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Global Corporate Tax Competition for Export Oriented Foreign Direct Investment

Jose Rene Rendon-Garza

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GLOBAL CORPORATE TAX COMPETITION
FOR EXPORT ORIENTED FOREIGN DIRECT INVESTMENT

BY

JOSE RENE RENDON-GARZA

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree
of Doctor of Philosophy
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ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics in the Andrew Young School of Policy Studies of Georgia State University.

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ABSTRACT

GLOBAL CORPORATE TAX COMPETITION
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Economic integration and mobility of capital have set the ground for a significant competition over resources. Tax competition for internationally mobile tax bases such as foreign direct investments has become an important matter of study. Nevertheless, literature has focused on a regional or geographical neighboring condition competition through taxes. This dissertation aims to test whether tax competition for foreign direct investment has changed its regional characteristic towards a global or world-wide competition. Global or world-wide tax competition can be thought as uncooperative tax policy reactions between governments of different countries of the world not necessarily near each other geographically, but in similar economic conditions and with the purpose to influence the allocation of mobile tax bases world-wide. For the purpose of this study, export oriented foreign capital investment was referred to as the internationally mobile tax base.

A theoretical model was constructed allowing for three countries, geographical distance, transportation costs, labor and technology skills, as well as four types of individuals: workers, capitalists, and two types of entrepreneurs. Optimal corporate statutory and average effective tax rates were obtained in order to serve as reaction functions between governments and evaluate the presence of tax competition.

A spatial econometric model was used to estimate the empirical approximation of the theoretical model. Four types of weight matrixes were computed: homogeneous weights, similar economic conditions, similar transportation costs from the FDI host country to the FDI home country, and neighboring conditions of FDI host countries. The sample covered 53 countries from different areas of the world from 1984 to 2002.

Regarding the data, several variables were constructed, among those: the corporate average effective tax rate. The statutory corporate tax rate was discarded since it misses important factors for capital investment such as tax holidays and depreciation schedules.

The principal result suggests that countries from the sample appear to behave in a tax competitive way not only in geographical neighboring terms but also in a global or world-wide approach. In fact, countries appear to compete in a stronger way in global or world-wide terms than when assuming a regional or neighboring condition.

CHAPTER 1

INTRODUCTION

Mobility of capital and economic integration have had an enormous impact in improving living standards around the world by providing firms and consumers with new options of prices, products and forms of financing. Nonetheless, they have also brought new ways to increase competition and relocate resources worldwide. In fact, mobility of capital has set the ground for a significant competition over resources. Of particular concern is tax competition over internationally mobile tax bases, such as foreign direct investments (FDI).

In this sense, recently, the Mexican Ministry of Economy (MME) has noticed that many foreign firms (export maquila) from the electronic, textile, plastic, and furniture sectors, among others, previously functioning on Mexican territory, have decided to fly away to countries in completely different regions of the world, such as China, Philippines, Czech Republic, Thailand, and Malaysia. Additionally, Palencia and Angeles (2003a) from the Mexican National Board of the Export Maquila Industry (CNIME) have pointed towards the loss of competitiveness of Mexico against China, Malaysia, Korea and Thailand in the electric and electronic sectors, among others.[1] Both, MME and Palencia and Angeles (2003a), have concluded that among several factors affecting Mexico's FDI inflows, corporate tax rates appear to be not as competitive as those of the other countries to where many foreign firms are moving (see Palencia & Angeles, 2003a, 2003b; Secretaría de Economía [MME], 2002).

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[1] Additionally, empirical work by García-Herrero and Santabárbara (2004) show that from 1995 to 2001 China's inward foreign direct investment appears to have reduced that of Mexico and Colombia.

Analyzing those conclusions, it is clear that the countries above could be more competitive or less competitive than Mexico, in terms of wages, infrastructure, or transportation costs, but the fact that the Czech Republic, Philippines and Singapore, have reduced their corporate tax rates since 1997,[2] while China, Malaysia, and Thailand have given highly preferential treatments to foreign firms such as tax reductions and exemptions, accelerated depreciation, investment credits, and special deductions, represent an additional factor towards increasing competitiveness and attracting foreign capital.[3] Comparatively, Mexico has the highest statutory corporate tax rate among these countries of about 35 percent until 2002, 34 percent in 2003 and 33 percent in 2004.[4] On the other hand, Mexican policymakers have also encouraged attractive corporate tax policies in the form of special deductions, tax exemptions, and investment credits, but none of them at a similar level than in the countries mentioned previously (Ley del Impuesto Sobre la Renta, 2002). Thus, neither Mexico's corporate tax rates, nor its tax policies, seem as competitive as those of the previous countries and the conclusions provided by MME and Palencia and Angeles (2003a) from CNIME could not be that far from reality.

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[2] The Czech Republic, Philippines and Singapore reduced their statutory corporate tax rate set in 1997 at 39 percent, 35 percent, and 26 percent, respectively, to 28 percent, 32 percent, and 22 percent in 2004. On the other hand, China, and Thailand maintained their corporate tax rate at 33 percent and 30 percent, respectively since 1997, while Malaysia fixed its tax rate at 28 percent since 1998. See KPMG (1998, 1999, 2000, 2001, 2002, 2003, 2004).

[3] For example, the 33 percent corporate tax rate of China is composed of a 30 percent state tax and a 3 percent local tax. Nonetheless, the state tax may be reduced to a 15 percent or 24 percent if the foreign investment firms are located in a specially designated zone or associated in special operations or projects. Additionally, a foreign investment firm can be entitled to a tax exemption or reduction during a tax holiday period. Furthermore, the 3 percent local tax can be waived by the local government. In Thailand, the corporate tax rate is set at 30 percent; however, for small and medium enterprises or companies with less than Baht 5 million paid up capital, the corporate tax rate is 20 percent on the first Baht 1 million of net taxable profits and 25 percent on the next Baht 2 million. The corporate tax rate is also reduced to 20-25 percent for companies registered with the Stock Exchange of Thailand.

[4] See KPMG (2002, 2003, 2004).

