)	(5.86)	(5.87)	(5.88)
Constant	12.94	10.02	7.67	12.09	24.91	28.51	31.66
LnY_{94}	–0.94	–0.60	–0.41	–0.90	–2.24	–2.62*	–2.87**
(0.15)	(2.08)	(1.45)	(1.35)	(1.33)	(1.41)	(1.36)	(1.25)
Natural Resources $_{94}$		–10.23***	–9.11**	–6.78*	–4.09	–2.55	–0.15
(0.06)		(3.86)	(3.83)	(3.92)	(3.57)	(3.61)	(3.13)
Investment $_{94}$			0.27	0.24	0.37**	0.29*	0.24
(1.01)			(0.19)	(0.17)	(0.17)	(0.16)	(0.18)
Schooling $_{94}$				0.88**	0.99***	0.85**	1.04***
(0.38)				(0.38)	(0.37)	(0.42)	(0.38)
Openness $_{90\text{-}94}$					5.66***	4.58*	6.14**
(0.07)					(2.13)	(2.46)	(2.56)
R&D $_{95}$						0.33	0.22
(1.21)						(0.23)	(0.23)
Corruption $_{94\text{-}00}$							–0.33***
(1.34)							(0.12)
R^2 adjusted	0	0.19	0.21	0.25	0.29	0.33	0.42
N	49	49	49	49	49	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.23. *Indirect transmission channel as in equation (5.3) for Openness* $_{90\text{-}94}$

	Openness $_{90\text{-}94}$ (5.89)	Openness $_{90\text{-}94}$ (5.90)
Constant	0.08	0.91
Ln Y_{90}		0.21***
(0.20)		(0.05)
Natural Resources $_{90}$	–0.19**	–0.31***
(0.08)	(0.09)	(0.10)
R^2 adjusted	0.03	0.34
N	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

(iii). Different proxies

Auty (2000, 2001) argues that minerals influence local economies in a more distortionary manner than crops. When using the primary sector's production attributed to mining (metals and fuels) as a measure of resource abundance, results are similar to those in the main analysis (see Table 5.24 and 5.25). On the other hand, we found agricultural production to remain insignificant in most cases throughout our regression analysis both in the growth and transmission specifications (not shown). In this respect, the resource curse across U.S. states seems to be indeed mainly mineral-based.

In our main analysis, we follow Atkinson and Hamilton (2003), Gylfason (2000, 2001a), Ross (2001), and Sachs and Warner (1995, 2001) among others that use relative measures of resource abundance in their analysis (resource rents in GDP, primary production in GDP, primary exports in GDP, natural capital in total capital). As Stijns (2001a, 2001b) argues, switching from relative measures of resource abundance to absolute measures makes the resource curse disappear across countries. To check for the robustness of our results, we also calculated the value of primary production per square mile and per capita for each state. When using the value of primary production per capita (*Natural Resources per Capita*), our results are very similar to the analysis presented in the main text (see Table 5.26). In contrast, the value of primary production per square mile is not correlated with economic growth (not shown).

TABLE 5.24. *Growth regressions as in equation (5.1) with mineral production as a proxy for resource abundance*

Dependent variable: $G_{1986\text{-}2000}$	(5.91)	(5.92)	(5.93)	(5.94)	(5.95)	(5.96)	(5.97)
Constant	21.50	18.02	17.63	19.04	26.01	25.40	26.96
$Ln Y_{86}$	–1.90**	–1.54***	–1.53***	–1.68***	–2.42***	–2.36***	–2.48***
(0.19)	(0.93)	(0.60)	(0.58)	(0.59)	(0.73)	(0.68)	(0.66)
Mineral Production		–5.75**	–4.29	–3.54	–1.64	–1.47	–0.87
(0.05)		(2.82)	(–2.86)	(2.86)	(2.82)	(2.77)	(2.55)
Investment			0.27***	0.24***	0.32***	0.28***	0.20*
(0.78)			(0.10)	(0.09)	(0.09)	(0.09)	(0.11)
Schooling				0.25*	0.32**	0.25	0.31*
(0.44)				(0.13)	(0.12)	(0.16)	(0.16)
Openness					1.30**	1.02	1.12*
(0.17)					(0.64)	(0.65)	(0.62)
R&D						0.15	0.10
(0.97)						(0.10)	(0.10)
Corruption							–0.11*
(1.65)							(0.05)
R^2 adjusted	0.22	0.36	0.42	0.42	0.46	0.48	0.52
N	49	49	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.25. *Indirect transmission channel as in equation (5.2) with mineral production as a proxy for resource abundance*

	Investment (5.98)	Schooling (5.99)	Openness (5.100)	R&D (5.101)	Corruption (5.102)
Constant	1.14	0.77	0.20	1.32	2.78
Mineral Production (0.05)	–5.46*** (1.10)	–3.15*** (0.69)	–0.49* (0.25)	–5.33*** (1.61)	8.66** (4.15)
R^2 adjusted	0.12	0.13	0	0.07	0.06
N	49	49	49	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.26. *Growth regressions as in equation (5.1) (Natural Resources per Capita)*

Dependent variable: $G_{1986\text{-}2000}$	(5.103)	(5.104)
Constant	15.30	25.16
LnY_{86} (0.19)	–1.26** (0.52)	–2.29*** (0.66)
Natural Resources per Capita (1.82)	–0.19*** (0.07)	–0.05 (0.07)
Investment (0.78)		0.19* (0.10)
Schooling (0.44)		0.27* (0.16)
Openness (0.17)		1.04* (0.61)
R&D (0.97)		0.10 (0.11)
Corruption (1.65)		–0.11** (0.05)
R^2 adjusted	0.39	0.52
N	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

We also used a measure of financial depth (the percentage of GSP attributed to finance, insurance and real estate) as a proxy for investment.[46] A discussion and empirical investigation on the relationship between investment and financial depth is given by Gylfason and Zoega (2001). Acemoglu and Zilibotti (1997) also make the point that low levels of financial depth slow down capital accumulation because of the presence of indivisible projects. We verify the robustness of the positive correlation between this measure and growth, and the negative correlation between this measure of investment and resource abundance (not shown).

Since a highly-educated labour force can be very mobile across U.S. states, we carried out alternative calculations replacing our initial schooling variable with one that measures the percentage of people of 25 years old and over that hold an advanced degree (master's, doctorate, or professional) for each U.S. state in 1990 (see Table 5.27).[47] We found this educational proxy to enter the growth regressions positively but not with a significant coefficient. Educational expenditures (*Schooling*) is a broader measure of the private and public efforts directed at improving skills and labour productivity and we conjecture that its broad capturing of investment in human capital may compensate for its weakness in terms of correlations with demographic characteristics and the possible leakage of human capital to other states. As Table 5.28 suggests, the new educational proxy remains, however, strongly influenced in a negative manner by resource abundance.

[46] Data provided by the Bureau of Economic Analysis of the U.S. Ministry of Commerce (2003).

[47] Data provided by the U.S. Census Bureau (2003).

TABLE 5.27. *Growth regression as in equation (5.1) with advanced degree holders as a proxy for schooling*

Dependent variable: $G_{1986\text{-}2000}$	(5.105)
Constant	30.19
LnY_{86}	–2.86***
(0.19)	(0.74)
Natural Resources	–0.44
(0.06)	(2.16)
Investment	0.29***
(0.78)	(0.10)
Advanced Degree	9.71
(0.02)	(6.89)
Openness	1.10*
(0.17)	(0.57)
R&D	0.08
(0.97)	(0.11)
Corruption	–0.09*
(1.65)	(0.05)
R^2 adjusted	0.51
N	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts * and *** correspond to a 10 and 1% level of significance.

TABLE 5.28. *Indirect transmission channel as in equation (5.2) with advanced degree holders as a proxy for schooling*

	Advanced Degree (5.106)
Constant	0.07
Natural Resources	–0.08**
(0.06)	(0.04)
R^2 adjusted	0.07
N	49

Note: Robust standard errors for coefficients in parentheses. Superscript ** corresponds to a 5% level of significance.

(iv). Time Horizon

To see whether our results are persistent over a longer time horizon, we constructed income data for an extended period (1977-2000) using nominal income figures and the U.S. GDP deflator (following Barro and Sala-i-Martin 1992b, 1995). A serious problem for this extended dataset is that it suffers from not capturing inter-state price differences, which our 1986-2000 dataset corrects for. We still found support for a strong contracting impact of resources ($Natural\ Resources_{77}$) on growth for this extended period. Furthermore, when we correct growth for the variation in investment at the beginning of the period ($Investment_{77}$) and schooling ($Schooling_{77}$), the magnitude of the resource impact diminishes as implied by our original analysis. Unfortunately, there is a lack of data for the rest of the growth-relevant variables at a state level before the mid 80's. Results are presented in Table 5.29.

TABLE 5.29. *Resource abundance and income growth for 1977-2000*

	Dependent variable: $G_{1977\text{-}2000}$ (corrected for $Ln\,Y_{77}$)	Dependent variable: $G_{1977\text{-}2000}$ (corrected for $Ln\,Y_{77}$, Investment$_{77}$, Schooling$_{77}$)
Constant	0.37	0.21
Natural Resources$_{77}$ (0.07)	–4.85*** (1.17)	–2.77*** (0.81)
R^2 adjusted	0.38	0.18
N	49	49

Note: Robust standard errors for coefficients in parentheses. Superscript *** corresponds to a 1% level of significance.

Furthermore, we acknowledge that we need to be careful with respect to the period selection. The first half of the period before the mid 1990s is characterised by relatively low rates of economic growth. After the mid 1970s there was a considerable productivity growth slowdown relative to the post-war average (see e.g. Jorgenson and Fraumeni 1992) that lasted approximately till the mid 1990s for the U.S. (Jones 2002). After the mid 1990s economic growth rates rose substantially and economists often refer to the corresponding period as the "New Economy" (Gordon 2000, Nordhaus 2002). We repeat the growth analysis of Sections 5.2 and 5.3 in order to investigate the characteristics of different sub-periods within the overall period and the respective growth determinants. During the first period of interest (1986-1994), we find strong support for the absolute conditional hypothesis (results are presented in Table 5.30). Economic characteristics other than initial income do not account for the variability in income growth among U.S. states. This holds also when we replace our R&D proxy with the innovation measure capturing regional spillovers.

For the second period of high economic growth (1994-2000), we observe that initial income by itself is not an important determinant of regional economic growth (see Table 5.31). Our measures of resource abundance ($Natural\ Resources_{94}$), investment ($Investment_{94}$), and education ($Schooling_{94}$) refer to 1994. Our innovation proxy refers to 1995 ($R\&D_{95}$) and our corruption and openness measures to 1994-2000 and 1994-1999 respectively ($Corruption_{94\text{-}00}$ *and* $Openness_{94\text{-}99}$). For that period, we find variables that are considered to be important growth determinants at a cross-sectional level (such as resource abundance, investment, and schooling) to have a particularly important explanatory power when addressing regional variation in economic growth performance. Our R&D measure, however, performs poorly similarly to our results in Table 5.1. As a next step, we replace our innovation proxy ($R\&D_{95}$) with our innovation measure accounting for regional spillovers for 1995 ($Innovation_{95}$). Results are presented in Table 5.32. Innovation remains significant at the 10% level, justifying the importance of regional spillovers. As Table 5.33 indicates, natural resources remain strongly associated with reduced investment, schooling, openness, R&D (with and without regional spillovers), and increased corruption. In Tables 5.34 and 5.35, we estimate the relative importance of each transmission channel for the 1994-2000 subperiod for the two adopted specifications of R&D respectively. When abstracting from regional spillovers in R&D, we find schooling to be the most important channel, accounting for 34% of the negative association between resources and growth. In Table 5.35, innovation (with regional spillovers) again becomes the most important mechanism as in Table 5.8. The knowledge-based channels (innovation and schooling) account for 58% of the resource curse correlation. As an extension of our analysis it would be particularly appealing to identify the underlying mechanisms that explain such an observed differential behaviour between the two sub-periods.

TABLE 5.30. *Growth regressions as in equation (5.1) for 1986-1994*

Dependent variable: $G_{1986\text{-}1994}$	(5.107)	(5.108)	(5.109)	(5.110)	(5.111)	(5.112)	(5.113)
Constant	28.88	28.97	28.48	28.33	29.06	28.74	29.40
LnY_{86} (0.19)	–2.70*** (0.42)	–2.71*** (0.45))	–2.68*** (0.45)	–2.66*** (0.48)	–2.74*** (0.62)	–2.72*** (0.57)	–2.77*** (0.58)
Nat (0.06)		0.43 (1.78)	1.01 (1.86)	0.92 (1.98)	1.11 (2.06)	1.54 (2.04)	1.23 (2.25)
Investment (0.78)			0.13 (0.10)	0.14 (0.11)	0.15 (0.11)	0.11 (0.11)	0.09 (0.12)
Schooling (0.44)				–0.03 (0.17)	–0.03 (0.16)	–0.08 (0.17)	–0.08 (0.17)
$Openness_{90\text{-}94}$ (0.07)					0.37 (1.89)	–0.21 (1.90)	–0.13 (1.89)
R&D (0.97)						0.16 (0.10)	0.14 (0.12)
$Corruption_{91\text{-}94}$ (0.47)							– 0.11 (0.19)
R^2 adjusted	0.44	0.43	0.44	0.43	0.41	0.43	0.42
N	49	49	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.31. *Growth regressions as in equation (5.1) for 1994-2000*

Dependent variable: $G_{1994\text{-}2000}$	(5.114)	(5.115)	(5.116)	(5.117)	(5.118)	(5.119)	(5.120)
Constant	12.94	10.02	7.67	12.09	30.16	32.69	35.76
LnY_{94}	–0.94	–0.60	–0.41	–0.90	–2.81*	–3.07**	–3.32***
(0.15)	(2.08)	(1.45)	(1.35)	(1.33)	(1.46)	(1.38)	(1.26)
Nat_{94}		–10.23***	–9.11**	–6.78*	–2.46	–1.31	1.21
(0.06)		(3.86)	(3.83)	(3.92)	(3.70)	(3.69)	(3.36)
$Investment_{94}$			0.27	0.24	0.42**	0.34**	0.30
(1.01)			(0.19)	(0.17)	(0.19)	(0.17)	(0.19)
$Schooling_{94}$				0.88**	1.17***	1.01**	1.23***
(0.38)				(0.38)	(0.37)	(0.43)	(0.39)
$Openness_{94\text{-}99}$					6.11***	5.12***	6.29***
(0.09)					(1.66)	(1.88)	(1.81)
$R\&D_{95}$						0.30	0.19
(1.12)						(0.21)	(0.21)
$Corruption_{94\text{-}00}$							– 0.34***
(1.34)							(0.12)
R^2 adjusted	–0.01	0.19	0.21	0.25	0.33	0.36	0.45
N	49	49	49	49	49	49	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.32. *Growth regression as in equation (5.1) with R&D spillovers for 1994-2000*

Dependent variable: $G_{1994\text{-}2000}$	(5.121)
Constant	34.90
$Ln\,Y_{94}$ (0.15)	–3.27*** (1.12)
Nat_{94} (0.06)	1.38 (3.08)
$Investment_{94}$ (1.01)	0.27 (0.19)
$Schooling_{94}$ (0.38)	0.92** (0.47)
$Openness_{94\text{-}99}$ (0.09)	5.68*** (1.68)
$Innovation_{95}$ (0.79)	0.54* (0.32)
$Corruption_{94\text{-}00}$ (1.34)	– 0.28** (0.11)
R^2 adjusted	0.50
N	49

Note: Standard deviations for independent variables in parentheses; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 5.33. *Indirect transmission channels as in equation (5.2) for 1994-2000*

	Investment_{94} (5.122)	Schooling_{94} (5.123)	$\text{Openness}_{94\text{-}99}$ (5.124)	$\text{R\&D}_{95}$ (5.125)	Innovation_{95} (5.126)	$\text{Corruption}_{94\text{-}00}$ (5.127)
Constant	1.65	0.70	0.12	1.78	1.73	1.78
Nat_{94} (0.06)	–4.23*** (1.62)	–2.66*** (0.69)	–0.39*** (0.14)	–7.56*** (1.98)	–5.93*** (1.70)	7.23** (3.58)
R^2 adjusted	0.04	0.17	0.05	0.15	0.19	0.09
N	49	49	49	49	49	49

Note: Robust standard errors for coefficients in parentheses. Superscripts ** and *** correspond to a 5 and 1% level of significance.