Acknowledging the above fact, could it be possible that countries' policymakers in China, Philippines, Czech Republic, Thailand, or Malaysia have internalized that corporate taxes represent a factor towards increasing competitiveness, and given the high mobility of capital of these days, they have embarked on a reduction in corporate tax rates or in the provision of other corporate tax incentives in order to attract internationally mobile firms. Is it possible that Mexico, China, Philippines, Czech Republic, and Malaysia, could be presenting a degree of corporate tax competition to attract FDI? Note that these countries differ in competitiveness, but principally in the geographical region (i.e., continent) in which they are located.[5] Hence, restructuring the question above, does corporate tax competition among countries from far away geographical regions of the world occur?

In this context, what does the literature on tax competition states regarding a corporate tax competition scheme among countries at different regions of the world not located as geographical neighbors?

First we need to define the term "tax competition." According to Wilson and Wildasin (2004), tax competition can be defined as "non-cooperative tax setting by interdependent governments, under which each government's policy choices influence the allocation of a mobile tax base among regions represented by these governments." Alternatively, Alfano (2001) defines tax competition as "the possibility of countries to modify their tax base against the reduction of other countries' tax base." Thus, tax competition can be viewed as a reduction in domestic tax rates, or the implementation of partial exemption schemes, in order to enlarge the domestic tax base, or at least to attract economic activity.

[5] These countries are located far away in geographical distance terms.

Tax competition to attract foreign direct investment has been brought to debate from different lines of thought. One of such lines represented by authors as Zodrow and Mieszkowski (1986), Wilson (1986), Keen and Marchand (1997), Janeba and Wilson (1999), and Wellisch (2000) highlights its potential negative effects as tax competition may reduce welfare by leading to inefficient low levels of public expenditure and tax rates, limiting the scope of taxation, the ability to relocate income among citizens, and the provision of public goods.

Another line of thought comes from the public choice literature, which represents the strongest challenge to the notion that tax competition reduces welfare. Work by Brennan and Buchanan (1980), Rauscher (1997, 1998), Wilson and Wildasin (2004), and Parry (2001) indicate that tax competition benefits countries by improving welfare through a reduction in wasteful government spending. The reasoning behind their proposal is that politicians and government officials act to maximize their own objectives or are at least greatly influenced by rent-seeking special interest groups. Government provides the infrastructure and institutional framework in which economic activity takes place. If it is inefficient, mobile factors are driven out of the country leading to a decline in income and employment of the immobile factors. As a consequence, the voters would be worse off and would punish the government by electing other parties or candidates counteracting the politicians own objectives of reelection. The government, then, is forced to act and increase the jurisdiction's attractiveness to mobile factors of production requiring lower taxes and better public services. For that reason, the part of the budget spent by public officials for their own interests must shrink, allowing government's officials to reduce waste in government spending. Furthermore, tax competition potentially serves an important beneficial role in that it may limit the tendency of local governments to overexpansion.

Considering the above arguments it is clear that there is no common consensus on the basic literature of tax competition. However, there is a mutually used common characteristic in these approaches, and that is that both lines of thought build their studies on a regional tax competition basis, which implies competition through tax rates along a given neighboring geographical area or region.

Hence, a corporate tax competition scheme among countries at different regions of the world has not been brought into debate in the current literature of tax competition.

In this sense, it results important to research if policymakers of countries such as China or Czech Republic are taking into account other countries' corporate tax policies from far away geographical regions of the world when setting their own. Furthermore, mobility of capital and economic integration could be setting the ground for a world-wide corporate tax competition for internationally mobile firms that could not be just limited to a regional competition through corporate taxes.

Thus, this dissertation differs from the contributions of previous literature in the sense that it considers competition through corporate taxes globally or world-wide. Global or world-wide tax competition can be thought as uncooperative tax policy reactions between governments of different countries of the world not necessarily near each other geographically, but in similar economic conditions and with the purpose to influence the allocation of mobile tax bases world-wide. For the purpose of this study, export oriented foreign capital investment was referred to as the internationally mobile tax base. For countries in similar economic conditions we assume economies that fall in a given interval of gross national product per capita.[6]

The idea behind this argument is that export oriented firms search for the most profitable after tax location for their investments taking into account the whole package of costs, such as labor costs, capital costs, and transportation costs, but also the optimal level of labor and capital, as well as taxes, among other deterministic factors. The most profitable location does not need to be in the neighboring country of where the firm is already located, and in fact it could be in a completely different continent if costs of production determine so. Countries, on the other hand, seek to attract FDI by increasing their relative competitiveness; this is determined by the countries' level of infrastructure, wages, transportation costs, openness to trade, taxes, skills, technology, and availability of labor, among other factors. For example, a country in the American continent can offer higher after tax profits to an export oriented firm located in Asia and encourage that firm to relocate. The country in America would certainly have to be more attractive than that in Asia for the relocation to occur. Hence, countries in different geographical areas can compete to attract FDI by being more competitive, offering lower wages, greater infrastructure, more skills and technology, higher rates of allowance, and lower corporate taxes. There are factors such as wages and labor availability that depend on labor market conditions rather than on governments' decisions, at least directly; others such as infrastructure, labor skills and technology can not be changed in a short period of time or they are fixed at the short run. This may leave as the only viable options in the short run to decrease the country's corporate tax rate or to offer a more generous allowance under

[6] One of such classification of the world economies is provided in World Bank (2003, 2004).

the corporate income tax. Thus, it is in this form that a global or world-wide tax competition may take place.

The main objective of this dissertation is to research if there is corporate tax competition, not only from a regional point of view, but from a global perspective also. In other words, the purpose of this work is to evaluate the possibility of corporate tax competition among countries that are located far away from each other in different geographical areas or regions; that is, without a geographical neighboring condition. Additional questions are established in the dissertation in order to examine the effects on the corporate tax rates of the difference in wages, in openness to trade, in FDI attraction, and in technological skills among countries.

Several critical assumptions are needed in order to conduct this study. One assumption is related to the type of firms interested in relocating without regard to the country or continent. These firms are likely to be of an export oriented type; seeking for the most profitable (after tax) locations, see for example Reuber (1973), Guisinger (1985), and Coyne (1994). A second central assumption is the presence of a proactive government, one that reacts to deficiencies or improvements in its economy by proposing, in a reasonable period of time, diverse policies in order to stabilize, correct, or improve the economic situation of its country. Without this assumption, we would have non-proactive governments which would not provide the required framework for tax competition, neither regional, nor global.

The theoretical model in this dissertation follows the approach developed by Devereux, Lockwood, and Redoano (2002) but their framework is expanded to allow for a third country, workers, two types of entrepreneurs and capital, geographical distance between countries, transportation costs, labor skills, and technology skills. The model starts with the discussion of the two tax instruments the government uses to finance the provision of a public good. After that, we describe the income and preferences of four types of individuals: capitalists, workers, home producing entrepreneurs, and export oriented entrepreneurs. The model recognizes the four of them by maximizing a social welfare function, which is simply the sum of the utilities of the different types of individuals, subject to the firms' location decision constraint. The model is divided into different stages each corresponding to an event. First, governments in both countries choose their optimal corporate tax instruments; second, entrepreneurs make relocations decisions; third, entrepreneurs purchase capital inputs and hire workers; and four, production, consumption and exports take place. Although the four stages are important, our interest relies on the first three, with primary concern of what happens at stage one. The objective of the model is to search for the optimal corporate tax rate that would serve as reaction functions between governments. The existence of these reaction functions will allow us to evaluate the presence of tax competition. As we will see in the theoretical model, the corporate tax rate reaction of a country does not depend only on its own country's factors such as wages, transportation costs, skills, and technology, but also on the competing countries' factors such as corporate tax rates, wages, transportation costs, skills, and technology.

A spatial econometric model is used to estimate the empirical approximation of the model presented in the theoretical section. Four types of weight matrixes are computed in order to provide the basis for an evaluation of the presence of a global (corporate) tax competition: (1) homogeneous weights; (2) similar economic conditions (global tax competition); (3) similar transportation costs (approximated by the geographical distance between home and host FDI countries); and (4) neighboring condition of FDI host countries.

Several variables such as average effective tax rates, wage differences, and differences in foreign direct investment inflows, among others, are specified and calculated in order to develop the empirical model properly.

The empirical approach follows a similar methodology to that used in Cavlovic and Jackson (2003), Altshuler and Goodspeed (2002), Hayashi and Boadway (2001), Brueckner (2003), Revelli (2000), and Brueckner and Saavedra (2001). The approach represents a derivation from the spatial econometric model described in Anselin (1999), and Lopez and Chasco (2004) as a "pure space-recursive model" or a "non-contemporary or lagged spatial dependence model," respectively.

The empirical evaluation comprises four estimation methods, for each of the four weight matrixes: fixed individual and time effects jointly, fixed individual effects only, fixed time effects only, and no fixed effects (simple panel data).

Among the most important findings, one of them considers that the countries from the sample behave in a tax competitive way, not only in geographical neighboring terms as the current corporate tax competition literature suggest, but also in a global or world-wide approach assuming similar economic conditions, and when internalizing the fact that their competitors have similar transportation costs.

Another conclusion implies that the level of competition appears to be greater for the global tax competition framework than that regarding regional tax competition, and when assuming similarity in transportation costs. Nonetheless, the greatest influence on the optimal corporate tax rate comes from the same weights approach. In this sense, countries could be synthesizing several distinctive factors from each of the three other weighting schemes that could explain the highest value of the estimated effect under the homogeneous weights matrix.

The rest of this dissertation is organized as follows. Chapter 2 provides a brief overview of the background stylized facts that lead us to consider the idea of the presence of global tax competition. Chapter 3 offers a review of the literature on regional tax competition starting with the earliest theoretical works and ending with recent empirical researches. Chapter 4 presents the theoretical model of corporate tax competition identifying corporate tax reaction functions that take into account deterministic variables for each country. Chapter 5 presents the empirical specification as well as the econometric approach. It describes the computation of the weight matrixes, the measurement of the most appropriate effective tax rates, and wage differences, among other estimations. Chapter 6 presents regressions' results with a focus on identifying the most appropriate estimation method. Finally, Chapter 7 provides a summary of the conclusions of this dissertation, some policy implications, as well as suggestions for future research.

CHAPTER 2

AN OVERVIEW OF INTERNATIONAL TRENDS IN FDI

Economic integration and factor mobility have facilitated the creation of a single world economy; greater capital mobility, rapid transfers of technology and increasing flows of trade and investment have helped increase this level of integration. At the same time, many governments have taken key measures to encourage this integration, of which reductions in trade and investment barriers and the deregulation of financial markets are among the most important.

The world has witnessed an increased movement of capital investments flows in the last few decades. Physical distance, previously a great obstacle for mobility, eventually has become an irrelevant determinant of businesses location today. As a consequence of globalization, firms and consumers have benefited from new options for prices, products, and forms of financing. It is clear that new ways of doing business have emerged with this new economic environment, but it is also evident that new forms of competition are now present in the world economy. Global competition through taxes, the topic of this dissertation, is one of them.

The objective of this chapter is to present an overview of international trends in foreign direct investment (main investors and recipients) and governments' corporate tax policies as a background for the theoretical model and empirical work of the latter chapters in the dissertation.

Foreign Direct Investment

World economies have become more tightly integrated in recent decades. Rapid growth in cross border investment encouraged by technological advances and government deregulation has been a key determinant of integration. Since the 1970s, most countries have reduced or eliminated controls on foreign currency exchange, the purchase of foreign securities, and the ability of foreigners to buy domestic securities and companies.[7] Hundreds of bilateral investment treaties have been signed to lower investment barriers, in addition financial markets have been deregulated in dozens of countries, making them more attractive to foreign investors.

Throughout the world, direct investment flows have boomed from $55 billion in 1980 to $208 billion in 1990 and $1.397 trillion in 2000 (United Nations Conference on Trade and Development [UNCTAD], 2005b).[8] These boosts represent an increase of $153 billion from 1980 to 1990, a $1.06 trillion from 1990 to 2000, and a $1.34 trillion from 1980 to 2000. Nonetheless, between 2000 and 2001, foreign direct investment flows into and out of countries recorded their largest drop in recent decades. In this period, world's total inflows fell from $1.397 trillion to $826 billion, or a decline of around 41 percent, of which developed countries accounted for 39 percentage points and developing economies for 2 percentage points. Alternatively, the European Union countries FDI inflows declined significantly in 2001 on the order of $311.4 billion, that is, a 46 percent plunge. (UNCTAD, 2005b)

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[7] See International Monetary Fund (2001, October).