TABLE 5.34. *Relative importance of transmission channels as in equation (5.2) for 1994-2000*

Transmission channels	α_3 (Table 5.31)	β_1 (Table 5.33)	Contribution to $\alpha_2+\alpha_3\beta_1$	Relative Contribution
Natural Resources			1.21	–13%
Investment	0.30	–4.23	–1.27	13%
Schooling	1.23	–2.66	–3.27	34%
Openness	6.29	–0.39	–2.45	26%
R&D	0.19	–7.56	–1.44	15%
Corruption	–0.34	7.23	–2.46	25%
Total			**–9.68**	**100%**

TABLE 5.35. *Relative importance of transmission channels as in equation (5.2) with regional R&D spillovers for 1994-2000*

Transmission channels	α_3 (Table 5.32)	β_1 (Table 5.33)	Contribution to $\alpha_2+\alpha_3\beta_1$	Relative Contribution
Natural Resources			1.38	–14%
Investment	0.27	–4.23	–1.14	12%
Schooling	0.92	–2.66	–2.45	25%
Openness	5.68	–0.39	–2.22	23%
Innovation	0.54	–5.93	–3.20	33%
Corruption	–0.28	7.23	–2.02	21%
Total			**–9.65**	**100%**

APPENDIX 5.2: LIST OF VARIABLES USED IN MAIN ANALYSIS

G	Average annual growth in real GSP (Gross State Product) per person between 1986-2004, $G=(\ln(Y_{2000}/Y_{1986})/14)\times 100\%$. GSP data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce (BEA 2003).
$\ln Y_{86}$	The log of real GSP per capita in 1986 (Chained (1996) U.S. Dollar Prices) (Data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce) (BEA 2003).
Natural Resources	The share of the primary sector's production (agriculture, forestry, fishing and mining) in GSP for 1986 (values in the range of 0 to 1) (Data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce) (BEA 2003).
Investment	The share of industrial machinery production in GDP in 1986 (Data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce) (BEA 2003).
Schooling	The contribution of educational services in GDP in 1986. Data from the Bureau of Economic Analysis of the U.S. Ministry of Commerce (BEA 2003).
Openness	The ratio of net international migration (the difference between migration to an area from outside the United States and migration from that area) for the 1990-99 for each state to the population of the state in 1990. Data from the U.S. Census Bureau (U.S. Census Bureau 2003).
R&D	The share of R&D expenditure in GSP for 1987. Data provided from the Industry, Research and Development System (IRIS) of the National Science Foundation (NSF 2003).
Corruption	The number of prosecuted corrupted public officials over 1991-2000 per 100000 citizens. Data from the Criminal Division of the United States Department of Justice (U.S. Department of Justice 2003).

APPENDIX 5.3: TRANSMISSION CHANNELS WITH INITIAL INCOME AS AN ADDITIONAL EXPLANATORY VARIABLE

TABLE 5.36. *Indirect transmission channels as in equation (5.3)*

	Investment (5.128)	Schooling (5.129)	Openness (5.130)	R&D (5.131)	Corruption (5.132)
Constant	3.76	–3.98	–4.82	–5.92	1.90
$\mathrm{Ln}\,Y_{75}$	–0.25	0.48	0.50***	0.74	0.08
(0.19)	(0.41)	(0.30)	(0.12)	(0.73)	(1.30)
Natural Resources	–4.42***	–3.47***	–0.91***	–6.39***	5.93
(0.06)	(1.24)	(0.79)	(0.32)	(1.84)	(3.63)
R^2 adjusted	0.07	0.19	0.34	0.11	0.01
N	49	49	49	49	49

Note: robust standard errors for coefficients in parentheses. Superscript *** corresponds to a 1% level of significance.

APPENDIX 5.4: TWO-STAGE LEAST-SQUARES ESTIMATION OF GROWTH REGRESSION (5.1)

TABLE 5.37. *2SLS regression of equation (5.1) with international migration in 1990 ($Openness_{90}$) as an instrument for average openness*

Panel A: Dependent variable: $G_{1986\text{-}2000}$	(5.133)
Constant	26.10
LnY_{86}	–2.39***
(0.19)	(0.68)
Natural Resources	–0.63
(0.06)	(2.16)
Investment	0.19*
(0.78)	(0.11)
Schooling	0.31*
(0.44)	(0.17)
Openness	0.88
(0.17)	(0.65)
R&D	0.12
(0.97)	(0.11)
Corruption	–0.11*
(1.65)	(0.06)
R^2 adjusted	0.50
N	49
Panel B: Dependent variable: *Openness*	
Openness90	1.04***
(1.65)	(0.05)
R^2 adjusted	0.95
N	49

Note: Standard deviations for independent variables in parentheses, based on the sample N=49 of regression (7); robust standard errors for coefficients in parentheses. Superscripts * and *** correspond to a 10 and 1% level of significance.

APPENDIX 5.5: RELATIVE IMPORTANCE OF TRANSMISSION CHANNELS WITH ALTERNATIVE SPECIFICATIONS

TABLE 5.38. *Relative importance of transmission channels. Specification (5.3) adopted for the openness channel and specification (5.2) for the rest*

Transmission channels	α_3	β_1 (γ_2 for openness)	Contribution to the overall effect (column (5.16) of Table 5.4)*	Relative Contribution
Natural Resources			–0.14	3%
Investment	0.21	–4.45	–0.93	20%
Schooling	0.34	–3.32	–1.13	24%
Openness	1.28	–0.91	–1.16	25%
R&D	0.10	–6.16	–0.62	14%
Corruption	–0.11	5.96	–0.66	14%
Total			**–4.66**	**100%**

* The coefficient of resource abundance after substituting equation (5.3) for openness and equation (5.2) for the rest of the transmission variables into (5.1).

TABLE 5.39. *Relative importance of transmission channels. Specification (5.3) adopted for all transmission channels*

Transmission channels	α_3	γ_2	Contribution to the overall effect (column (5.17) of Table 5.4)*	Relative Contribution
Natural Resources			–0.14	3%
Investment	0.21	–4.42	–0.93	20%
Schooling	0.34	–3.47	–1.18	25%
Openness	1.28	–0.91	–1.16	25%
R&D	0.10	–6.39	–0.64	13%
Corruption	–0.11	5.93	–0.65	14%
Total			**–4.72**	**100%**

* The coefficient of resource abundance after substituting equation (5.3) into (5.1) for all transmission variables.

6. A LONG-TERM INSTITUTIONAL PERSPECTIVE OF THE RESOURCE IMPACT *

Recent research has emphasised the influence of colonisation on the institutional development and economic performance in former European colonies. Where European colonisers settled, they replicated the investment-conducive institutions found at home. It has been argued that a harsh disease environment and a highly urbanised native population worked against colonisation. We show evidence for another significant element explaining the endogenous character of colonisation strategies and the formation of institutions. We find that the presence of precious metals (gold and silver) resulted in an increase in European settlements and an improvement in institutional quality. Highly valued gold and silver reserves attracted Europeans in large numbers and resulted in an institutional upgrade of mineral-rich areas.

6.1. Introduction

A number of recent studies has placed a particular emphasis on the role of institutions in explaining the large differences in income per capita observed across the world (see e.g. Acemoglu *et al*. 2001, 2002, Knack and Keefer 1995, Mauro 1995, 1998). An average citizen in the U.S. receives an annual income more than 20 times larger than an average civilian in Ethiopia or Sri Lanka. "Good" institutions create an environment conducive to investment in physical and human capital, and thereby contribute to substantial income improvements. On the other hand, "bad" institutions discourage individuals from undertaking investments by creating uncertainty and low expected returns.

The distinction between "good" and "bad" institutions for long-term development is, however, not obvious. To some extent, "institutions" is such a vague notion that can include almost everything that affects long-term income. It can comprise the extent of democratic liberties, the degree of corruption, the level of political stability, as well as all kinds of regulations that encourage (or discourage) investment, schooling or trade. A major institutional feature itself is the system that governs how prices are determined or how the market for production and inputs is regulated.

In this chapter, we capture institutional differences among countries by focusing on the variation in the extent of property rights. The importance of property rights in encouraging investment, entrepreneurship, and income growth has long been established in the literature (Hayeck 1960, North 1991, Landes 1998). In this context, good institutions relate to secure

* This chapter is a slightly revised version of Papyrakis and Gerlagh (2005).

and effective rights for private property, that ensure secure investment opportunities (and thus returns) to a broad section of society. On the other hand, bad institutions imply a high risk of expropriation for investors, a limited allocation of property rights within the local population, as well as severe difficulties in enforcing them. In that respect, we largely follow Acemoglu *et al*. (2001, 2002), who also emphasise the importance of property rights for investment, industrialisation, and long-term development.

Acemoglu *et al*. (2001, 2002) argue that institutional development outside Europe was influenced to a large extent by the colonisation policies of the European powers. The colonising powers developed two different strategies that created an institutional divergence within colonies. In some colonies, Europeans settled in large numbers, importing the institutions prevailing in their countries of origin. They tried to replicate the institutional framework of their metropolises, largely based on the protection of private property rights. In the other colonies, Europeans settled in small numbers, and mainly limited the institutional set up to an efficient administration for extracting resources from the local economies. Acemoglu *et al*. find two explanations for the two different settlement strategies of the colonisers. First, they claim that the disease environment played an important role (see Acemoglu *et al*. 2001). Secondly, they argue that sparsely populated (and urbanised) regions enabled Europeans to settle in larger numbers compared to densely-populated areas (Acemoglu *et al*. 2002).

We build on the same framework and extend it, analysing another determinant of European settlements. The resource affluence of the colonising area also determined the settlement strategy of colonisers. We argue that the variability of endowments in the precious metals of gold and silver across colonised areas is likely to have affected the settlement planning of Europeans. Precious metals were to a large extent the main minerals reaching Europe from the New World countries. Gold and silver were exported to meet demand by the elites of the European societies. The prestigious character of these precious metals of relative high value and low labour-intensive production established their producing regions as prominent settlement destinations among colonisers. In the eyes of settlers, the sparkle of gold and silver made their countries of origin gleam as well. Figure 6.1 illustrates the variation in the production of precious metals outside Europe in 1900.

Our analysis is of particular relevance to the wider discussion on the impact of resource abundance on economic prosperity. Our findings in Chapters 2–5 as well as a large body of empirical and theoretical work (e.g. Atkinson and Hamilton 2003, Auty 1994, Bulte *et al*. 2005, Gylfason 2000, 2001a, 2001b, Leite and Weidmann 1999, Mehlum *et al*. 2003, Neumayer 2004, Rodriguez and Sachs 1999, Ross 1999, 2001a, 2001b, Sachs and Warner 1995, 2001, Stevens 2003, and Torvik 2001, 2002) establish a negative link between resource affluence and economic performance. Other studies either cast doubt on these findings; criticising the assumptions adopted, or the statistical estimations, or they accentuate the beneficial role of natural resources on development in the past (see Davis 1995, Manzano and

Rigobon 2003, Stijns 2001a). We argue that in colonial history, mineral endowments supported income improvements by attracting colonisers and stimulating the set up of good market institutions. The impact of resources on colonisation strategies is still reflected in the income distribution observed nowadays across the world. In that respect, we claim that institutions have been a positive transmission mechanism through which resource affluence raised income levels outside Europe. Even if natural resources had a negative impact on growth rates the last three decades through several indirect channels as suggested in Chapter 4, they may have had a long-lasting impact on income levels through an institutional mechanism during the colonisation era.

Section 6.2 summarises the various hypotheses on the causes of colonisation strategies and it tests them empirically. Specifically it analyses the significance of precious metals as an additional explanatory variable for both settlement behavior and institutional development. Section 6.3 briefly extends the analysis to agricultural commodities. Section 6.4 concludes.

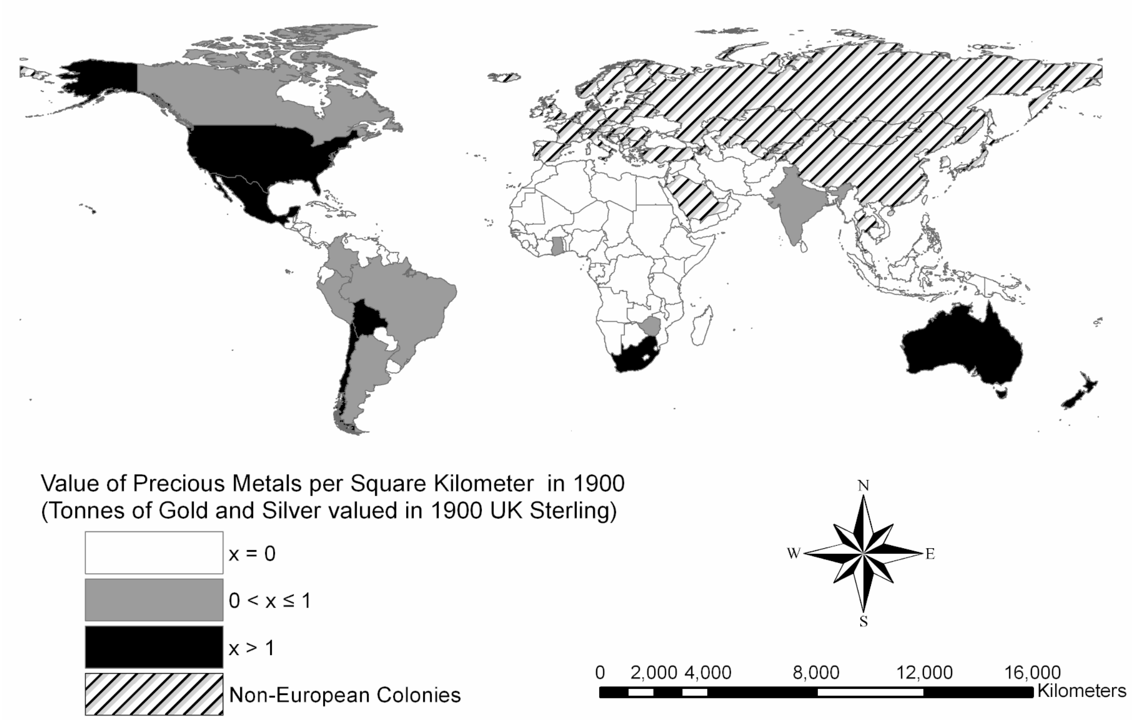

FIGURE 6.1. *Precious metals in colonised countries*

6.2. Patterns of Colonisation

(i). The Mortality Hypothesis

The Mortality Hypothesis presupposes a negative relationship between European mortality rates in colonised areas and European settlements, and a positive relation of the latter with the establishment of a pro-growth institutional framework. According to this hypothesis, Europeans settled in small numbers in regions with higher mortality rates, mainly caused by malaria and yellow fever (see Curtin 1964, 1998). On the other hand, Europeans settled in larger numbers in areas where they faced a less harsh disease environment, outnumbering in some cases the indigenous population. In turn, the magnitude of the settlers' influx to the colonised regions was a major determinant of the institutional policies established there. Europeans attempted to reproduce a European structural organisation in the newly-colonised areas, and succeeded to replicate the home institutions when settling in large numbers (Denoon 1983). In that respect, institutions of extensive and well-guarded property rights were broadly established to accommodate the demands of colonisers to imitate the capitalist structure of their societies (e.g. La Porta *et al*. 1998, 1999).

Acemoglu *et al*. (2001) establish the link between the disease environment of the colonised world and its institutional development, using data on the mortality rates of soldiers, bishops and sailors between the 17th and 19th centuries. They argue that local diseases were often fatal to many European settlers, while the indigenous populations had developed immunity to them.[48] Awareness, back in Europe, of this disease environment influenced to a large extent the settlement decisions of the colonising powers. In that respect, mortality rates determined consecutively settlement policies, institutional development, and economic affluence.

(ii). The Urbanisation Hypothesis

The Urbanisation Hypothesis stresses the importance of urbanisation patterns across different parts of the colonised world in shaping the immigration patterns of European settlers (for a discussion on the issue see Sokoloff and Engerman 2000 and Acemoglu *et al*. 2002). Europeans had a preference for sparsely populated areas, where they could settle in large numbers without engaging in frequent conflicts with the native populations. To the extent that urbanisation reflects the level of development, highly urbanised local societies corresponded to affluent and well-structured social structures, which were more likely to rebel against the imposition of European law and order than the less organised sparsely-distributed populations. Densely-populated areas were thus less desirable for European emigration, and when

[48] See Diamond (1997) for a broader discussion on the effect of diseases and climate on human history.

Europeans moved to these areas, they preferred to settle in small numbers and to set up institutions for resource wealth extraction, rather than to imitate the pro-growth institutional framework of their home countries. The extractive institutions were framed to force the local labour force to work in plantations, and to reap a share of local income through taxation. In such densely and highly-urbanised areas, the Europeans established administrations based on the concentration of power in the hands of a few settlers, which could create income through oppression (see Dunn 1972).