[8] Foreign direct investment can be defined as the direct investment of a firm made outside of its home country. More specific definitions are given in UNCTAD (2001, September), and Drabek and Payne (2001).

When assessing the causes of the drop in international investment in 2001 it is essential to keep in mind the previous year's levels of FDI ($1.397 trillion). The total amount of FDI in 2000 stood at an all-time historical high, at almost five times the levels recorded in 1994 ($260 billion). The decline between 2000 and 2001 essentially eliminated two thirds of the increase by reducing FDI inflows to more than twice the level they had reached in the mid-1990s ($341 billion in 1995). In other words, the developments in 2001, rather than an influential decline in international investment flows, appear to have marked a correction toward more sustainable levels, following what could arguably have been an investment bubble in 1999 and 2000 (UNCTAD, 2005b).

Regarding 2004, world FDI inflows reached $648 billion registering a slightly increase of 15.5 billion since 2003; however, in comparison to 2001, they showed a decline of $177.8 billion, that is a 22 percent decrease.[9] The reduction in the FDI inflows in developed countries was 36 percent, while developing economies presented an increase of 17 percent. Within the developed economies, the European Union showed a decrease of 46 percent. Adding up the decline in the FDI inflows of Canada, United States, France, Netherlands and Germany, the total amount reached $232.6 billion, a greater sum than the total world FDI inflows fall from 2001 to 2004 (UNCTAD, 2005b).

Additionally, from 2001 to 2004 developing economies from America recorded a decline of $21.6 billion, or 24 percent. At the same time, African countries FDI inflows decreased $1.9 billion.

In contrast, Asia and Oceania developing economies showed an increase in their FDI inflows in the order of $38.9 billion, or 36 percent. It must be noted that, taking into

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[9] The comparison is made against 2001, since 2000 appears to be an investment boom year, and 2001 appears to have marked a correction toward more sustainable levels of FDI inflows.

account the whole period from 2000 to 2004, the countries that received the most in foreign direct investment inflows were China accumulating $20 billion, and Australia with $28 billion in that period (UNCTAD, 2005b).

The reasons for the 2002 and 2003's significant downturn appeared to have been weak economic growth, tumbling stock markets (which contributed to a plunge in cross-border mergers and acquisitions) and institutional factors such as privatizations in several countries. However, in 2004 global inflows of FDI rose for the first time in four years. The recovery appeared to have responded to a favorable recuperation in the macro, micro and institutional factors. For example, the process of privatization came to an end in several countries, and the strong economic growth and the large scale restructuring and consolidation of businesses brought many companies back to profit making in 2004 (UNCTAD, 2005a).

In recent years, direct investment has primarily flowed out of United Kingdom, France, Belgium, Luxemburg, Spain, Netherlands, Germany, Hong Kong, Canada, United States, and Japan. In 2004 the United States was the highest foreign investor with $229.3 billion, followed by the United Kingdom with $65.4 billion. It must be noted that the United States and the United Kingdom amounted for the 31 percent and 9 percent, respectively, of the FDI outflows from that year, which reached $730.3 billion. On the other hand, the developed economies that attracted the most direct investment inflows in 2004 are: United States, United Kingdom, Australia, Ireland, France, Belgium, Luxemburg, Spain, and Italy (UNCTAD, 2005b). Among these, the highest recipient in 2004 was the United States with $96 billion, closely followed by the United Kingdom with $78.4 billion. With regard to the developing economies, China was the highest recipient with $60.6 billion, followed by Hong Kong with $34 billion, Brazil with $18.2 billion, Mexico with $16.6 billion and Singapore with $16.1 billion. The global FDI inflows in 2004 amounted $648 billion.

As illustrated previously, countries have continuously sought to attract direct investment inflows due to their notable advantages; besides providing with more choice variety of products, services and prices, FDI can provide more jobs, higher wages, greater consumption, tax revenues and investments from outsiders and insiders.

For these reasons, countries often have modified their economic fundamentals in order to attract foreign investment. These changes have included a stable currency, trustworthy legal rules, and liquid and transparent financial markets. Dozens of formerly socialist countries have begun to get the fundamentals right in the past decade and most industrial countries have made substantial market reforms. As a consequence of these processes, tax policy has risen in importance as a factor influencing global investment flows. The fundamental reason is that, as other factors become more equalized among countries, investors have become increasingly more sensitive to differences in tax treatment.

Taxes as a Determinant of Foreign Direct Investment

There is increasing evidence that decisions about the location of businesses have become more sensitive to tax factors. Traditionally, an important reason to invest abroad was to gain access to fixed resources, such as oil deposits or land. Today, more industries are highly mobile and can be located just about anywhere. For example, according to the United States Department of Commerce, finance and services are the two fastest growing areas of American direct investment abroad.[10] Also, an increasing share of product value is in the form of intangibles such as knowledge, trademarks, and patents, since the profits from intangibles may be easily moved to low-tax countries. Because of laxer controls and more pro-business legal environment, corporations, today, have greater ability to move profits to low-tax locations than previously was the case.

Academic empirical research has confirmed that foreign direct investment is becoming more sensitive to taxes. In a compilation of studies on the issue, Grubert and Mutti (2000) suggest that the location of U.S. multinational firms may have become more sensitive to differences in after tax returns between 1982 and 1992. Also, work by Bénassy-Quéré, Fontagné, and Lahrèche-Révil (2001) using OECD's data from 1985 to 1995 shows that firms react to tax discrepancies when deciding their location, that is, a tax cut in one country encourages an increase of FDI to that country, at the expense of other countries.

Alternatively, Hines (1999) concludes that besides corporate borrowing, transfer pricing, dividend and royalty payments, and research and development performance, taxes affect in a significant form the location of foreign direct investment. In addition, work by Altshuler, Grubert, and Newlon (2001) finds that American multinationals became more sensitive to taxes on FDI between 1984 and 1992. The results of the study indicate that countries with an increase of 10 percent in their tax rates received 30 percent less American direct investment in 1992.