Acemoglu *et al*. (2002) provide econometric evidence on the linkage between urbanisation patterns and the development of subsequent institutions across the colonised world using population density data and numbers of population centers consisting of more than 5,000 people. They claim that countries that were more prosperous and densely populated in 1500 became disadvantaged in terms of their institutional inheritance by European colonisers. Affluent densely-populated regions attracted few European settlers who established extractive institutions. Ultimately, this colonisation pattern resulted in a reversal of fortune.

(iii). The Precious Metals Hypothesis

According to the Precious Metals Hypothesis, the mineral endowment of colonies influenced to a large extent the colonising policies of Europeans. The hypothesis rests on the following premises. First, newly discovered regions provided Europe with substantial amounts of gold and silver. Those newly-discovered countries were not homogeneous in terms of their resource endowment. Some countries had a larger potential as producers of precious metals, a distinction the importing European countries were aware of. Second, the extent of resource endowment influenced the settlement decision of Europeans. Gold and silver – high-valued commodities exported to the elites of the European societies – added a prestigious reputation to their areas of origin. The lucrative nature of those metals was reflected enticingly in the settlement decisions of Europeans. Third, the settlement pattern in a specific area substantially influenced the institutional framework established. This third premise is shared with the Mortality and Urbanisation hypothesis. Fourth, in addition to settlement decisions, precious metals also affected the institutional set up more directly. Settlers in a resource-rich environment demanded better institutions than settlers in a resource-poor environment. Fifth, institutions of safe and extensive property rights support the process of economic development and, thus, facilitate the attainment of a higher level of income per capita. This fifth premise is also shared with the other hypotheses.

We focus on gold and silver because of their relatively high value per weight, but also due to the fact that these were the main minerals exported to the colonising powers. Furthermore, most non-ferrous mineral production (such as copper, zinc, aluminium, chromium, and lead) was either of negligible amount or non-existent during the colonisation process of most countries. Our analysis bears resemblance to the approach by Easterly and Levine (2003) that also focuses on the impact of primary commodities on institutions, although they use recent dummy variables rather than detailed historical data and they do not relate their findings to the colonisation strategies of Europeans. Furthermore, they do not discern between agricultural commodities and minerals, and they exclude gold production from their dummy index, while we specifically focus on gold as probably the most valuable mineral at the time of colonisation.

Table 6.1 presents two-stage least-squares (2SLS) estimates of causes of recent economic prosperity in the colonised countries, as captured by the log of GDP in 1995 (data provided by the World Bank (WB) 1999). Panel A shows that institutions have a large and very significant effect on the level of economic affluence across the colonised world. Following Acemoglu *et al*. (2001) we use an index of protection against expropriation risk averaged over 1985-1995 (*Institutions 85*-95) varying in the 0 to 10 range, where higher values correspond to better enforcement of property rights.[49]

Panel B of Table 6.1 exposes the endogenous character of institutions as dependent on factors related to European colonialism. To test the Mortality Hypothesis, we use the death rate among 1,000 soldiers for the first year in the 19th century for which data are available (*Log Settler Mortality*), as in Acemoglu *et al.* (2001). To test the Urbanisation Hypothesis, we use the percentage of indigenous population living in urban centers of at least 5,000 inhabitants in 1500 (*Urbanisation 1500*), as in Acemoglu *et al.* (2002). For the Precious Metals Hypothesis, new in the analysis, we use the value of gold and silver per square kilometer in 1900 (*Gold and Silver 1900*) as a measure of resource affluence (data on prices and quantities are provided by Schmitz 1979). For all three independent variables, we also tested the impact on income through alternative channels to institutions, by running a regression with income dependent on institutions and settlements, and *Log Settler Mortality*, *Urbanisation 1500*, and *Gold and Silver 1900*. None of these variables has explanatory power, implying that their only impact on income goes indirectly through their effect on settlements and institutions. This justifies the use of these variables as valid instruments.

As depicted in Panel A of Table 6.1, there is a strong positive correlation between institutions and income per capita. This finding has been largely exposed also in Acemoglu *et al*. (2001, 2002). What is more of interest, though, is the endogenous character of institutional development outside Europe. Acemoglu *et al*. (2001) accentuate the importance of the disease environment in attracting settlers and institutions across the globe (i.e. the Mortality Rate Hypothesis). Similarly, Acemoglu *et al.* (2002) emphasise the influence of urbanisation and population density on shaping colonisation strategies and institutional development (i.e. the Urbanisation Hypothesis). These two hypotheses are tested in columns (6.2)-(6.3) of Table 6.1

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[49] Acemoglu *et al*. (2001) comment on how institutions persist over time. Their institutional measure at the end of the 20th century is strongly correlated with its values at the beginning of the century.

independently and jointly. The focal point of our analysis lies in a third factor, the role of precious metals on the flow of settlers and the corresponding import of their institutional background. In Panel B, columns (6.2)-(6.3), we confirm the negative role that urbanisation patterns and the disease environment played in the institutional development of the colonised world. Column (6.3), however, casts some doubt on the role of early urbanisation in shaping institutions when controlling for the disease environment. Subsequently, columns (6.5)-(6.6) add precious metals to the list of explanatory variables and find a strongly significant contribution thereof to the establishment of income-supporting institutions. The Precious Metals Hypothesis is robust when tested jointly with the urbanisation and settler mortality hypotheses. When testing all hypotheses simultaneously (column (6.6)), we find the Precious Metals and Settler Mortality Hypotheses to complement each other in explaining institutional divergence across the world, while urbanisation seems to bear a lower explanatory power.

In column (6.7) we further analyse the role of precious metals and settler mortality in shaping institutions, when we control for the fraction of the population of European descent in 1900 (*Settlements 190*0, as in Acemoglu *et al.* 2001). *Urbanisation 1500* turns out to be insignificant and we drop it from the regression. A benefit thereof is that we can use a much larger sample. Both coefficients for *Precious Metals* and *Log Settler Mortality* fall, compared to column (6.4), but remain highly significant. This suggests that a large part of the impact of precious metals and the disease environment on institutions went through influencing colonisation strategies, but that both variables also had a more direct impact on institutional shaping.

Whereas the first table analysed the effect of precious metals and a less urbanised and milder disease environment on institutions, in Table 6.2 we go back one step, to the settlement decisions, and examine the variables' effects on colonisation strategies, and subsequently on present-day income. Table 6.2 presents two-stage least-squares (2SLS) estimates of recent income levels in former colonies, using the settlement variable as an intermediate channel. The settlement proxy is positively correlated with the institutional measure at the 1% level of significance. Panel A of Table 6.2 reveals that, indeed, areas where Europeans settled in large numbers managed to achieve higher levels of economic prosperity through the course of time. Panel B examines the endogenous character of settlement decisions. Columns (6.9)-(6.10) reveal that a high urbanisation level and a harsh disease environment discouraged European migration. Both variables are also significant when tested jointly (column (6.10)). In columns (6.11)-(6.13), we add precious metals to the list of independent variables and find strong evidence for a tendency of European settlers to migrate to regions abundant in precious metals. The last column (6.13) reveals that, when testing jointly for all three hypotheses, precious metals had a more significant influence on settlements than the disease environment.

To sum up, our findings extend the analysis by Acemoglu *et al.* (2001, 2002) on the link between settlements, institutions and income levels in the following manner. When examining all hypotheses jointly (column entries (6.6) and (6.13)), we find indigenous urbanisation patterns to negatively and significantly affect the establishment of European settlements, but to impose a rather limited effect on institutional development. Conversely, we find settler mortality to be of limited power in explaining settlements policies, while being negatively and significantly correlated with institutional quality. Precious metals, at the same time, had a long-lasting effect on income both through increasing the number of European settlements and by leading to improved institutions, consecutively.

To study whether, indeed, precious metals have a particular and positive effect on present-day income, we analyse the statistical association between current production levels of various minerals and present-day income levels when examined jointly with gold production (*Gold 1995*). We obtain data on the value of several minerals per square kilometer in 1995 from the 1995 Commodity Yearbook of the United Nations Conference on Trade and Development (United Nations (UN) 1995). In Table 6.3 we present some tentative results using disaggregated data for mineral production. Our results must be treated, though, with caution, since disaggregated mineral data do not exist for a large sample of countries. Our results confirm that countries rich in gold tend to be relatively more prosperous nowadays, perhaps reflecting the long-term effect implied by the Precious Metals Hypothesis. This tendency holds when controlling for the production levels of other minerals. On the other hand, all other minerals have an insignificant effect on income levels, and some minerals (zinc, bauxite, copper, lead and nickel) even seem to impose a contractionary impact on income. The special character of gold is reflected by its strong association with institutional quality, as depicted in Table 6.4, column (6.25). For a large part, the correlation between gold and income goes through the early development of institutions, indeed, as column (6.26) shows. When controlling for *Gold and Silver 1900*, the coefficient on current gold production and its significance drop substantially. Also, when including the institutional proxy in the regressions of Table 6.3, the coefficient of gold production typically halves. For as much as gold is concerned, there is no evidence of a reversal of the resource fortune.

TABLE 6.1. *GDP per capita and institutions*

Panel A: Dependent variable: log GDP per capita in 1995 (Two-Stage Least Squares)	(6.1)	(6.2)	(6.3)	(6.4)	(6.5)	(6.6)	(6.7)
Constant	2.04	3.37	4.49	2.73	4.35	4.53	2.59
Institutions 85-95	0.92***	0.74***	0.58***	0.82***	0.60***	0.57***	0.84***
(1.47, 1.45, 1.47)	(0.17)	(0.16)	(0.07)	(0.13)	(0.08)	(0.07)	(0.12)
R^2 adjusted	0.36	0.24	0.52	0.41	0.43	0.53	0.45
N	38	38	38	64	38	38	63
Panel B: Dependent variable: *Institutions 85-95* (First Stage Regressions)							
Constant	9.37	6.30	12.11	8.64	7.28	11.21	7.76
Gold and Silver 1900				0.43***	0.55***	0.25*	0.23***
(0.98, 1.23, 0.99)				(0.12)	(0.10)	(0.15)	(0.08)
Log Settler Mortality	–0.61***		–1.21***	–0.49***		–1.01***	–0.35**
(1.25, 1.25, 1.24)	(0.15)		(0.21)	(0.15)		(0.25)	(0.18)
Urbanisation 1500		–0.11**	–0.04		–0.10***	–0.05	
(5.10)		(0.04)	(0.03)		(0.04)	(0.03)	
Settlements 1900							1.79***
(0.26)							(0.65)
R^2 adjusted	0.26	0.25	0.50	0.32	0.32	0.53	0.36
N	64	38	38	64	38	38	63

Note: Standard deviations for independent variables in parentheses, based on the sample *N*=64 (*N*=38 and 63 when a second and third standard deviation is mentioned); robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 6.2. *GDP per capita and settlements*

Panel A: Dependent variable: log GDP per capita in 1995 (Two-Stage Least Squares)	(6.8)	(6.9)	(6.10)	(6.11)	(6.12)	(6.13)
Constant	7.24	7.85	7.71	7.41	7.90	7.85
Settlements 1900	4.96***	2.66***	3.23***	3.91***	2.47***	2.68***
(0.26, 0.29)	(1.20)	(0.57)	(0.88)	(0.80)	(0.32)	(0.41)
R^2 adjusted	0.34	0.25	0.37	0.39	0.36	0.40
N	63	38	38	63	38	38
Panel B: Dependent variable: *Settlements 1900* (First Stage Regressions)						
Constant	9.37	0.44	0.97	0.50	0.36	0.60
Gold and Silver 1900				0.11***	0.12***	0.10***
(0.99, 1.23)				(0.04)	(0.03)	(0.03)
Log Settler Mortality	–0.11***		–0.14**	–0.08***		–0.06
(1.25, 1.24)	(0.03)		(0.07)	(0.03)		(0.07)
Urbanisation 1500		–0.03**	–0.02***		–0.03***	–0.03***
(5.10)		(0.01)	(0.01)		(0.01)	(0.01)
R^2 adjusted	0.29	0.12	0.37	0.42	0.51	0.51
N	63	38	38	63	38	38

Note: Standard deviations for independent variables in parentheses, based on the sample *N*=63 (*N*=38 when a second standard deviation is mentioned); robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

TABLE 6.3. *Current resource abundance and income per capita*

Dependent variable: log GDP per capita in 1995	(6.14)	Oil 95 (6.15)	Zinc 95 (6.16)	Coal 95 (6.17)	Lignite 95 (6.18)	Bauxite 95 (6.19)
Constant	7.63	7.92	7.90	7.73	7.96	8.07
Gold 1995 (0.21, 0.22, 0.22, 0.23, 0.25, 0.27)	2.75*** (0.76)	2.60*** (0.77)	3.14*** (0.77)	3.09*** (0.86)	2.86 (2.00)	1.74 (1.82)
Alternative Fuel or Mineral 1995 (–, 5.44, 0.15, 1.15, 0.04, 0.48)		0.02 (0.03)	–0.72 (1.14)	0.12 (0.18)	8.05 (7.59)	–0.27 (0.47)
R^2 adjusted	0.28	0.26	0.36	0.31	0.06	–0.04
N	42	24	21	21	7	10

Note: Standard deviations for independent variables in parentheses, based on the sample of each regression; robust standard errors for coefficients in parentheses. Superscript *** corresponds to a 1% level of significance.

TABLE 6.3 cntd. *Current resource abundance and income per capita*

Dependent variable: log GDP per capita in 1995	Copper 95 (6.20)	Iron 95 (6.21)	Lead 95 (6.22)	Nickel 95 (6.23)	Phosphate 95 (6.24)
Constant	7.80	7.91	7.96	8.16	7.69
Gold 1995 (0.17, 0.26, 0.22, 0.23, 0.24)	3.30** (1.48)	1.84** (0.81)	2.87*** (0.78)	2.19*** (0.77)	2.96** (1.19)
Alternative Fuel or Mineral 1995 (0.30, 0.20, 0.05, 0.10, 0.08)	–0.46 (0.92)	1.35 (0.95)	–0.75 (3.73)	–0.19 (0.35)	1.23 (3.54)
R^2 adjusted	0.16	0.20	0.31	0.19	0.25
N	19	22	21	18	13

Note: Standard deviations for independent variables in parentheses, based on the sample of each regression; robust standard errors for coefficients in parentheses. Superscripts ** and *** correspond to a 5 and 1% level of significance.

TABLE 6.4. *Current resource abundance and institutions*

Institutions85-95	(6.25)	(6.26)
Constant	6.07	6.00
Gold 1995 (0.21)	3.21** (1.35)	1.83* (1.01)
Gold and Silver 1900 (0.99)		0.55*** (0.15)
R^2 adjusted	0.17	0.33
N	42	42

Note: Standard deviations for independent variables in parentheses, based on the sample of each regression; robust standard errors for coefficients in parentheses. Superscripts *, **, *** correspond to a 10, 5, and 1% level of significance.

6.3. From Precious Metals to Resource Abundance

The analysis above focuses on the beneficial role of precious metals through attracting European settlers and improving institutions. In this section, we briefly examine whether we can extend the Precious Metals Hypothesis to agricultural productivity as another natural resource highly valued at the time of colonisation. In the eyes of potential European settlers, the colonised areas were perceived as regions producing precious metals but also agricultural commodities (mainly coffee, tea, cocoa, and sugar). In many colonies, large plantations were established where production was feasible. In general, countries with a high agricultural potential could sustain and feed a much larger native population, and as such they provided a large native labour force for plantations. At the same time, however, these countries were more densely populated and urbanised, discouraging Europeans to settle in large numbers, but rather establish a small local elite that could regulate agricultural exploitation.

In Table 6.5, columns (6.27) and (6.28), we replicate columns (6.5) and (6.4) of Table 6.1, incorporating in Panel B the value of the production of coffee, sugar, cocoa, and tea per square kilometer in 1970 (*Plantations 1970*) as a proxy for the agricultural potential across the colonised world. We focus on the production of coffee, sugar, cocoa, and tea, since these were the major agricultural export commodities from European colonies at the time. Although other secondary agricultural products may have been exported to Europe, we believe that focusing on these four commodities depicts in a reasonably accurate manner the agricultural potential of an area and the importance of plantations as an economic activity. We acknowledge that earlier data would be preferable, but extensive disaggregated information on commodity volumes and prices do not exist for earlier periods (see United Nations Conference on Trade and Development (UNCTAD), Commodity Yearbook 2000). Furthermore, the potential to produce these agricultural commodities during the period of colonisation should be still largely captured by our proxy, to the extent that climatic and hydro-geologic conditions that largely determine such a capacity are persistent. Similarly, Easterly and Levine (2003) used dummy variables for primary commodities reflecting whether a country produced a commodity or not in 1998-1999, assuming that production patterns persist over time.

In line with the findings for precious metals, we find agricultural production to positively affect the establishment of good institutions (as in Easterly and Levine 2003). In that respect, our findings contradict the "crops hypothesis" by Engerman and Sokoloff (1997) and Sokoloff and Engerman (2000) that argue in favour of a negative impact of large-scale plantations on institutional quality. The coefficients for the other variables are not affected by the inclusion of agricultural potential.

Subsequently, in columns (6.29) and (6.30), we replicate columns (6.12) and (6.11) of Table 6.2, adding agricultural productivity as an additional regressor to examine whether the positive association between institutions and plantations can be attributed to European settlements. Or in other words, is it the case that areas of high agricultural potential established better institutions by attracting relatively more European settlers? Panel A reaffirms the beneficial role of European settlements on income levels, but in Panel B, we find that, in contrast to the abundance of precious metals, agricultural productivity discouraged immigration. The relation even holds after controlling for the possibility that areas with a high agricultural potential could sustain high levels of native population, and thereby discourage European immigration. This finding is consistent with Sokoloff and Engerman's (2000) argument that privileged elites in areas with plantations often imposed institutions discouraging European immigration in order to preserve their exclusive position. To summarise, colonies rich in agricultural products did not attract many European settlers, but nonetheless, the presence of plantations is positively correlated to better institutions.

TABLE 6.5. *GDP per capita, institutions and settlements (Precious metals and plantations)*

Panel A: Dependent variable: log GDP per capita in 1995 (Two-Stage Least Squares)	(6.27)	(6.28)	(6.29)	(6.30)
Constant	2.65	4.08	7.46	7.99
Institutions 85-95 (1.47, 1.45)	0.83*** (0.13)	0.64*** (5.68)		
Settlements 1900 (0.25, 0.29)			3.58*** (0.66)	2.08*** (0.36)
R^2 adjusted	0.42	0.46	0.37	0.30
N	64	38	63	38
Panel B: Dependent variable: (First Stage Regressions)	*Institutions 85-95*		*Settlements 1900*	
Constant	8.44	7.18	0.55	0.39
Gold and Silver 1900 (0.95, 1.23, 0.99)	0.45*** (0.13)	0.57*** (0.11)	0.10** (0.04)	0.12*** (0.03)
Plantations 1970 (0.73, 0.54, 0.43)	0.34** (0.17)	0.39** (0.16)	–0.08** (0.03)	–0.09*** (–0.03)
Log Settler Mortality (1.24)	–0.45*** (0.16)		–0.09*** (0.03)	
Urbanisation 1500 (5.10)		–0.10** (0.04)		–0.03*** (–0.01)
R^2 adjusted	0.32	0.32	0.43	0.52
N	64	38	63	38

Note: Standard deviations for independent variables in parentheses, based on the sample *N*=64 (*N*=38 when a second standard deviation is mentioned); robust standard errors for coefficients in parentheses. Superscripts ** and *** correspond to a 5 and 1% level of significance.

6.4. Conclusions

Many scholars have been concerned with explaining the divergent development paths of non-European economies after the era of European colonisation. Recently, much attention has been given to the institutional aspect of economic development and its origin in European immigration. Europeans immigrated and imported their income-supporting institutions in regions of scarce indigenous populations and of mild disease environments. In our analysis, we highlight another factor that significantly describes the endogenous character of colonisation strategies, namely the endowment of precious metals. We find that regions rich in highly-valued gold and silver were prominent settlement destinations, and that subsequently these areas were fortunate enough to inherit better institutions. This finding suggests that, even if nowadays minerals have a contractionary impact on economic growth as suggested by the resource curse hypothesis, in the past natural resources have been beneficial for income levels.

We consider several extensions of our analysis that are of interest for studying the institutional dimensions of economic development and its relationship to European immigration. The hypothesis that European immigration resulted in an investment-conducive institutional framework should be tested, for instance, for a more extensive array of institutional proxies. Additionally, we want to search for other intermediate variables as determinants of long-term income, and see whether these are linked to colonisation policies. Thirdly, although the focal point of the analysis lies in the impact of precious metals on colonisation policies and institutions, we believe the association between agricultural production and institutional quality deserves further investigation. Although beyond the scope of our analysis at this stage, we believe it is of interest to examine in more detail the mechanisms through which agricultural potential resulted in good institutions. Specifically, we would like to further investigate the relation between resource affluence, population density, schooling, and institutional quality.

7. CONCLUSIONS

7.1. Research Conclusions

Concerns over the impact of resource wealth, and windfall gains in general, on the process of economic development have been at the heart of economic thinking for centuries. In that respect, sixteenth century philosopher Jean Bodin stated:

> Men of a fat and fertile soil are most commonly effeminate and cowards; whereas contrariwise a barren country makes men temperate by necessity, and by consequence careful, vigilant and industrious (Bodin, 1962 [1576]).

A century later, Adam Smith commented in his influential manuscript "An Inquiry into the Nature and Causes of the Wealth of Nations":

> Projects of mining, instead of replacing the capital employed in them, together with the ordinary profits of stock, commonly absorb both capital and stock. They are the projects, therefore, to which of all others a prudent law-giver, who desired to increase the capital of his nation, would least chuse to give any extraordinary encouragement (Smith, 1976 [1776]).

The disappointing economic performance of many resource-affluent economies (such as the OPEC cartel countries) over the last three decades has revived interest in the impact of resource wealth on economic development. Overvalued currencies, underinvestment, low levels of human capital, and extensive corruption have accompanied resource rents in most cases. In this thesis we explored several aspects of the resource curse hypothesis, in order to elucidate the tendency of resource-dependent countries to underperform in terms of economic growth. We obtained both theoretical and empirical insights into this paradoxical relationship in order to derive both explanations and policy remedies of the phenomenon.

(i). Theory

During the last few decades there have been numerous attempts to deviate from neoclassical models of economic growth and allow for endogenous technological change. A key feature of such models is their adopted assumption that technological progress is not exogenously given to the economic system but endogenously determined by choices and actions within the system.

The research undertaken within Chapters 2 and 3 has been much inspired by recent developments in economic thinking on income growth and its endogenous character. In Chapter 2 we developed an OverLapping-Generations (OLG) model, to show how savings adjust downwards to income from natural resources. Our analysis provided a theoretical justification to the empirical observation that resource-dependent countries generally do not reinvest resource rents in other forms of capital. We believe that the mechanisms behind the failure of many resource-dependent countries to reinvest resource rents deserves particular attention. In our model, a continuous stream of resource wealth reduces the necessity to save and thus results in decreased levels of investment and manufactured output. A high responsiveness of labour productivity to capital accumulation enhances the negative impact of resource wealth on the steady-state levels of capital and man-made income per person. We showed that such knowledge spillovers matter a lot in terms of determining overall income levels. The contracting effect of natural resources on physical capital and manufactured output outweighed by far any positive direct impact of resource income in the case of strong knowledge spillovers. The existence of such knowledge spillovers is essential for the analysis, since the resource curse becomes an issue of concern only when such spillovers exist.

In Chapter 3 we developed a variation of the Ramsey-Cass-Koopmans model with endogenous growth features in order to provide insights into the impact of resource booms on innovation activities. In the literature, approaches attempting to explain the resource curse paradox through the impact of resource rents on labour productivity usually take technological progress as a side-effect (learning-by-doing) without inputs being devoted explicitly to R&D activities. Chapter 3 assumed on the contrary that innovation is the outcome of intentional actions rather than the by-product of other activities. The analysis is novel in that respect, since it attempted to elucidate how resource abundance may distort the incentives to engage in R&D activities. In our analysis, individuals trade off consumption and leisure in terms of utility and as a result an increase in resource wealth induces a reduction in the steady-state labour supply. This is a consequence of the fact that resource revenues allow agents to pay for extra consumption without additional work effort. Furthermore, we illustrated how resource rents induce a smaller proportion of the labour force to engage in innovation. Reducing work intensity and R&D participation are likely to constrain the growth capability of the economy.

(ii). Empirics

In Part III of the thesis we moved from theory to empirics in order to confirm the resource curse hypothesis and attribute it to several transmission mechanisms. The main purpose of the analysis was twofold. On the one hand, we verified the hypothesis and tested the contracting effects of resource rents on a number of growth determinants as suggested in the resource curse literature. Secondly, we confirmed that the theoretical mechanisms exposed in Part II of the thesis explain a large part of the negative correlation between resource abundance and economic growth. In Chapter 4 we devoted our analysis to cross-country growth regressions for the 1975-1996 period and found resource rents to be negatively associated with institutional quality, investment, openness, terms of trade, and education. Additionally, we found that the negative indirect impact of resource affluence on growth disappears when we account for the aforementioned indirect channels. This implies that at a country level natural resources are not harmful to economic growth *per se*. Furthermore, an important contribution of our analysis lies in allowing the evaluation of the relative importance of each transmission channel in explaining the negative correlation between resources and growth. We found investment to be the most important intermediate mechanism through which the resource curse takes place across countries, accounting for almost half of the correlation. This confirms that the theoretical investment mechanism exposed in Chapter 4 can be particularly relevant in terms of elucidating the occurrence of resource curse phenomena.

In Chapter 5 we investigated whether "resource curse" phenomena are relevant at a regional level as well. We compiled a novel U.S. state-disaggregated database and conducted cross-state growth regressions in order to test the existence of a regional U.S. resource curse. Confirming our hypothesis, we found evidence of a negative correlation between resource dependence and economic growth for the 1986-2000 period. Our empirical analysis confirmed that several crowding-out mechanisms identified in our cross-country analysis (such as investment and corruption) apply across regions. Furthermore, we found innovation to be a significant channel through which resource rents inhibit economic growth across states. Innovation and education played the major role in explaining the resource curse across U.S. states, giving substance to the theoretical mechanism exposed in Chapter 3. Our analysis is novel in two respects. Our approach challenged the absolute convergence hypothesis – often adopted in regional empirical analysis – that focuses on initial income levels as the sole determinant of growth rate variation across regions. We identified a number of growth-relevant variables including resource abundance to be significant determinants of economic growth, as found across sovereign countries. Secondly, to our knowledge this is the first empirical study of the resource curse at a regional level conducted in such an elaborate manner. In that respect, it was of particular interest to discover that intermediate mechanisms bear different relative importance across countries and regions.

In Chapter 6 we examine the impact of natural resources on income levels from a long-term historical perspective. Contrary to the negative impact of resource wealth on economic growth during the last few decades, as suggested by the resource curse hypothesis, we found mineral resources to be beneficial for institutional quality and thus indirectly on income levels in the far past. This suggests that the resource curse is a relatively recent phenomenon. Our analysis extends existing approaches on exogenous determinants of institutions and therefore indirectly of long-term income. Europeans settled in large numbers in some colonies and established the investment-conducive institutional framework found in their countries of origin. Such institutions protected property rights and supported high levels of income. In other colonies where Europeans decided to settle in small numbers, they established local elites in order to regulate production and extract resources. It has been documented in the literature the extent to which the settlement decisions of colonisers were influenced by the urbanisation patterns and disease environment found in the newly-discovered regions. Europeans preferred to immigrate to areas with a mild disease environment and scarce indigenous populations. We built on the same framework and revealed that regions rich in precious metals (gold and silver) became prominent settlement locations, attracting European colonisers and institutions. On the other hand, we found the production of a series of agricultural commodities reaching Europe at the time of colonisation (coffee, tea, cocoa, and sugar), to discourage European immigration, but nonetheless, to be positively correlated to institutional quality.

7.2. Policy Issues

Many countries in the developing world possess large amounts of resource wealth, yet they continue to suffer from poverty. Despite the well-documented failure of most countries to convert resource rents into increased overall income levels, national governments still continue investing in resource-based projects. Resource-dependent countries are generally characterised by underinvestment, low levels of human capital, corruption, overvalued currencies, and technological stagnation. Although there is no single recipe to deal with the resource curse, there are some policy remedies that could potentially transform the curse into a blessing.

(i). Transmission Mechanisms

Our findings in both Parts II and III of the thesis suggest that the resource curse is not attributed to resource affluence itself but rather to the crowding-out impact of resources on several growth-promoting activities. This implies that the policy focus has to shift to those crowding-out mechanisms responsible for the curse. In Chapter 2, we showed how resource rents can create a false sense of confidence and reduce domestic savings and investment. Governments in developing countries are often tempted to transfer resource rents to the public in order to prolong their stay in power. This reduces public awareness for the need to save and invest for the future. In that respect, it is vital to ensure that rents are invested in projects with high rates of return rather than given as a supplement to domestic consumption. In our formal model, a transfer of resource revenues in the form of public expenditures such as social security came out as a very bad policy. It is wise perhaps to create resource funds with an explicit aim in reinvesting resource rents domestically and abroad. In Chapter 4 we found that the contracting impact of natural resources on investment accounts for the largest part of the negative correlation between resource rents and economic growth across countries. This suggests that investment policies are likely to play a crucial role in avoiding the resource curse trap.

In our formal model of Chapter 3, we showed how resource income can induce a shift of talented individuals outside the R&D sector by essentially distorting wage differentials. Talented individuals find it more profitable to engage in other sectors, especially since they cannot reap fully their social marginal product. In Chapter 5 we concluded that knowledge (schooling and innovation) is the most important mechanism in explaining the negative correlation between resource abundance and economic growth among U.S. states. Our findings provided evidence of the fact that resource-dependent regions even within a developed country may experience a comparative disadvantage in growth terms. Policy attention has to be drawn to this issue in countries where regional inequality is a major concern. Entrepreneurial talent is often limited in the economy and a shift of high-skilled individuals outside innovative activities can have a substantial impact on labour productivity. It is important in this respect that the government uses such resource rents to correct for the contracting effect of resources on innovative activities. Injecting funds into R&D sectors and providing stimulating incentives for research can increase innovation and productivity growth in the economy.

As additional policy remedies, governments should also attempt to tackle issues of corruption, underinvestment in human capital, and limited trade openness. Even if these channels bear smaller explanatory power in elucidating the resource curse paradox, they are still relevant and potentially play a very significant role for individual countries. For instance, devaluations can increase the competitiveness of exporting sectors in economies of overvalued currencies. Governments should direct resource funds to promote educational standards and diversify the economy in order to increase demand for human capital. For instance, governmental support for industries adding value to raw materials can immediately increase the need for more skilful personnel. Finally, wherever this is possible without external intervention (from international organisations and agencies), governments should improve transparency on the disclosure and use of all revenues from primary sector companies. In this respect there should be a well-monitored allocation of resource rights and independent inquiries on the amount of resource rents and their corresponding use.

(ii). Neutralisation of Resource Impact

Since the inherent nature of the resource curse appears to be related to distortionary effects of resource income, an obvious policy remedy would be to protect the domestic economy from an abrupt influx of resource revenues. Shielding the local economy against such resource windfalls can take place in a number of ways. The most obvious manner to decrease the inflow of resource income domestically is to develop the resource sector at a slower pace. Rapid development of extractive projects can be particularly appealing for politicians especially when income injections in the local economy seem to be much needed. What may benefit the primary sector and the local economy in the short run, however, can turn out to be disastrous for the economy in the long term in the case that the resource curse materialises.

Alternatively, instead of discouraging the expansion of the primary sector, policy makers can promote the establishment of stabilisation funds that insulate the economy from rapid resource shocks. Resource revenues are deposited in these funds and are subsequently invested abroad. Usually, the interest earned on the resource assets re-enters the local economy while most of the resource revenues remain in the fund. Additionally, such a fund may help smooth consumption over time by allowing governments to channel more resources into the economy in periods of recession. Apart from accumulating resources for future investment, resource funds achieve a fairer intergenerational distribution of resource wealth. What is of particular importance, however, is that resource funds are not misused by government officials either for political or individual purposes. In that respect, there must be transparent rules governing the fund and independent monitoring of its activities and assets.

An alternative method to insulate the local economy from abrupt resource shocks is to use the resource rents to repay accumulated public debts. This policy is particularly relevant for resource-rich countries, which in general use their resource base as collateral to facilitate their foreign borrowing. Additionally, resource windfalls often create an artificial optimism that materialises in excessive spending and budget deficits. A fall in primary commodity prices makes obviously debt repayments difficult and increases the probability to default. In that respect, a scheme to utilise the resource rents as debt repayments will have multiple benefits. It will shield the local economy from the resource rents and will reverse the economic behaviour with respect to foreign borrowing. Following the oil booms in the 1970s, Indonesia adopted such prudent policy measures for its debt management by controlling budget expenditure and impeding the foreign borrowing of state enterprises. Furthermore, using the resource revenues to decrease the debt burden is important in terms of sustainability, since ultimately debts have to be paid back and it is unfair to postpone these payments for future generations to incur.