Similarly, Gropp and Kostial (2000) found strong evidence that FDI is affected by tax factors. This study found that, of the countries examined, those with lower taxes had larger inflows of FDI than those with higher taxes. Sullivan's (2002) analysis

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[10] See Bureau of Economic Analysis [BEA] (2000, July).

indicated that Ireland, Netherlands, Luxembourg, and Switzerland, four European countries with favorable tax regimes, have accounted for 9 percent of European GDP but attracted 38 percent of American FDI in Europe between 1996 and 2000 (Sullivan, 2002).

In conclusion, given the high mobility of capital of these days, taxes have become a factor of observance by mobile firms since it represents an important part of their profits (after tax). In other words, recent literature has suggested that FDI has become more sensitive to corporate tax policies than before.

The following section provides an insight into how countries' policymakers acknowledging the above fact have made corporate taxes a factor of action towards maintaining or increasing the economies' competitiveness.

Global Reduction in Tax Rates

The great majority of industrial nations have reduced their corporate income tax rates in the last decades to ensure that their economies remain attractive for foreign investment. In this context, a significant part of the recent tax reforms in the European Union (EU) has been devoted to reductions in corporate taxation. These measures aim, in the first place, to raise investment and production incentives and, in some cases, to remove existing tax distortions. Countries such as Belgium, Denmark, France, Luxemburg, Germany, Ireland, and Netherlands, among others, have reduced its corporate tax rate in recent years. Portugal approved a decrease in its corporate tax rate from 32 percent in 2000 to a 30 percent in 2002, and it is proposing an even steeper decline in the rate to a 25 percent by 2006. Furthermore, other countries such as Austria have reduced their corporate tax base in 2000 through increased research and development allowance, and deemed interest deduction on equity investment (Bénassy-Quéré, Fontagné & Lahrèche-Révil, 2001).

On the other hand, some Nordic countries have adopted dual income tax systems in response to rising tax competition. These systems feature a low flat rate on capital income (interest, dividends, and capital gains) while retaining progressive rates on labor income. Denmark, Finland, Norway, and Sweden implemented such reforms a decade ago and Netherlands and Austria have recently enacted similar reforms. Joumard (2001) notes that such moves toward a lower and flat tax on capital income has often reflected the need to remain competitive on international capital markets.

Figures from the OECD confirm countries' desire to remain attractive for FDI with the average top corporate tax rate for national governments in the OECD falling from 41 percent in 1986 to 32 percent by 2000 (Edwards & de Rugy, 2002; Organisation for Economic Cooperation and Development [OECD], 2001).

Alternatively, KPMG surveys which take into account both national and sub-national taxes, show that the average corporate tax rate fell from 36.8 percent in 1997 to 30.0 percent by 2004, a drop of 6.8 percentage points in seven years (see KPMG, 1998, 1999, 2000, 2001, 2002, 2003, 2004). The highest decline on corporate tax rates belongs to Ireland with a 23.5 percentage points decrease from 1997 to 2004. Other countries that followed this trend are Czech Republic, Germany, Iceland, Italy, Poland, Portugal, and Turkey, all of these with decreases greater than 10 percentage points in seven years. In contrast, the average corporate tax rate for selected Non-OECD countries decreased 2.6

percentage points, from 31.2 percent in 1997 to 28.6 percent in 2004.[11] The largest 2004's negative deviation from average belongs to Cyprus with a difference of 14 percentage points, followed by Chile and Hong Kong, with 12 and 11.5 percentage points, respectively. On the other hand, the lowest corporate tax rate of both groups, OECD and Non-OECD, is Ireland's 12.5 percent; that is a 17.5 percentage point deviation from OECD's average.

The statutory corporate tax rate is just one factor determining the attractiveness of a business tax climate, an additional indicator is the corporate effective marginal tax rate, which must take into account depreciation deductions, investment credits, and other provisions.[12] Effective corporate tax rates have fallen in the OECD countries in recent years, although not by as much as statutory rates (Bénassy-Quéré, Fontagné & Lahrèche-Révil, 2001). For many corporate decisions, statutory rates are nonetheless the relevant tax factor to consider. As Mintz and Smart (2004) noted, reported income of corporations can be highly elastic with respect to the statutory tax rate since income can be easily shifted from one tax jurisdiction to another without moving real assets.

Asian countries, such as China, Korea, Thailand, Malaysia, and Singapore, among others, have also reacted to the world's trend by providing tax incentives towards attracting FDI. China, for example, regardless of instituting a uniform corporate tax rate of 33 percent for foreign investment enterprises and domestic companies since 1991, has

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[11] The selected Non-OECD countries are: Argentina, Bangladesh, Belize, Brazil, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Dominican Rep., Ecuador, El Salvador, Fiji, Guatemala, Honduras, Hong Kong, India, Indonesia, Malaysia, Pakistan, Panama, Paraguay, Peru, Philippines, Romania, Russia, Singapore, South Africa, Taiwan, Thailand, Ukraine, Uruguay, Venezuela, and Vietnam. These countries were selected since data for them continuously appeared in the KPMG surveys of 1998, 1999, 2000, 2001, 2002, 2003, and 2004.

[12] The statutory tax rate is the tax rate established by the government. The marginal effective tax rate is measured by the difference between the pre-tax and after tax rates of return on the investment. On the other hand, the average effective tax rate is measured by dividing actual taxes paid by an independent measure of income. See Chapter 5 for a further explanation.

set highly preferential treatments of foreign investment enterprises through various tax incentive practices such as tax reductions and exemptions, investment credits, rate reductions, accelerated depreciation, and special deductions (KPMG, 2004).

Singapore has also tasted the improvements brought by FDI in such a form that they have acted towards providing tax incentives by reducing its corporate tax rates from 26 percent in 2000 to 22 percent in 2004. Furthermore, Singapore does not tax capital gains, and operating expenses are generally deductible except for a small number that are statutorily disallowed.

The strongest pressure towards tax competition appears to occur between countries that have deep trade, investment, and cultural ties. For example, after the United States cut tax rates in 1986, Canadian policy makers were very concerned that American companies would shift profits from their more highly taxed Canadian subsidiaries to their American operations (Whalley, 1990). They could do this relatively easily by increasing debt financing in their Canadian subsidiaries to shift taxable income out of Canada. As a consequence, Canada moved quickly to cut its corporate tax rate to avoid losing its tax base. Canada's corporate tax rate dropped 8.5 percentage points from 44.6 percent in 1997 to 36.1 in 2004 (KPMG, 1998, 1999, 2000, 2001, 2002, 2003, 2004).