Finally, instead of reducing the amount of resource rents entering the economy in absolute terms, it can be equally desirable to control the relative importance of the primary sector in the local economy. Such a policy does not necessarily focus on discouraging the development of resource projects, but rather on encouraging projects in other sectors possibly with the support of the resource rents. In order to promote such diversification, resource rents may be used to develop, for instance, industries that add value to the resources. One problem for this policy approach, lies in the fact that developed countries often impose lower tariffs on imported raw materials compared to processed resources. Such tariff differentiation can obviously hamper the development of alternative industries and the respective potential for economic diversification.

(iii). International Intervention

Many of the extractive projects in developing countries are funded to a large extent by multinational development banks and international organisations such as the World Bank and the International Monetary Fund. This implies that there is great potential for external pressure on local governments on how to utilise their resource rents. Lending agencies should demand that local governments and resource firms disclose complete information on their activities and accounts. Furthermore, they should ensure that resource revenues do not accrue to a few individuals, such as politicians or members of the local elites, or accommodate the needs of specific societal layers, ethnic or religious groups and geographic areas. For that purpose, loans for extractive projects might be provided in the form of conditional aid. International lenders should fund projects in countries where governments agree in advance to an independent monitoring of the resource rents and ways to spend them. It is essential to specify beforehand ways the way in which resource rents will be utilised to alleviate poverty and improve welfare levels. In that respect, most of the resource rents should reach the largest base of the society in terms of investments in education, health projects, infrastructure, rural development and environmental programmes dealing with the negative externalities of extraction.

7.3. Future Research

More than ten years after the seminal paper by Sachs and Warner (1995) on resource abundance and economic growth, much research has been undertaken at a theoretical and empirical level on investigating the mechanisms behind the resource curse. Clearly the whole issue of what determines whether resource affluence is a curse rather than a blessing is a rather complex one and, in that respect, the thesis is not meant to be exhaustive in illuminating all paradoxical aspects of the phenomenon. Below, we briefly mention some additional research questions that can potentially develop further our understanding of the resource curse hypothesis.

Firstly, we believe that the informal character of resource production in many developing countries can have serious implications for their development potential, and as such it deserves explicit policy attention. In many parts of the developing world where property rights are loosely defined, it is not uncommon for natural resources to be informally exploited. Individuals illegally engage in harvesting tropical timber or extracting diamonds, since such activities can prove to be particularly profitable. The presence of easily lootable resources stimulates predatory behaviour in the economy and entices individuals to direct their work effort to such activities. Having an extensive informal sector can be particularly harmful to economic development, especially when individuals compete aggressively for the acquisition of the resource. Labour productivity improvements in terms of infrastructure investment, educational projects or health programmes are mostly financed by public revenues in developing regions. This implies that a contraction of the formal economy due to an extensive informal resource sector will directly constrain the capability of public officials to obtain tax revenues and reinvest them for the benefit of all individuals.

Secondly, it is of particular interest to examine the evolution of the resource impact on income over time. It is challenging to examine whether the resource curse has been a recent phenomenon of the last four decades, investigating at the same time whether resources have been supporting the development process in earlier periods. Perhaps, in an era of continuously declining transportation costs, domestic natural reserves become less of a prerequisite for successful development strategies. If this indeed holds, going back over time would imply an overall increasing role of resources in supporting income levels. Furthermore, this potentially implies that the past beneficial role of resource affluence is likely to have had an enduring impact on income levels that can be still traced in the current world income distribution. In other words, even if resources retarded economic growth in the last half of the twentieth century, this does not necessarily mean that resource-dependent countries are necessarily poorer than resource-scarce ones.

An appealing extension of the analysis would be to enrich our dataset with new variables and time-disaggregated data. For instance, it would be of interest to also incorporate a credible measure of technological intensity for our cross-country sample in Chapter 4, as we did in our cross-U.S. state analysis in Chapter 5. Overcoming the scarcity of data and, thus, expanding the time disaggregation of our variables will allow us to perform a panel data analysis for subperiods in order to reinforce our findings of Chapters 4 and 5.

A promising additional area of research, perhaps more for political scientists rather than economists, may focus on the role international lending agencies can play in facilitating a prudent spending of resource rents. To the extent that resource-based projects are financed by international loans, such agencies can demand that local governments commit themselves in advance on ways to spend resource revenues. A recent attempt in that direction has been the arrangement between the World Bank and the Chad government to deposit oil revenues into an offshore account and jointly monitor their spending. It is particularly appealing to examine whether such measures of international pressure can reverse the resource curse pattern and bear fruitful results in practice.

Finally, it is perhaps of interest to forecast the effect natural resource dependence will have on economic development for the forthcoming decades. Current rising oil prices pose a challenge, for instance, on whether this windfall will be sensibly used by the producing states to promote development. If high prices of oil persist, however, there could be an additional repercussion especially for the poorest group of the underdeveloped countries. Booming economies such as China and India drive oil prices high and can afford to continue importing large amounts of oil for their expanding industries. High oil prices, however, can inhibit the development process of poor countries that are growing at a more modest pace. As a consequence, there may be a significant divergence within developing countries with respect to their capability to cope with oil prices and their capacity to grow.

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Summary

The Political Economy of King Midas: Resource Abundance and Economic Growth

Introduction (Part I)

Common economic intuition suggests that resource windfalls should provide additional revenues that help improve living standards and reduce poverty levels. Resource-rich developing countries should benefit from accrued resource rents as these can help to reduce formerly accumulated debts, overcome credit constraints, and implement ambitious development programmes. If a "big push" in terms of a positive income shock is needed to escape from a vicious circle of stagnation, then injections of resource revenues should assist in attaining a development path of robust growth. In that direction, economic historians accentuated the importance of mineral reserves in supporting the industrial expansion of economies such as the United States and the United Kingdom at the turn of the 20th century. More recently, countries such as Norway and Botswana took advantage of their resource earnings from oil and diamond reserves, respectively, promoting income expansion.

In recent years interest in the impact of resource affluence on economic development has been invigorated in the economic literature. Many studies asserted that resource abundance had adverse rather than beneficial consequences for (the rate of) economic growth over the last three decades. The tendency of resource-rich countries to be underperformers in terms of income growth became known as the "resource curse" hypothesis. Although concerns over the potential contracting impact of resource windfalls can be traced back to the writings of Adam Smith, the topic rejuvenated attention when in the 1950s Prebisch and Singer explicated the potential failure of resource-dependent development pointing to declining relative prices for primary commodities relative to manufactured goods. The appreciation of the Dutch guilder and corresponding decline in manufacturing in the Netherlands, following the discovery and exploitation of large gas fields in the Groningen area in the 1960s, gave rise to a literature on the "Dutch disease" that highlighted the harmful role of resource windfalls on trade competitiveness. Finally, in their seminal NBER paper in the mid 1990s, Sachs and Warner provided the first extensive statistical analysis and gave an empirical justification for the resource curse hypothesis. Their work has stimulated further interest and discussion on the issue. This thesis is part of this literature on the paradoxical negative association between resource abundance and economic growth, focusing on the intermediate mechanisms through which the phenomenon takes place.

Part I of the thesis provides an introduction to the resource curse literature and existing explanations of the phenomenon. Additionally, it briefly comments on the implications of unsuccessful resource-based development in terms of sustainability. A contracting economy following a resource windfall can be perceived both as a missed chance to catch up with economies that were more successful, and as a failure to translate resource income into opportunities for future generations. At the end, Part I provides an overview of the thesis and it outlines the research questions that are explored in Part II and III.

Formal Analysis (Part II)

Part II of the thesis consists of Chapters 2 and 3 that theoretically explore two mechanisms that can explain the deleterious effect of resource affluence on economic development. The analysis in both chapters makes extensive use of insights found in the endogenous growth literature, assuming that technological progress (or improvements in labour productivity) is either a side-effect of production (learning-by-doing in Chapter 2) or a deliberate outcome of R&D activities within the economy (Chapter 3).

The research focus in Chapter 2 lies in exploring the interrelationship between resource windfalls and aggregate savings in resource-rich economies. Resource abundance can easily create a false sense of security and reduce the need to exercise care in economic planning. Reliance on a continuous stream of resource revenues is likely to induce economic agents to become short-sighted and devote inadequate attention to prudent economic behaviour. An important aspect of economic planning deals with decisions regarding the division of income between savings and consumption. We develop an OverLapping-Generations (OLG) model, where individuals live for two periods, implying that at each time interval there is an overlap of a young and an old generation. Individuals work when young and live from their savings when they turn old and enter the second period of their life cycle. Each generation values consumption at both periods of its life cycle, and it maximises the utility derived from consumption subject to the budget constraint it faces, i.e. total wage income. We show how resource rents can induce savings to adjust downwards in the case that resources are considered public property and are used to pay for public expenditures such as social security. Under such a scenario, resource revenues reduce the necessity to save, since they become a means to enhance future income levels. The immediate consequence of a savings contraction is a decline in investment and future physical capital. Additionally, there will be a decrease in manufactured output, to the extent that its production is capital-intensive. This reduction in manufactured income is exacerbated when, in turn, labour productivity (through technology or education) depends on the level of physical capital. We show that in the case of strong knowledge diffusion within the economy, any positive short-term impact of natural resources on welfare is likely to be outweighed by their contracting indirect effect on physical capital. If this is the case, total welfare will decline and the resource curse will come into effect. To a large extent, the effect of resource rents on savings depends on the distribution of resource rents over generations. Savings adjust to a smaller extent when resources are considered common property and the rents are equally distributed over all consumers.

In Chapter 3 we shift our attention to an alternative model, where technological progress depends on R&D activities. The engine of economic growth lies in the work effort specifically directed towards innovation and entrepreneurship. The model assumes infinitely-living households that choose over time the level of consumption and the share of time devoted to leisure, both of which contribute to their utility. There is necessarily a trade-off between consumption and leisure due to the fact that consumption depends positively on labour income. The economy consists of four sectors. First, there is a manufacturing sector using as input a share of the labour force and a range of intermediate capital goods, the latter representing distinctive designs of capital. Secondly, there is a capital goods sector, where firms produce the intermediates using raw capital and the corresponding innovative ideas (patents). Third, we assume an R&D sector, where the designs for new intermediate goods are produced adding to the stock of knowledge in the economy. The R&D sector employs the remainder of the labour force not employed in manufacturing. Last, there is a primary sector depending positively on the resource endowment of the economy. Our primary concern is with the effect of an expanded primary sector on income growth. We analyse how resource rents decrease the fraction of time allocated to work and increase leisure correspondingly. An increased amount of resource wealth gives the opportunity to enjoy the same level of consumption for a reduced labor effort. In the model, we show that an additional indirect repercussion of increased resource revenues is to affect the allocation of entrepreneurial activity between the manufacturing and the R&D sector in favor of the former. Economic growth slows down for two reasons: due to the fact that individuals devote less time to working and that a smaller share of them engages in R&D. Broadly perceived, the analysis describes the failure of resource-rich countries to make efficient use of their labour force and its potential in terms of skills and entrepreneurial talent.

Empirical Analysis (Part III)

In Part III of the thesis we move from theory to empirics in order to explore statistically the impact of resource abundance on economic growth. The purpose of the analysis is twofold. First, it aims at verifying the resource curse hypothesis and investigating whether it is mainly attributed to the negative impact of resources on several growth-related variables as suggested in the literature. The association of natural resources with several growth determinants is often referred to as the resource curse transmission channels. On the other hand, the empirical part of the thesis simultaneously explores the importance of our theoretical mechanisms exposed in Part II in terms of accounting for the detrimental effect of resources on growth. In that respect, the formal and empirical parts of the thesis complement and reinforce each other.

The focal point of our analysis in Chapter 4 lies in examining the direct and indirect impact of resource rents on economic growth across countries for the 1975–1996 period. To identify the dependence of economic growth on resource dependence we estimate cross-country growth regressions, i.e. we examine the role of several variables in accounting for growth differences among the sample of countries. The set of our growth-determining variables include initial income, a resource abundance proxy, and indices for investment, human capital, institutional quality, trade openness and competitiveness. As a proxy of resource abundance we use the share of mineral production in GDP (overall value of production in the economy) at the beginning of the period. When incorporating solely initial income and our resource proxy in our analysis we find a strong and negative statistical association between economic growth and resource abundance. We progressively add the other growth-related variables in our statistical analysis and observe the negative association between resources and growth gradually to fade away. This implies that resource rents are not bad to economic growth per se but their growth-contracting effect goes indirectly through their association with other growth-related variables. The set of these growth-related indices is shown to be rich enough to account fully for the initial negative association between resources and growth. We successively verify that mineral production indeed decreases investment, schooling and openness and deteriorates trade competitiveness and institutional quality. An important contribution of our analysis lies in evaluating the relative contribution of each transmission channel in explaining the resource curse hypothesis. We find investment to be the most important mechanism, through which natural resource inhibit the economic growth progress. The contracting impact of resource rents on investment accounts for almost half of the initial negative association between resource abundance and growth. The openness and terms of trade explanations follow in terms of relative importance. This finding underpins the relevance of our theoretical investment mechanism exposed in Chapter 2 in elucidating the "resource curse" phenomenon. Not only we provide empirical justification to the investment channel but we also corroborate its importance in explaining the disappointing economic performance of resource-rich countries.

The analysis in Chapter 5 poses the research question of whether the "resource curse" may be a relevant phenomenon across regions within a country as much as across countries. In order to explore the issue we utilise a U.S. state-disaggregated dataset to test whether resource-rich states underperform in terms of economic growth. Our analysis challenges the "absolute convergence" hypothesis often adopted in regional economics, which assumes that initial income is the only important factor across regions accounting for differences in growth rates. We explore whether U.S. states are dissimilar in a number of other characteristics that may matter in capturing differences in growth rates. Following a similar approach to Chapter

4, we explore whether economic growth across U.S. states for the 1986–2000 period depends on a number of growth-related variables, found to be important across sovereign countries. First, we include a resource proxy (the share of primary sector in Gross State Product (GSP) i.e. the state equivalent of GDP) to confirm that resource-rich U.S. states such as Alaska and Louisiana experienced a relative disadvantage in terms of income growth over that period. We consecutively include proxies for investment, schooling, openness, corruption and innovation in the growth analysis and verify their important role in explaining growth performance. Similar to our findings in Chapter 4, the negative impact of natural resources on growth across U.S. states disappears once we incorporate all aforementioned variables in our growth analysis. This suggests the existence of transmission mechanisms being important in explaining a resource curse phenomenon across U.S. states. Indeed, we find resource-dependent U.S. states to suffer from lower levels of investment, schooling and innovation and be at the same time less open to immigration and more corrupted as economies. Contrary to our cross-country results, though, we find the knowledge-based channels of schooling and R&D to play a much larger role than investment. A "resource curse" across relatively-wealthy regions within a developed country seems to be therefore of a different nature and mostly related to differences in educational standards and R&D expenditure rather than differences in infrastructure and trade openness.

Chapter 6 turns towards the relation between resources and welfare from a long-term historical perspective. Many scholars have emphasised the importance of natural resources in the industrial expansion of many resource-rich countries in the 18th and 19th centuries. This line of argument suggests that the negative effect of resource affluence on economic growth is most likely to be a recent phenomenon of the last few decades to the extent that declining transportation costs and trade barriers make the availability of domestic resource supplies less of a prerequisite for economic development. To the degree that this holds, the earlier positive role of resource abundance on income growth may have had a long-lasting effect that can be still reflected in the current world income distribution. Our approach focuses on the relationship between current income levels, institutions, colonisation policies and resource endowments. In places where Europeans settled in large numbers, they imported the investment-conducive institutional framework found in their countries of origin, largely based on the protection of private property rights. In other areas Europeans preferred to settle in small numbers and rather to establish a local elite to regulate local production. The differences in colonisation strategies and imported institutions have had an important effect reflected in current relative welfare levels. We analyse the endogenous character of the colonisers' settling decisions and confirm earlier literature that state that settlers had a preference for areas of a mild disease environment and less-organised indigenous populations. More important for the subject of this thesis, we find regions rich in precious metals (gold and silver) to be prominent settling destinations in the past and fortunate to inherit the settlers' institutional framework.