Mexico, on the other hand, has reacted to the global trends and has approved a gradual reduction of its corporate tax rate of 35 percent in 2002 to a 30 percent by 2005. The reduction would be of the order of one percentage point since 2005 until it reaches 28 percent by 2007. Furthermore, this new law eliminates the option to defer a portion of the corporate tax when dividends are not distributed. Additionally, this new law also eliminates the 5 percent withholding tax on dividend distributions (see Servicio de Administración Tributaria, 2005; KPMG, 2002, 2003, 2004).

A different tax factor, the corporate capital gains tax, has been cut in numerous countries. For example, Germany's recent tax reforms abolished its 50 percent capital gains tax on sales of stakes in other companies because of competitiveness concerns. In fact, the German reforms prompted the European Union to express concern that this may constitute unfair tax competition because it will attract foreign holding companies to Germany (Lomas, 2001). Holding companies and corporate head-quarters have long been attracted to Netherlands because it does not tax corporate capital gains, and has a territorial tax system for businesses (Lodin, 2001).

Another policy response to tax competition has been the reduction and elimination of special taxes on wealth, which have been undermined by capital mobility. In the 1990s, Norway and Sweden reduced their wealth taxes and Denmark, the Netherlands, Austria, and Germany abolished them (Messere, 2000). Huizinga and Nicodeme (2004) surveyed 19 countries and found that the average wealth tax has fallen 40 percent since the mid-1980s. Tax competition has also driven down with-holding taxes, these are taxes placed on payments to foreigners of interest, dividends, and other investment returns. Withholding taxes create an investment disincentive by placing an exit fee on repatriated income. The survey of 19 major economies found that the withholding tax on bank interest has been more than cut in half in the past decade.

In summary, tax competition has caused substantial cuts in corporate statutory income tax rates. Other reforms have included reductions in wealth taxes, withholding taxes, and capital gains taxes.

Global Tax Competition

Mobility of capital and economic integration have expanded the wave of possibilities and competition around the world. Distance has been changing its nature from deterministic to non-deterministic among the firms' decisions. Export oriented firms with the aim to invest abroad have demonstrated predilection for countries which provide them with higher profits, among other reasons because of taxes. And lastly, given the obvious advantages of direct investment inflows into a country, economies have embarked on the reduction of their statutory corporate tax rates or in the provision of other corporate tax incentives, showing a degree of competition through taxes.

Examples of world-wide tax competition are becoming more common. For example, in 2002 the Mexican Ministry of Economy (MME) noticed that foreign firms from the export maquila of important sectors of the economy, previously functioning on Mexican territory, decided to leave the country in order to locate in a complete different region of the world, such as China, Philippines, Czech Republic, Thailand, and Malaysia, among others. Alternatively, in 2003 researchers and analysts from the Mexican National Board of the Export Maquila Industry (CNIME), Palencia and Angeles (2003a), signalized and highlighted the lost of competitiveness of Mexico against China, Malaysia, Korea and Thailand, again in important sectors of the economy.

An interesting conclusion of MME and CNIME researchers was that, among several factors influencing Mexico's FDI inflows, corporate tax rates seem not as competitive as those of the countries above, and that issue appeared to be a determinant factor in the firms' location decision.

On the evaluation of their arguments, the countries mentioned previously could have similar of completely different levels of infrastructure, wages or transportation costs than Mexico, making them more competitive or less competitive in those terms, but there are interesting facts when observing the corporate tax policies evolution of these countries. First, the Czech Republic, Philippines, and Singapore, have reduced their corporate tax rates since 1997 (KPMG, 1998, 1999, 2000, 2001, 2002, 2003, 2004). In 1997 the statutory corporate tax rate of the Czech Republic was set at 39 percent, while in 1998 it was 35 percent, 31 percent in 2000, and finally 28 percent in 2004. That is an 11 percentage points decrease in 8 years. Regarding Philippines and Singapore, they reduced their statutory corporate tax rate from 35 percent and 26 percent, respectively, in 1997, to 32 percent, and 22 percent in 2004. On the other hand, since 1997 China and Thailand maintained their corporate tax rate at 33 percent and 30 percent, while Malaysia fixed its tax rate at 28 percent since 1998.

Additionally, China, Malaysia, and Thailand have given highly preferential treatments to foreign firms such as tax reductions and exemptions, accelerated depreciation, investment credits, and special deductions. China, for example, has a 33 percent corporate tax rate, which is composed of a 30 percent state tax and a 3 percent local tax. Nevertheless, the state tax can be reduced to a 15 percent or 24 percent if the foreign investment firms are located in a specially designated zone or are related to associated operations or projects. Additionally, a foreign investment firm can be entitled to a tax exemption o reduction during a tax holiday period. On the other hand, the 3 percent local tax can be waived by the local government.

In Thailand, the corporate tax rate is set at 30 percent; however, for small and medium enterprises or companies with less than $122,000 (Baht 5 million) paid up capital, the corporate tax rate is 20 percent on the first $24,360 (Baht 1 million) of net taxable profits and 25 percent on the next $48,700 (Baht 2 million). The corporate tax rate is also reduced to 20-25 percent for companies registered with the Stock Exchange of Thailand.

On the other hand, Mexico has the highest statutory corporate tax rate among these countries of about 35 percent until 2002, 34 percent in 2003 and 33 percent in 2004 (see KPMG, 2002, 2003, 2004). Furthermore, Mexican policymakers have also encouraged attractive corporate tax policies in the form of special deductions, tax exemptions, and investment credits, especially in sectors such as agriculture, fishing, and transport (Ley del Impuesto sobre la Renta, 2002). However, none of them at a similar level than in the countries above. In addition, since the last President's administration (1994-2000) and until the current administration (2000-2006), Mexico has been waiting for a complete Tax Policy Reform that could make the country competitive in tax terms.

Hence, neither Mexico's corporate tax rates, nor its tax policies, have been considered as competitive as those of the countries previously mentioned, and MME and Palencia and Angeles (2003a) from CNIME could be right in their conclusions.