On the other hand side, we find a series of important agricultural commodities at the time of colonisation (coffee, tea, cocoa and sugar), to discourage European immigration, but nonetheless, to be positively correlated to better institutions. Our findings suggest that indeed natural resources have played a beneficial role in economic development in the past, despite the current trend of resource-rich countries to experience lower rates of income growth.

Finally, Chapter 7 summarises and brings together the main conclusions of all chapters. At the same time, it draws policy recommendations based on our research findings and suggests remedies to tackle the resource curse. Policy has to focus on those intermediate mechanisms responsible for the resource curse. Savings and investment policies are likely to play a major role in avoiding the resource curse trap in resource-rich developing countries. Also, utilising resource rents to correct for the contracting effect of resources on R&D activities seems a relevant strategy. Additionally, resource rents may be deposited in investment funds that ensure transparent and efficient management of resource revenues. It is needless to say that this thesis is far from exhaustive in terms of elucidating all paradoxical aspects of the resource curse. Chapter 7 provides suggestions on future extensions of the research undertaken in this thesis. Expanding the current dataset, obtaining historical data of resource abundance and examining the informal nature of resource production in many developing countries are some potential directions of future research. Since current rising oil prices are likely to create a new positive income shock for many countries, it is of great interest to see what has been learnt from past resource mismanagement and the capacity oil producing countries have built to transform resource rents into overall economic prosperity in the near future.

SAMENVATTING (SUMMARY IN DUTCH)

DE ECONOMIE VAN KONING MIDAS:
NATUURLIJKE HULPBRONNEN EN ECONOMISCHE GROEI

Introductie (Deel I)

Het algemeen geaccepteerde economisch inzicht is dat een ruime voorziening in natuurlijke hulpbronnen extra opbrengsten genereert die de welvaart kan verhogen en de armoede kan verlichten. Ontwikkelingslanden die grote voorraden hulpbronnen hebben, zouden baat moeten hebben bij de toegenomen inkomsten uit de hulpbronnen. Deze inkomsten dragen bij aan het aflossen van eerder aangegane schulden, het opheffen van kredietbeperkingen en het implementeren van ambitieuze ontwikkelingsprogramma's. Als een positieve inkomensschok nodig is om te ontsnappen aan een vicieuze cirkel van schuld en stagnatie, dan zou de exploitatie van natuurlijke hulpbronnen de economische ontwikkeling moeten kunnen sturen naar een pad van robuuste groei. Inderdaad benadrukken historici het belang van minerale voorraden voor de economische ontwikkeling. Deze waren essentieel voor de industriële ontwikkeling van de Verenigde Staten en het Verenigd Koninkrijk aan het begin van de 20^{e} eeuw. Meer recentelijk hebben landen zoals Noorwegen en Botswana gebruik gemaakt van de inkomsten uit hun hulpbronnen, respectievelijk olie en diamanten, om een substantiele inkomensgroei te realiseren.

De relatie tussen natuurlijke rijdkom en economische ontwikkeling heeft veel aandacht gekregen in de economische literatuur van de afgelopen jaren. Veel studies beweerden dat, bekeken over de laatste drie decennia, natuurlijke rijkdom eerder negatieve dan positieve gevolgen had voor de economische groei. Landen met grote voorraden natuurlijke hulpbronnen bleken onder de maat te presteren in termen van inkomensgroei en dit werd bekend als de hypothese van de "resource curse" – de vloek van de natuurlijke rijkdom. Zorgen over het mogelijk negatieve effect op de economie van inkomen uit hulpbronnen kan al gevonden worden bij vroegere schrijvers als Adam Smith, maar het onderwerp kreeg hernieuwde aandacht door een publicatie in 1950 van Prebisch en Singer. Zij lieten zien dat op de wereldmarkt de relatieve prijs van primaire goederen daalde ten opzichte van de prijs van industriële goederen. Het gevolg was dat landen die veel primaire goederen exporteerden hun inkomsten zagen dalen in plaats van stijgen. De ontdekking en exploitatie van de grote gasvelden bij Groningen rond 1960, en de daarop volgende appreciatie van de gulden en afname van industriële productie in Nederland gaven aanleiding tot een stroom artikelen over de “Dutch disease”. Deze literatuur benadrukte de schadelijke invloed van inkomsten uit natuurlijke hulpbronnen op de concurrentiepositie in de internationale markt voor industriële goederen. Een mijlpaal werd bereikt met een innovatief artikel halverwege de jaren 1990, waarin Sachs en Warner de eerste uitgebreide statistische analyse leverden en zo een empirische onderbouwing konden geven voor de “resource curse” hypothese. Hun werk stimuleerde de aandacht voor en de discussie over het onderwerp. Dit proefschrift maakt deel uit van deze literatuur waarin de paradoxale negatieve samenhang tussen natuurlijke rijkdom en economische groei centraal staat. In dit proefschrift gaat de aandacht daarbij vooral uit naar de tussenliggende mechanismen door middel waarvan dit fenomeen zich voltrekt.

Deel I van dit proefschrift geeft een inleiding in de literatuur over de “resource curse” en de bestaande verklaringen van dit fenomeen. Ook geeft het een kort commentaar op de betekenis van het gebruik van hulpbronnen en economische ontwikkeling voor duurzaamheid. Een krimpende economie ondanks een grote natuurlijke rijkdom kan gezien worden als een gemiste kans om economieën in te halen die meer succes hadden én als een mislukte poging om inkomen uit hulpbronnen te vertalen naar mogelijkheden voor toekomstige generaties. Als afsluiting van Deel I is er een overzicht van dit proefschrift en een uiteenzetting van de onderzoeksvragen die behandeld worden in Delen II en III.

Formele Analyse (Deel II)

Deel II van dit proefschrift bestaat uit de hoofdstukken 2 en 3, die op theoretische wijze twee mechanismen onderzoeken die het negatieve effect van natuurlijke rijkdom op economische ontwikkeling kunnen verklaren. In beide hoofdstukken maakt de analyse uitvoerig gebruik van inzichten uit de literatuur over endogene groei. In hoofdstuk 2 wordt verondersteld dat technologische vooruitgang en de daaraan gekoppelde toename van arbeidsproductiviteit een direct bijkomend effect is van productie (“learning-by-doing”), terwijl in hoofdstuk 3 wordt verondersteld dat technologische vooruitgang een uitkomst is van doelgerichte onderzoek en ontwikkeling (O&O) activiteiten.

De aandacht van hoofdstuk 2 is gericht op het onderzoek naar de samenhang tussen inkomsten uit natuurlijke hulpbronnen en geaggregeerde besparingen in economieën die beschikken over grote voorraden natuurlijke hulpbronnen. Natuurlijke rijkdom kan een onterecht gevoel van zekerheid creëren en zo de behoefte aan een zorgvuldige economische planning beperken. Door te vertrouwen op een continue stroom van inkomsten uit natuurlijke hulpbronnen kan er toe leiden dat economische actoren kortzichtig worden en onvoldoende aandacht besteden aan voorzichtig economisch gedrag. Een belangrijk element van dergelijke voorzichtigheid heeft betrekking op de verdeling van het inkomen over besparingen en consumptie. We ontwikkelen in dit hoodstuk een levenscyclus model waarin individuen gedurende twee perioden leven; ze zijn de eerste periode ‘jong’, en de tweede periode ‘oud’.

In elk tijdsinterval leeft een jonge en een oude generatie samen (in het engels staat dit model bekend als een “Overlapping Generations” (OLG) model). Individuen werken en sparen als ze jong zijn en leven van hun spaargelden als ze oud zijn geworden in de tweede periode van hun levenscyclus. We laten zien hoe inkomsten uit natuurlijke hulpbronnen ertoe kunnen leiden dat besparingen verminderen, in het geval dat deze inkomsten worden gebruikt voor publieke uitgaven zoals sociale zekerheid. De reden is dat de publieke voorzieningen de noodzaak verminderen van besparingen voor de oude dag. Het directe gevolg van verlaagde besparingen is een afname van investeringen en toekomstig kapitaal. Bovendien zal er een afname optreden in de industriële productie, afhankelijk van de kapitaalintensiteit van deze productie. Deze teruggang in inkomen uit productie wordt versterkt als de arbeidsproductiviteit op haar beurt afhankelijk is van het kapitaal (via technologie of opleidingen). We laten zien dat, in het geval van sterke kennisverspreiding binnen de economie, het korte-termijn positieve effect van natuurlijke hulpbronnen op de welvaart tenietgedaan wordt door het negatieve lange-termijn effect van lagere investeringen en kennisontwikkeling. Als dit het geval is, zal de totale welvaart afnemen en treedt de “resource curse” op. We merken nog op dat het negatieve effect van natuurlijke rijkdom op besparingen minder sterk is als de inkomsten uit natuurlijke hulpbronnen gelijkelijk verdeeld worden over de generaties, in plaats van dat ze voornamelijk gebruikt worden voor de sociale zekerheid en pensioenvoorzieningen.

In hoofdstuk 3 verschuiven we onze aandacht naar een alternatief model, waarin technologische vooruitgang afhangt van O&O activiteiten. De motor van economische groei is de inspanning die specifiek geleverd wordt ten behoeve van innovatie. Het model gaat uit van oneindig lang levende huishoudens die een keuze moeten maken tussen het consumptieniveau met de daarbij behorende arbeidsinspanning, en vrije tijd. Noodzakelijkerwijs is er een afweging tussen consumptie en vrije tijd, omdat beiden bijdragen aan het nut. De economie bestaat uit vier sectoren. Ten eerste is er de productiesector, met arbeid en kapitaalgoederen als input. Ten tweede is er de kapitaalgoederensector. De productiviteit van kapitaal hangt af van de variëteit in kapitaalgoederen, en deze is weer afhankelijk van het aantal innovatieve ideeën (patenten) dat beschikbaar is. Deze ideeën worden geproduceerd in de derde sector, de O&O sector, met arbeid als productiefactor. Als laatste is er de primaire sector die positief afhankelijk is van de mate waarin natuurlijke hulpbronnen beschikbaar zijn voor de economie. Hoofdzakelijk zijn we geïnteresseerd in het effect van een toenemende primaire sector op de inkomensgroei. We analyseren hoe inkomsten uit natuurlijke hulpbronnen de keuze voor vrije tijd doen toenemen, en het deel van de tijd dat besteed wordt aan werk verminderen. Een toegenomen rijkdom aan hulpbronnen geeft de mogelijkheid om hetzelfde consumptieniveau te genieten bij een lagere arbeidsinspanning. In het model laten we zien dat een bijkomstige indirecte effect is dat de allocatie van arbeid tussen de productie en de O&O sectoren verschuift ten koste van de laatste. De economische groei vertraagt door twee redenen: het feit dat individuen minder tijd besteden aan werk en het feit dat een kleiner deel van hen O&O activiteiten ontplooit.

Empirische Analyse (Deel III)

In Deel III van dit proefschrift gaan we van theorie naar empirie; we proberen het effect van inkomsten uit natuurlijke hulpbronnen op economische groei statistisch te onderzoeken. Het doel van de analyse is tweeledig. Ten eerste probeert het de "resource curse" te verifiëren en te onderzoeken of de resource curse voornamelijk te wijten is aan het negatieve effect van hulpbronnen op een aantal groeigerelateerde variabelen (zoals investeringen). De verbanden die bestaan tussen natuurlijke hulpbronnen en de zogenaamde groeideterminanten worden de transmissiekanalen van de "resource curse" genoemd. Ten tweede verkent het empirische deel van dit proefschrift het belang van de mechanismen die zijn onderzocht in Deel II. Op dit punt complementeren het formele en het empirische deel van dit proefschrift elkaar.

In hoofdstuk 4 gaat de aandacht vooral uit naar een vergelijking tussen landen over de periode 1975-1996. Om de relatie tussen economische groei en natuurlijke rijkdom te duiden schatten we cross-country regressies van groei; m.a.w., we onderzoeken de rol van verschillende variabelen voor de verklaring van verschillen in economische groei tussen de landen. De variabelen waarvan de relatie met economische groei wordt onderzocht zijn initieel inkomen, natuurlijke rijkdom, investeringen, menselijk kapitaal, institutionele kwaliteit, openheid van de economie en de internationale concurrentiepositie. Als benadering voor natuurlijke rijkdom gebruiken we het aandeel in het Bruto Nationaal Product (BNP; de totale waarde van productie in de economie) van de productie van mineralen aan het begin van de periode. Indien we in onze analyse alleen kijken naar initieel inkomen en onze benadering voor natuurlijke rijkdom, dan vinden we een sterke en negatieve statistische relatie tussen economische groei en natuurlijke rijkdom. Door steeds meer groeigerelateerde variabelen toe te voegen aan onze statistische analyse verdwijnt beetje bij beetje deze negatieve relatie tussen natuurlijke rijkdom en groei. Dit suggereert dat natuurlijke rijkdom op zich niet slecht is voor economische groei, maar dat het groeibeperkende effect indirect werkt via het verband met andere groeigerelateerde variabelen. De set van deze determinanten van groei blijkt rijk genoeg te zijn om het initiële negatieve verband tussen natuurlijke hulpbronnen en groei volledig te verklaren. Daarna laten we zien dat productie van mineralen inderdaad een negatieve invloed heeft op investeringen, onderwijs, openheid van de economie, internationale concurrentiepositie en institutionele kwaliteit. Een belangrijke bijdrage van onze analyse is gelegen in de evaluatie van de relatieve bijdragen van elke transmissiekanaal in het verklaren van de "resource curse" hypothese. We tonen aan dat de investeringen het belangrijkste transmissiekanaal zijn waardoor natuurlijke hulpbronnen de economische groei beperken. Dit transmissiekanaal neemt bijna de helft van het initiële negatieve verband tussen natuurlijke rijkdom en groei voor zijn rekening. Openheid van de economie en de concurrentiepositie volgen wat betreft relatief belang. Deze bevindingen ondersteunen de relevantie van het transmissiekanaal van investeringen, dat theoretisch wordt aangetoond in hoofdstuk 2, voor het verhelderen van het fenomeen van de "resource curse". Niet alleen geven we een empirische rechtvaardiging van het investeringsmechanisme, maar we bekrachtigen het belang ervan voor het verklaren van de teleurstellende economische prestaties van landen die rijk zijn aan natuurlijke hulpbronnen.

De analyse in hoofdstuk 5 stelt de onderzoeksvraag of de "resource curse" ook een relevant fenomeen is voor de vergelijking van regio's binnen een land. Om dit vraagstuk te verkennen gebruiken we datasets voor individuele staten in de Verenigde Staten. Hiermee testen we of staten die rijk zijn aan hulpbronnen onder de maat presteren in termen van economische groei. Onze analyse stelt de absolute-convergentie hypothese op de proef, vaak aangeroepen binnen de regionaal-economische theorie. Deze hypothese stelt dat regio's binnen een land convergeren naar hetzelfde inkomensniveau, zodat het initiële inkomen de enige belangrijke factor is in het verklaren van interregionale verschillen in de groeivoet. Met dezelfde aanpak als in hoofdstuk 4 onderzoeken we of economische groei in de staten van de Verenigde Staten in de periode 1986-2000 afhangt van een aantal groeideterminanten die ook belangrijk zijn gebleken tussen soevereine landen. Ten eerste nemen we als benadering van inkomsten uit natuurlijke hulpbronnen het aandeel van de primaire sector in het Bruto Staatsproduct (BSP; het equivalent van BNP op het niveau van staten), en we bevestigen dat staten die rijk zijn aan hulpbronnen, zoals Alaska en Louisiana, een relatief lagere inkomensgroei hadden in die periode. We voegen opeenvolgend indicatoren toe voor investeringen, onderwijs, openheid, corruptie, en innovatie, en bevestigen hun belang in het verklaren van groeiprestaties. Gelijk aan onze bevindingen in hoofdstuk 4, verdwijnt het negatieve effect van natuurlijke rijkdom op groei indien we alle eerdergenoemde variabelen opnemen in onze analyse. Dit suggereert dat de 'resource curse' ook bestaat tussen staten binnen de Verenigde Staten, en dat dezelfde transmissiekanalen bestaan en een belangrijke verklaring vormen voor het fenomeen. We concluderen specifiek dat de staten die rijk zijn aan natuurlijke hulpbronnen te maken hebben met lagere niveaus van investeringen in kapitaal, onderwijs en innovatie, terwijl ze tegelijkertijd minder open zijn wat betreft immigratie én meer corruptie kennen. In aanvulling op onze cross-country resultaten, blijkt dat de kanalen die op kennis gebaseerd zijn, onderwijs en O&O, een grotere rol spelen dan investeringen in kapitaal.

Hoofdstuk 6 onderzoekt het verband tussen natuurlijke hulpbronnen en welvaart vanuit een lange-termijn historisch perspectief. Veel wetenschappers hebben het belang van natuurlijk hulpbronnen benadrukt voor de industriële ontwikkeling in de 18^{e} en 19^{e} eeuw. Dit argument suggereert dat het negatieve effect van natuurlijke rijkdom op economische groei een recent fenomeen is dat pas de laatste decennia optrad, ermee rekening houdend dat afnemende transportkosten en handelsbarrières de aanwezigheid van binnenlandse natuurlijke hulpbronnen wellicht minder cruciaal maakten voor economische ontwikkeling. Voor zover dat inderdaad zo is, kan een eerdere positieve bijdrage van hulpbronnen op inkomensgroei inderdaad een langdurig effect zijn geweest, dat nog steeds te zien is in de huidige verdeling van inkomens in de wereld. Onze aanpak richt zich op het verband tussen de natuurlijke rijkdom van kolonieën, het beleid van de kolonisator, de ontwikkeling van instituties, en de huidige inkomensniveaus in voormalige kolonieën. Op die plaatsen waar Europeanen zich in grote getale vestigden, importeerden zij uit hun thuislanden het institutionele raamwerk dat voornamelijk gebaseerd is op de bescherming van private eigendomsrechten en daarmee investeringen begunstigt. In andere kolonieën verkozen vestigden zich minder Europeanen en werd een lokale elite gevestigt die de lokale productie moest reguleren van goederen die werden ge-exporteerd naar de kolonisator. Het verschil tussen deze kolonisatiestrategieën en de geïmporteerde instituties hebben een belangrijke effect gehad dat terug te vinden is in de huidige relatieve welvaartsniveaus. We analyseren het endogene karakter van het vestigingsbeleid van kolonisten en bevestigen de stellingen van eerdere literatuur, dat kolonisten een voorkeur hadden voor gebieden met een relatief laag ziekte- en sterfterisico en waar de oorspronkelijke bevolking een lage organisatiegraad kende. In aanvulling daarop laten we zien dat regio's die rijk waren aan edelmetaal (goud en zilver) vooraanstaande vestigingsplaatsen waren in het verleden en dat deze regio's het institutioneel kader van de kolonist overnamen. Tegelijkertijd zien we dat een aantal belangrijke landbouwgoederen ten tijde van de kolonisaties (koffie, thee, cacao en suiker) Europese immigratie ontmoedigden, maar desondanks positief gecorreleerd zijn aan betere instituties. Onze bevindingen suggereren dat in het verleden natuurlijke hulpbronnen inderdaad een gunstige bijdrage hebben geleverd aan economische ontwikkeling, in tegenstelling tot de huidige trend dat landen die rijk zijn aan hulpbronnen een lagere economische groei laten zien.

In hoofdstuk 7, tot slot, worden de belangrijkste conclusies van alle voorgaande hoofdstukken samengevat en bijeen gebracht. Daarnaast worden aanbevelingen voor beleid ontwikkeld die zijn gebaseerd op de bevindingen van ons onderzoek en worden handreikingen gegeven om de "resource curse" aan te pakken. Beleid moet zich richten op de intermediaire mechanismen die verantwoordelijk zijn voor de "resource curse". Beleid dat besparingen en investeringen stimuleert kan waarschijnlijk een grote rol spelen in het vermijden van de "resource curse". De inkomsten uit natuurlijke hulpbronnen kunnen bijvoorbeeld ondergebracht worden in investeringsfondsen die deze transparant en efficiënt moeten beheren. Bovendien lijkt het een goede strategie om de inkomsten uit natuurlijke hulpbronnen te gebruiken om O&O activiteiten te stimuleren. Het behoeft niet gezegd te worden dat dit proefschrift bij lange na niet uitputtend is en dat er vele paradoxale aspecten van de "resource curse" niet onderzocht zijn. Hoofdstuk 7 geeft suggesties voor richtingen waarin dit onderzoek in de toekomst uitgebreid kan worden. Uitbreiden van de huidige dataset voor zogenaamde panel data analyse, het verkrijgen van historische gegevens over rijkdom aan hulpbronnen, en het onderzoeken van de informele aard van exploitatie van hulpbronnen in veel ontwikkelingslanden zijn enkele van die toekomstige richtingen. Aangezien de huidige prijsstijgingen van olie waarschijnlijk leiden tot een nieuwe positieve inkomensschok voor veel olieproducerende landen, is het zeer interessant om te zien welke lessen men heeft getrokken uit eerdere fouten en in hoeverre olieproducerende landen het vermogen hebben om hun extra inkomsten om te zetten in algemene economische welvaart voor de nabije en verdere toekomst.

ΠΕΡΙΛΗΨΗ (SUMMARY IN GREEK)

Η ΠΟΛΙΤΙΚΗ ΟΙΚΟΝΟΜΙΑ ΤΟΥ ΒΑΣΙΛΙΑ ΜΙΔΑ: ΑΦΘΟΝΙΑ ΦΥΣΙΚΩΝ ΠΟΡΩΝ ΚΑΙ ΟΙΚΟΝΟΜΙΚΗ ΑΝΑΠΤΥΞΗ

Εισαγωγή (Μέρος Ι)

Η κοινή οικονομική λογική υποδεικνύει ότι οι φυσικοί πόροι δίνουν την δυνατότητα επιπλέον εσόδων προς αξιοποίηση για την βελτίωση των συνθηκών διαβίωσης και μείωσης της φτώχειας. Αναπτυσσόμενες χώρες πλούσιες σε φυσικούς πόρους θα πρέπει λογικά να επωφεληθούν από τα επιπλέον έσοδα αξιοποιώντας τα για την αποπληρωμή συσσωρευμένων χρεών, για την βελτίωση της πιστοληπτικής τους ικανότητας και την υιοθέτηση φιλόδοξων αναπτυξιακών προγραμμάτων. Εάν αυτό που απαιτείται για την έξοδο από έναν φαύλο κύκλο οικονομικής στασιμότητας είναι μια γενναία εισοδηματική ενίσχυση, τότε τα έσοδα από φυσικούς πόρους θα μπορούσαν να βοηθήσουν στην μετάβαση σε μια εύρωστη αναπτυξιακή τροχιά. Ως προς τούτο, οικονομολόγοι ιστορικοί επέτειναν την σημασία των αποθεμάτων σε φυσικούς πόρους στην βιομηχανική επέκταση σε οικονομίες όπως αυτές των Ηνωμένων Πολιτειών και του Ηνωμένου Βασιλείου στην αλλαγή του 20^{ου} αιώνα. Πρόσφατα, χώρες όπως η Νορβηγία και η Μποτσουάνα εκμεταλεύτηκαν τα έσοδα από το εμπόριο πετρελαίου και διαμαντιών αντιστοίχως για να ενισχύσουν την οικονομική τους ανάπτυξη.

Τα τελευταία χρόνια έχει αναζωπυρωθεί το ακαδημαϊκό ενδιαφέρον γύρω από τον αντίκτυπο της αφθονείας φυσικών πόρων στην οικονομική ανάπτυξη. Πολλές μελέτες ισχυρίζονται ότι τα έσοδα από φυσικούς πόρους είχαν αρνητικές παρά θετικές συνέπειες για τον ρυθμό οικονομικής ανάπτυξης τις τελευταίες τρεις δεκαετίες. Η τάση των πλουσίων σε φυσικούς πόρους χωρών να μειοψηφούν ως προς την οικονομική ανάπτυξη έγινε γνωστή στη βιβλιογραφία ως η 'κατάρα της φυσικής αφθονείας' (resource curse). Παρόλο που η ανησυχία για τον αρνητικό αντίκτυπο των φυσικών πόρων μπορεί να εντοπιστεί ήδη στα συγγράμματα του Adam Smith, το ενδιαφέρον ενισχύθηκε την δεκαετία του 50, όταν οι Prebisch και Singer συσχέτισαν την αποτυχία αναπτυξιακών πολιτικών βασισμένων σε φυσικούς πόρους με την συνεχή φθίνουσα τάση των σχετικών τιμών των φυσικών αγαθών με αυτών των βιομηχανικών. Η ανατίμηση του ολλανδικού νομίσματος και η μείωση της ζήτησης βιομηχανικών προϊόντων μετά από την ανακάλυψη και εκμετάλλευση φυσικού αερίου στο Groningen το 60, αποτέλεσε την αφετηρία για την σύσταση βιβλιογραφίας πάνω στο φαινόμενο 'Dutch disease' (Ολλανδική Ασθένεια), που επικεντρώθηκε στον αρνητικό αντίκτυπο των φυσικών πόρων στην ανταγωνιστικότητα του εμπορίου. Τέλος, το NBER άρθρο των Sachs και Warner στα μέσα του 1990, αποτέλεσε την πρώτη εμπεριστατωμένη εμπειρική μελέτη και στατιστική επιβεβαίωση του φαινομένου. Η εργασία τους τόνωσε το ενδιαφέρον στο αντικείμενο και ενέτεινε το ακαδημαϊκό ενδιαφέρον. Η διατριβή αποτελεί μέρος της βιβλιογραφίας γύρω από την παράδοξη αρνητική συσχέτιση φυσικών πόρων και οικονομικής ανάπτυξης, επικεντρώνοντας στους ενδιάμεσους μηχανισμούς μέσω των οποίων το φαινόμενο λαμβάνει χώρα.

Το Μέρος Ι της διατριβής παρέχει μια εισαγωγή στην βιβλιογραφία της κατάρας των φυσικών πόρων και των υπαρχουσών προσεγγίσεων της. Επιπλέον, σχολιάζει εν συντομία τις συνέπειες μιας ανεπιτυχής αναπτυξιακής πολιτικής βασισμένης σε φυσικούς πόρους για την διατηρήσιμη ανάπτυξη (sustainability). Μια συρρικνώμενη οικονομία πλούσια σε φυσικούς πόρους αποτελεί παράδειγμα χαμένης ευκαιρίας για προσέγγιση με τις αναπτυγμένες οικονομίες και αποτυχημένης προσπάθειας να μεταφράσει τους φυσικούς πόρους σε ευημερία για μεταγενέστερες γενεές. Στο τέλος, το Μέρος Ι παρέχει μία επισκόπηση της διατριβής και σχεδιαγραφεί τα ερωτήματα προς διερεύνηση στα Μέρη ΙΙ και ΙΙΙ.

Θεωρία (Μέρος ΙΙ)

Το Μέρος ΙΙ της διατριβής αποτελείται από τα Κεφάλαια 2 και 3 που καταπιάνονται με δύο θεωρητικούς μηχανισμούς, ικανούς να εξηγήσουν τον αρνητικό αντίκτυπο της αφθονίας φυσικών πόρων στην οικονομική ανάπτυξη. Η ανάλυση και στα δύο κεφάλαια χρησιμοποιεί εκτενώς ιδέες από την βιβλιογραφία ενδογενούς οικονομικής μεγένθυσης, υιοθετώντας την άποψη ότι η τεχνολογική πρόοδος (ή οι βελτιώσεις στην παραγωγικότητα της εργασίας) είναι παράπλευρη συνέπεια της παραγωγικής διαδικασίας (learning-by-doing: Κεφάλαιο 2) ή οικειοθελές επακόλουθο του τομέα έρευνας (Κεφάλαιο 3).

Το επίκεντρο του Κεφαλαίου 2 είναι η εξερεύνηση της συσχέτισης φυσικών πόρων και αποταμίευσης στις πλουτοπαραγωγικές χώρες. Η αφθονία φυσικών πόρων μπορεί εύκολα να δημιουργήσει μία αίσθηση εφησυχασμού ως προς την ανάγκη προσεκτικού σχεδιασμού της οικονομικής πολιτικής. Η εξάρτηση από μία συνεχή ροή εσόδων από φυσικούς πόρους είναι ενδεχομένως ικανή να οδηγήσει σε χαλάρωση της οικονομικής πολιτικής και αύξηση της σπατάλης. Μία σημαντική συνιστώσα ορθού οικονομικού σχεδιασμού είναι η σωστή κατανομή του εισοδήματος μεταξύ αποταμίευσης και κατανάλωσης. Σε αυτό το κεφάλαιο αναπτύσσουμε ένα μοντέλο εναλλασσόμενων γενεών (OverLapping-Generations (OLG)), όπου διαδοχικές γενεές ζουν για δύο διαδοχικές περιόδους, έτσι ώστε σε κάθε περίοδο υπάρχει συνύπαρξη μιας νέας και μίας παλαιάς γενεάς. Κάθε γενεά εργάζεται στην νεαρή περίοδο της ζωής της και ζει από τις αποταμιεύσεις της όταν εισέλθει στην ηλικιωμένη περίοδο. Κάθε γενεά έχει ως στόχο την μεγιστοποίηση της χρησιμότητας (ευχαρίστησης) που απολαμβάνει από την κατανάλωση στις δύο διαδοχικές περιόδους της ζωής της, δεδομένου του εισοδηματικού περιορισμού που αντικρίζει. Αποδεικνύουμε τον τρόπο με τον οποίο οι φυσικοί πόροι μπορούν να μειώσουν την αποταμίευση όταν αποτελούν δημόσια περιουσία και χρησιμοποιούνται για την πληρωμή συντάξεων. Κάτω από αυτό το σενάριο, τα έσοδα από φυσικούς πόρους μειώνουν την ανάγκη για αποταμίευση μέσω της ενίσχυσης μελλοντικών εισοδημάτων. Η άμεση συνέπεια της συρρίκνωσης των αποταμιεύσεων είναι η μείωση της επένδυσης και μελλοντικού φυσικού κεφαλαίου. Επιπλέον, η βιομηχανική παραγωγή μειώνεται στον βαθμό που βασίζεται στο φυσικό κεφάλαιο. Η μείωση στο βιομηχανικό προϊόν ενισχύεται όταν η παραγωγικότητα της εργασίας (μέσω τεχνολογίας ή εκπαίδευσης) εξαρτάται από το επίπεδο του φυσικού κεφαλαίου. Αποδεικνύουμε ότι σε περίπτωση που η γνώση διαχέεται εκτενώς στην οικονομία, οποιαδήποτε βραχυπρόθεσμες θετικές συνέπειες των φυσικών πόρων στο επίπεδο ευημερίας είναι πιθανόν να υπερσκελιστούν από τον έμμεσο αντίκτυπο τους στο φυσικό κεφάλαιο. Σε αυτή την περίπτωση, το συνολικό επίπεδο ευημερίας θα μειωθεί και η κατάρα των φυσικών πόρων θα επακολουθήσει. Σε ένα μεγάλο βαθμό, ο αντίκτυπος των φυσικών πόρων εξαρτάται από τον καταμερισμό τους μεταξύ γενεών. Οι αποταμιεύσεις συρρικνώνονται σε μικρότερο βαθμό όταν οι φυσικόι πόροι θεωρούνται κοινό κτήμα και τα έσοδα τους καταμερίζονται ισότιμα μεταξύ καταναλωτών.

Στο κεφάλαιο 3 μετατοπίζουμε την προσοχή μας σε ένα εναλλακτικό μοντέλο, όπου η τεχνολογική πρόοδος εξαρτάται από έναν τομέα έρευνας. Η γεννήτρια της οικονομικής ανάπτυξης είναι η εργασία που αφιερώνεται αποκλειστικά στην εφευρετικότητα και την επιχειρηματικότητα. Το μοντέλο υποθέτει αθάνατα νοικοκυριά, που επιλέγουν σε κάθε περίοδο το επίπεδο της κατανάλωσης τους και το μερίδιο του χρόνου που αφιερώνουν στην ανάπαυλα, από τα οποία εξαρτάται η χρησιμότητα τους. Αναγκαστικά υπάρχει υποκατάσταση μεταξύ κατανάλωσης και ανάπαυλας δεδομένου ότι η κατανάλωση εξαρτάται από το εισόδημα εργασίας. Η οικονομία αποτελείται από τέσσερις τομείς. Υπάρχει ο βιομηχανικός τομέας, ο οποίος χρησιμοποιεί ως παραγωγικούς συντελεστές την εργασία και μια σειρά από ενδιάμεσα κεφαλαιουχικά αγαθά, τα οποία αποτελούν διαφορετικά είδη φυσικού κεφαλαίου. Έπειτα, υπάρχει ο τομέας κεφαλαιουχικών αγαθών, όπου οι επιχειρήσεις παράγουν τα ενδιάμεσα αγαθά χρησιμοποιώντας μη επεξεργασμένο φυσικό κεφάλαιο και τις σχετικές εφευρετικές ιδέες (πατέντες). Στη συνέχεια, έχουμε τον τομέα έρευνας, όπου τα νέα σχέδια ενδιάμεσων κεφαλαιουχικών αγαθών παράγονται, αυξάνοντας το επίπεδο γνώσης στην οικονομία. Ο τομέας έρευνας απασχολεί το υπόλοιπο της εργασίας που δεν απασχολείται στη βιομηχανία. Τέλος, υπάρχει ο πρωτογενής τομέας που εξαρτάται από τους φυσικούς πόρους της οικονομίας. Το κύριο ενδιαφέρον μας εστιάζεται στον αντίκτυπο μιας επέκτασης του πρωτογενούς τομέα στην οικονομική ανάπτυξη. Αναλύουμε τον τρόπο με τον οποίο τα έσοδα από φυσικούς πόρους μειώνουν το ποσοστό χρόνου που αφιερώνεται στην εργασία και αυξάνουν αντιστοίχως την ανάπαυλα. Μία αύξηση στον υπαρκτό φυσικό πλούτο δημιουργεί την δυνατότητα απόλαυσης του ίδιου επιπέδου χρησιμότητας με μειωμένο επίπεδο εργασιακού χρόνου. Στην ανάλυση, αποδεικνύουμε ότι ένας έμμεσος αντίκτυπος των αυξημένων εσόδων από φυσικούς πόρους είναι η μετατόπιση εφευρετικότητας (ευρηματικής εργασίας) από τον τομέα έρευνας στον βιομηχανικό κλάδο. Η οικονομική ανάπτυξη επιβραδύνεται για δύο λόγους: πρώτον, διότι αφιερώνουμε λιγότερο χρόνο στην εργασία, και δεύτερον διότι ένα μικρότερο ποσοστό του παραγωγικού δυναμικού αποφασίζει να ασχοληθεί με τον τομέα έρευνας.