The Mexican government's lack of providing opportune efficient tax policy reforms to combat neighboring and non-neighboring countries' tax policies and economic advantages could bear a part of the responsibility of the Mexican capital flight. Firms, as rent seekers, have been attracted by lower corporate tax rates and efficient tax policy reforms in different regions of the world. Their decision was to leave Mexico in order to reach higher profits (after tax) taking into account within their analysis factors such as distance, transportation costs, wages, and of course, corporate tax rates.

Extracted from the above there are different indicators that point towards the possibility of a tax competition framework among Mexico, China, Philippines, Czech Republic, and Malaysia, among many countries. A possibility that could indicate some signs that countries' policymakers in China, Philippines, Czech Republic, Thailand, or Malaysia have internalized corporate taxes as a factor towards increasing competitiveness, and given the recent high mobility of capital, they have embarked on a reduction in corporate tax rates or in the provision of other corporate tax incentives in order to attract internationally mobile firms. China, Philippines, Czech Republic, and Malaysia, among other countries, could be presenting a degree of corporate tax competition to attract FDI; these countries could have different levels of competitiveness, but most importantly, they are located far away from each other.

Hence, an important question arises when observing the previous arguments. Does corporate tax competition occur among countries from far away geographical regions of the world?

The next chapter provides an insight into the literature on corporate tax competition to attract FDI.

Summary

The new current global economic environment makes it more difficult to sustain high corporate and personal tax rates. The sensitivity of decisions about investments and location to taxation has increased since it is clear that individuals and businesses have gained greater freedom to take advantage of foreign economic opportunities. Pressure to reduce tax rates could stem from the direct loss of capital and perhaps skilled labor by countries that do not reform their tax systems and from the example of countries that are prospering under low tax regimes. Comparatively, high tax rates can cause large economic losses giving countries strong incentives to reduce rates. Consequently, tax competition appears to have increased as capital mobility has risen.

CHAPTER 3

LITERATURE REVIEW

Tax Competition: Definitions

In order to investigate the empirical evidence on tax competition, we need to define it. Wilson and Wildasin (2004) defined tax competition as "non-cooperative tax setting by interdependent governments, under which each government's policy choices influence the allocation of a mobile tax base among regions represented by these governments." On the other hand, tax competition was defined by Alfano (2001) as "the possibility of countries to modify their tax base against the reduction of other countries' tax base." Summarizing, tax competition can be thought as reductions in domestic tax rates or the implementation of partial exemption schemes, in order to broaden the tax base or to attract economic activity. Regardless the simplicity of the latter, the definition given by Wilson and Wildasin (2004) will be the one used in this study.

We must also establish a clear distinction between regional and global tax competition, given the importance of the latter for this study. Regional tax competition can be defined as the tax competition between countries located near each other in a well defined geographical area. Recent empirical work on this topic can be found on Brueckner (2003), Besley and Rosen (1998), Altshuler and Goodspeed (2002), Goodspeed (2000, 2002), Hayashi and Boadway (2001), and Esteller-Moré and Solé-Ollé (2001), among others. On the other hand, global or world-wide tax competition can be defined as the tax competition along an economical area without any particular bearing on the geographical location of the countries.[13] To my knowledge, there is no empirical work on this topic.

The aim of this chapter is to review the existing literature on regional tax competition starting with the earliest theoretical works and ending in the empirical models used in the latest research. Hence, most of the chapter is dedicated to summarize the relevant literature on regional tax competition.

Tax Competition Theory: Tiebout, Oates and the Standard Z-M Model

The general theory of regional tax competition goes back to Tiebout (1956), and Oates (1972), and it is formally modeled by Zodrow and Mieszkowski (1986), and Wilson (1986). This theory is commonly related to the view that competition for capital leads to inefficiently low levels of public expenditure and tax rates. Numerous writers have extended and refined this approach arguing that tax competition lowers welfare (Bucovetsky, 1991; Wilson, 1991; Haufler & Wooton, 1997, 1999). Nonetheless, alternative theories have been stating the possibility that tax competition may have desirable effects, among those are Brennan and Buchanan (1980), Oates (1985, 1989), Andersson and Forslid (2003), and Wilson and Wildasin (2004).

The starting point in tax competition theory comes from Tiebout's (1956) theory of local public goods provision. Tiebout (1956) states that competition among jurisdictions for households leads to an efficient provision of local public goods. In particular, households vote with their feet by efficiently sorting themselves across jurisdictions, and local governments respond by tailoring their taxes and expenditures to

[13] A wider definition of global tax competition is offered in the next chapter.

the preferences of their residents. Although this theory was originally applied to household mobility, it can also be applied, almost unaltered, to competition among jurisdictions for mobile firms as suggested by White (1975), and Fischel (1975) originally, and Wellisch (2000) more recently. As in the Tiebout model, the result of tax competition leads to an efficient outcome in the sense that the marginal benefit of providing public inputs are equalized to the marginal cost.

The Tiebout hypothesis has been widely questioned mostly because it relies on several restrictive assumptions. Among these is the assumption that the government can collect a non-distortionary head tax from each resident equal to the cost of providing him with his preferred level of public goods. Other underlying assumptions are the absence of scale economies in public goods provision, and a large number of jurisdictions in order to obtain efficient sorting of individuals. The inclusion of firms in the Tiebout model does not rely on milder assumptions since it requires the use of non-distortionary taxes in the sense that lump sum taxes are necessary to ensure an efficient location of firms. In reality, the taxation of capital is inefficient and the sorting mechanisms required by the Tiebout model are not in place. The departure from the idealized settings of the Tiebout model implies that competition to attract mobile capital leads to fiscal externalities among jurisdictions, which is at the heart of the analysis in modern models of tax competition.

Contrary to the conclusions from the Tiebout model, Oates (1972) retakes the competition discussion but argues that tax competition among jurisdictions can result in inefficient levels of public services. Local officials may hold public spending below the efficient allocation keeping taxes low in order to attract investment, particularly for those programs that do not offer direct benefits to local business. According to Oates (1972), the additional costs of an exhaustive tax competition might include lower wages and employment levels, capital losses on homes or other assets, and reduced tax bases. Their presence will reduce public spending and taxes to levels where the marginal benefits exceed the marginal costs. Oates's conclusion is that this behavior is inefficient and it rests on the idea that when all governments behave this way, none gain a competitive advantage, and consequently communities are all worse off than they would have been if local officials had simply used the conventional measures of marginal costs in their decision rules.