Οικονομετρική Ανάλυση (Μέρος III)

Στο Μέρος III της διατριβής μετατοπίζουμε το επίκεντρο του ενδιαφέροντος από την θεωρία στην εμπειρική ανάλυση και εξετάζουμε την στατιστική συσχέτιση μεταξύ της αφθονίας φυσικών πόρων και της οικονομικής ανάπτυξης. Ο σκοπός είναι διπλός. Πρώτα, στοχεύουμε να πιστοποιήσουμε την ύπαρξη της κατάρας των φυσικών πόρων και να εξετάσουμε εάν οφείλεται στον αρνητικό αντίκτυπο των φυσικών πόρων σε μια σειρά μεταβλητών που επηρεάζουν την οικονομική ανάπτυξη, όπως προτείνεται στη βιβλιογραφία. Η συσχέτιση των φυσικών πόρων με τις μεταβλητές οικονομικής ανάπτυξης αναφέρεται συχνά ως τα ενδιάμεσα κανάλια μετάδοσης (της κατάρας των φυσικών πόρων). Από την άλλη, το εμπειρικό τμήμα της διατριβής εξετάζει ταυτόχρονα την εγκυρότητα των θεωρητικών μηχανισμών του Μέρους II. Ως προς αυτό, το θεωρητικό και εμπειρικό μέρος ενισχύουν και συμπληρώνουν το ένα το άλλο.

Το κεντρικό ενδιαφέρον της ανάλυσης του Κεφαλαίου 4 είναι η εξέταση του άμεσου και έμμεσου αντίκτυπου των φυσικών πόρων στην οικονομική ανάπτυξη χωρών την περίοδο 1975-1996. Για να εξετάσουμε την εξάρτηση της οικονομικής ανάπτυξης στους φυσικούς πόρους, εκτιμούμε τον ρόλο μίας σειράς μεταβλητών στην ερμηνεία διαφορών στον ρυθμό ανάπτυξης μεταξύ των χωρών του δείγματος. Η σειρά των μεταβλητών που επηρεάζουν την οικονομική ανάπτυξη αποτελείται από το αρχικό εισόδημα, μια μεταβλητή φυσικής αφθονίας και δείκτες επένδυσης, ανθρώπινου κεφαλαίου (δεξιότητες), ποιότητας θεσμών, ελευθερίας του εμπορίου και ανταγωνιστικότητας. Ως δείκτη φυσικής αφθονίας, χρησιμοποιούμε το ποσοστό παραγωγής ορυκτών στο ΑΕΠ (παραγωγή του συνόλου των αγαθών) στην αρχή της περιόδου. Όταν ενσωματώνουμε μονάχα το αρχικό εισόδημα και τους φυσικούς πόρους, υπάρχει μία σημαντική αρνητική συσχέτιση μεταξύ οικονομικής ανάπτυξης και φυσικής αφθονίας. Διαδοχικά προσθέτουμε τις υπόλοιπες μεταβλητές και παρατηρούμε ότι η αρνητική συσχέτιση μεταξύ φυσικών πόρων και οικονομικής ανάπτυξης σταδιακά μειώνεται. Αυτή η μείωση μας οδηγεί στο συμπέρασμα ότι οι φυσικοί πόροι δεν είναι ανασταλτικός παράγοντας της οικονομικής ανάπτυξης ως έχει, αλλά ο αντίκτυπος τους λαμβάνει χώρα εμμέσως μέσω της συσχέτισης τους με τις άλλες μεταβλητές οικονομικής ανάπτυξης. Το σύνολο των υπολοίπων μεταβλητών είναι επαρκές ώστε να εξηγήσει πλήρως την αρνητική συσχέτιση μεταξύ φυσικών πόρων και ανάπτυξης. Διαδοχικά πιστοποιούμε ότι η παραγωγή ορυκτών πραγματικά μειώνει την επένδυση, την εκπαίδευση, το εμπόριο, την ανταγωνιστικότητα και την ποιότητα των θεσμών. Μία σημαντική προσφορά της ανάλυσης είναι η εκτίμηση της σχετικής συνεισφοράς των καναλιών μετάδοσης στην κατάρα των φυσικών πόρων. Βρίσκουμε την επένδυση τον πιο σημαντικό μηχανισμό μέσω του οποίου οι φυσικοί πόροι μειώνουν την οικονομική ανάπτυξη. Ο αρνητικός αντίκτυπος των φυσικών πόρων στην επένδυση αναλογεί περίπου στο ήμισυ της συσχέτισης μεταξύ φυσικής αφθονίας και ανάπτυξης. Το εμπόριο και η ανταγωνιστικότητα ακολουθούν ως προς την σχετική συνεισφορά στην εξήγηση του φαινομένου. Τα αποτελέσματα αυτά βεβαιώνουν την σημαντικότητα του θεωρητικού μηχανισμού του Κεφαλαίου 2 ως προς την εξήγηση της κατάρας των φυσικών πόρων. Επιβεβαιώνεται όχι μόνο εμπειρικά η επένδυση ως κανάλι μετάδοσης της κατάρας αλλά και η σημαντική συνεισφορά του μηχανισμού στην εξήγηση της απογοητευτικής οικονομικής ανάπτυξης των πλουσίων σε φυσικούς πόρους χωρών.

Η ανάλυση στο Κεφάλαιο 5 θέτει το ερώτημα εάν η κατάρα των φυσικών πόρων είναι ένα σχετικό φαινόμενο μεταξύ περιοχών μέσα στην ίδια χώρα πέρα από μεταξύ κρατών. Προκειμένου να ερευνήσουμε το θέμα, χρησιμοποιούμε μία βάση δεδομένων για τις Ηνωμένες Πολιτείες εξετάζοντας εάν οι πλούσιες σε φυσικούς πόρους πολιτείες αναπτύσσονται με μικρότερους ρυθμούς. Η ανάλυση μας έρχεται σε αντίθεση με την έννοια της "απόλυτης σύγκλισης" που συχνά υιοθετείται στα οικονομικά περιφερειακής ανάπτυξης, η οποία θεωρεί το αρχικό εισόδημα ως τον μοναδικό παράγοντα που εξηγεί τις διαφορές στους ρυθμούς ανάπτυξης μεταξύ περιοχών. Ερευνούμε εάν οι πολιτείες είναι διαφορετικές ως προς έναν αριθμό χαρακτηριστικών που συνήθως εξηγούν διαφορές στην αναπτυξιακή πορεία χωρών. Ακολουθώντας ανάλογη μεθοδολογία με αυτή του Κεφαλαίου 4, εξερευνούμε εάν η οικονομική ανάπτυξη μεταξύ των Ηνωμένων Πολιτειών για την περίοδο 1986-2000 εξαρτάται από ανάλογες μεταβλητές. Κατ'αρχάς ενσωματώνουμε έναν δείκτη φυσικών πόρων (το ποσοστό του πρωτογενούς τομέα στο Ακαθάριστο Προϊόν Πολιτείας (ΑΠΠ), το οποίο αναλογεί στο ΑΕΠ σε επίπεδο πολιτείας) και επιβεβαιώνουμε ότι πλούσιες πλουτοπαραγωγικά πολιτείες όπως η Αλάσκα και η Λουϊζιάνα έχουν ένα σημαντικό μειονέκτημα στην οικονομική ανάπτυξη. Διαδοχικά ενσωματώνουμε δείκτες για την επένδυση, την εκπαίδευση, το εμπόριο, την διαφθορά και την εφευρετικότητα και πιστοποιούμε τον σημαντικό τους ρόλο στην οικονομική ανάπτυξη. Παρόμοια με το Κεφάλαιο 4, ο αρνητικός αντίκτυπος των φυσικών πόρων στην ανάπτυξη εξαφανίζεται σταδιακά με την ενσωμάτωση των προαναφερθέντων μεταβλητών στην ανάλυση. Αυτό υπαινίσσεται την ύπαρξη ανάλογων ενδιάμεσων μηχανισμών της κατάρας των φυσικών πόρων σε επίπεδο πολιτειών. Οι πλούσιες σε φυσικούς πόρους πολιτείες υποφέρουν από μικρότερα επίπεδα επένδυσης, εκπαίδευσης και εφευρετικότητας και παράλληλα είναι λιγότερο ανοικτές στην μετανάστευση και περισσότερο επιρρεπείς στην διαφθορά. Σε αντίθεση με τα αποτελέσματα μας μεταξύ χωρών, βρίσκουμε τους μηχανισμούς γνώσης της εκπαίδευσης και έρευνας να παίζουν σημαντικότερο ρόλο από την επένδυση. Η κατάρα των φυσικών πόρων μεταξύ περιοχών μέσα σε μία αναπτυγμένη χώρα φαίνεται να είναι διαφορετικής φύσης και να σχετίζεται με διαφορές στα επίπεδα εκπαίδευσης και έρευνας παρά στις διαφορές σε υποδομές και εμπόριο.

Το κεφάλαιο 6 στρέφεται στην σχέση μεταξύ φυσικών πόρων και ευημερίας μέσω μιας μακροχρόνιας ιστορικής προοπτικής. Πολλοί οικονομολόγοι δίνουν έμφαση στη σημασία των φυσικών πόρων στην βιομηχανική επέκταση πολλών πλούσια πλουτοπαραγωγικά χωρών τον 18ο και 19ο αιώνα. Αυτή η επιχειρηματολογία έμμεσα υπονοεί ότι ο αρνητικός αντίκτυπος των φυσικών πόρων στην οικονομική ανάπτυξη είναι πιθανότατα ένα πρόσφατο φαινόμενο των τελευταίων δεκαετιών στον βαθμό που τα μειούμενα μεταφορικά κόστη και εμπόδια εμπορίου κάνουν την ύπαρξη εγχώριων φυσικών πόρων λιγότερο αναγκαία για την εξασφάλιση γρήγορων ρυθμών ανάπτυξης. Στον βαθμό που αυτό αληθεύει, ο προηγούμενος θετικός ρόλος των φυσικών πόρων στην οικονομική ανάπτυξη μπορεί να άφησε έναν μακροπρόθεσμο αντίκτυπο στην τωρινή κατανομή του παγκόσμιου εισοδήματος. Η προσέγγιση μας επικεντρώνεται στη συσχέτιση μεταξύ τωρινών επίπεδων εισοδήματος, θεσμών, πολιτικών εποικισμού και φυσικών πόρων. Οι Ευρωπαίοι εισήγαγαν το θετικό για την επένδυση θεσμικό υπόβαθρο της χώρας καταγωγής τους, βασισμένο στην προστασία των δικαιωμάτων προσωπικής ιδιοκτησίας, όπου μετοίκισαν σε μεγάλους αριθμούς. Σε άλλες περιοχές οι Ευρωπαίοι προτίμησαν να μετοικήσουν σε μικρούς αριθμούς και να δημιουργήσουν μία τοπική αριστοκρατία ικανή να ρυθμίζει την τοπική παραγωγή. Οι διαφορές στις αποικιοκρατικές πολικές και εισαγόμενους θεσμούς είχαν έναν σημαντικό αντίκτυπο που ακόμα αντικατοπτρίζεται στην σημερινή κατανομή επιπέδων ευημερίας. Αναλύουμε τον ενδογενή χαρακτήρα των αποικιοκρατικών αποφάσεων των εποίκων και επιβεβαιώνουμε αποτελέσματα υπάρχουσας βιβλιογραφίας ως προς την προτίμηση των εποίκων για περιοχές με περιβάλλον λιγότερο επιρρεπή σε ασθένειες και με χειρότερα οργανωμένους αυτόχθονους πληθυσμούς. Ακόμη πιο σημαντικό για το θέμα της διατριβής, βρίσκουμε ότι οι περιοχές πλούσιες σε φυσικούς πόρους (χρυσό και ασήμι) αποτέλεσαν ιδιαίτερα επιθυμητούς προορισμούς για εποικισμό και κληρονόμησαν το θεσμικό υπόβαθρο των μητροπολιτικών χωρών. Από την άλλη, βρίσκουμε μία σειρά από σημαντικά αγροτικά προϊόντα κατά την αποικιοκρατική περίοδο (καφές, τσάι, κακάο και ζάχαρη) να αποθαρρύνουν την ευρωπαϊκή μετανάστευση, αλλά παρόλαυτα να συνεισφέρουν θετικά στους οικονομικούς θεσμούς. Τα ευρήματα μας υπονοούν ότι οι φυσικοί πόροι διαδραμάτισαν θετικό ρόλο στην οικονομική ανάπτυξη στο παρελθόν παρά την σύγχρονη τάση των πλούσιων πλουτοπαραγωγικά χωρών να μεγεθύνονται οικονομικά με μικρότερους ρυθμούς.

Τέλος, το Κεφάλαιο 7 αποτελεί την περίληψη της διατριβής και των συμπερασμάτων ανά κεφαλαίο. Επιπλέον, σχεδιαγραφεί συστάσεις οικονομικής πολιτικής βασισμένων στα συμπεράσματα της έρευνας της διατριβής και προτείνει μέτρα αντιμετώπισης της κατάρας των φυσικών πόρων. Η οικονομική πολιτική πρέπει να επικεντρωθεί στους ενδιάμεσους μηχανισμούς υπεύθυνους για την κατάρα. Πολιτικές αποταμίευσης και επένδυσης πιθανότατα θα βοηθήσουν σημαντικότατα χώρες να αποδράσουν από την παγίδα της κατάρας των φυσικών πόρων. Επιπλέον, η χρησιμοποίηση των εσόδων από φυσικούς πόρους για έρευνα αποτελεί μια εναλλακτική επιλογή. Επιπρόσθετα, τα έσοδα μπορούν να κατατεθούν σε επενδυτικά προγράμματα που εξασφαλίζουν διαφάνεια και αποτελεσματική διαχείριση. Πρέπει να προσθέσουμε ότι η διατριβή είναι αδύνατον να διαλευκάνει όλες τις παράδοξες πλευρές του φαινομένου της κατάρας των φυσικών πόρων. Το κεφάλαιο 7 προτείνει επεκτάσεις της ανάλυσης για μελλοντική έρευνα. Επεκτάσεις της τωρινής βάσης δεδομένων, η απόκτηση ιστορικών στοιχείων φυσικών πόρων και η εξέταση του ανεπίσημου χαρακτήρα του πρωτογενή τομέα σε πολλές αναπτυσσόμενες χώρες είναι μερικές από τις δυνατές κατευθυντήριες γραμμές για μελλοντική έρευνα. Δεδομένου ότι οι ανερχόμενες πετρελαϊκές τιμές είναι πιθανόν να δημιουργήσουν ένα θετικό σοκ εισοδήματος για πολλές χώρες, είναι ιδιαίτερα σημαντικό να κρατήσουμε υπ’όψιν μας τα λάθη από την προηγούμενη κακοδιαχείριση των φυσικών πόρων και να αξιολογήσουμε τις νέες δυνατότητες για μετατροπή των εσόδων από φυσικούς πόρους σε μακροχρόνια οικονομική ευμάρεια.

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