Thus, the main theme of tax competition literature has been that it lowers government spending and taxes below their efficient levels. This is the "race to the bottom" argument. This view emerges empirically from the framework developed by Wilson (1986), and Zodrow and Mieszkowski (1986) who began building formal models based on Oates's (1972) discussion of tax competition.

The Zodrow-Mieszkowski (1986) model, or the standard Z-M model of tax competition, assumes a world consisting of a fixed number of identical (homogeneous) regions, each containing an immobile factor, labor, and a perfectly mobile factor, capital. The immobile factor is inelastically supplied by the region's residents. These residents also own fixed endowments of capital, and the assumption of perfect capital mobility means that they are free to invest their capital anywhere. Within each region, perfectly competitive firms use a constant-returns technology to produce output from this labor and interregionally-mobile capital. In addition, adding the capital endowments across the residents in all regions gives the fixed supply of capital in the world economy.

Alternatively, income distribution issues are ignored in the model by assuming, either, that each region's residents are identical, or that their aggregate welfare can be depicted by the preferences of a representative consumer. In particular, these preferences are represented by a utility function, $U(c, g)$, where c is private consumption and g is consumption of the public good. Consumers use their income from capital and labor endowments to purchase one final consumption good, c. The government also purchases output to use as the sole input into the production of a public good, g. A tax on the capital located within the region's borders is used to help finance g. There are two local tax instruments, a tax that applies to capital income and a head tax. A Nash's equilibrium is assumed in which each region takes the after-tax return to capital and the tax rates set by other regions as fixed. The public services only benefits residents, and there are no spillover effects to other regions.

The Zodrow-Mieszkowski (1986) model assumes that local governments set the public good and tax rate in order to maximize a representative resident's utility:

$$\begin{aligned} &\textit{Maximize} \quad U(c, g) \\ &\textit{Subject to:} \;\; g = tK(r+t) \end{aligned} \tag{1}$$

where r is the after-tax return on capital; t is the unit tax rate which is equated across regions by capital mobility but treated as fixed by any small region; and $K(r+t)$ is the region's demand for capital as a function of the before-tax return. Otherwise, the regions play a Nash game in tax rates, recognizing that the vector of all tax rates determines the equilibrium r. In either case, the critical condition for the optimal public good supply is:

$$\frac{u_g}{u_c} = \frac{1}{1 - \tau\varepsilon_K (1 + \frac{dr}{dt})} \tag{2}$$

where ε_K denotes the elasticity of demand for capital with respect to the before before-tax return (measured positively); τ is the ad valorem tax rate (i.e., τ = t/(r+t)); and *dr/dt* gives the marginal impact of the region's tax on the equilibrium *r*, which is negative or zero depending on whether the large or small region case is considered.[14]

The right hand side of Equation 2 represents the marginal cost, while the left hand side represents the marginal rate of substitution between the public good and private income. It should be observed that the marginal cost exceeds one because the denominator contains a term reflecting the cost of the capital outflow that occurs when a single region raises its tax rate. With the world economy's capital stock treated as fixed, a rise in the capital tax rate of one region causes a capital outflow in this region and a capital inflow in other regions. The inflow benefits these other regions because the marginal value of capital exceeds the opportunity cost from their point of view by an amount equal to the unit tax rate. Thus, there is a positive fiscal externality for other regions in this model. The size of this externality clearly depends on the number of competing regions. If this number is large, then the elasticity of a single region's capital supply with respect to its tax is small, since a rise in the tax rate depresses the return on capital, *r*, thereby dampening the impact of this tax change on the cost of capital.

[14] Lockwood (2004) notes that Nash equilibrium in capital taxes on the Zodrow-Mieszkowski (1986) model depends on whether these taxes are unit or ad valorem. His work indicates that the public good provision is lower with an ad valorem tax than with a unit tax; residents are better off when countries compete in unit taxes.

Nonetheless, governments in each region neglect the externalities since they are only concerned with the welfare of their own residents. The end result is that taxes are set too low resulting in underprovision of public goods levels, and thus, on a reduction of welfare. However, since all jurisdictions are identical and the national capital stock is fixed, the allocation of capital across regions is unaffected.

Extensions of the Standard Tax Competition Z-M Model

Most of the contributions on tax competition literature have been derived from the basic Zodrow and Mieszkowski (1986) model, all of which alter one or more of their assumptions. The following section provides a brief summary of some of these extensions.

Size of the Jurisdictions

The basic tax competition model is characterized by homogeneous jurisdictions, either small or large. A particular division in the literature has focused on tax competition between countries of different size. Bucovetsky (1991), and Wilson (1991) models include asymmetric tax competition between large and small jurisdictions. They have shown that when two countries, different in size and with equal per capita endowments, compete for internationally mobile capital, then the small country chooses the lower tax rate and attracts a more than proportional share of mobile capital and achieves a higher per-capita utility level than the larger country.

Different results are found Haufler and Wooton (1997, 1999). They extend the standard Z-M model analyzing tax competition between two countries of unequal size, but add the existence of trade costs and multiple tax instruments. Their studies consider two different fiscal instruments, the profit tax (subsidy) and the consumption tax. The results suggest that when regional governments have only a lump-sum profit tax (subsidy) at their disposal, but face exogenous and identical transport costs for imports, then both countries will always offer to subsidize the firm, and the maximum subsidy would be greater in the larger region than in the smaller region. However, if countries are given an additional instrument, either a tariff or a consumption tax, then the larger country will no longer underbid its smaller rival and its best offer may involve a positive profit tax. In both cases the equilibrium outcome is that the firm locates in the larger market, paying a profit tax that is increasing in the relative size of this market and which is made greater when the tariff (consumption tax) instrument is permitted.

About the regions' size, Zodrow and Mieszkowski (1983) show that as the number of jurisdictions gets large, interjurisdictional competition leads to abandonment of the property tax by all jurisdictions, coupled with sole reliance on head taxes. If the number of jurisdictions is large, then each jurisdiction perceives that it is unable to affect the after-tax return to capital, as it effectively faces a perfectly elastic supply of capital. Thus, any tax on mobile capital will be shifted to immobile local factors of production, the labor in the Zodrow-Mieszkowski (1986) model, as will the excess burden attributable to the tax-induced outflow of capital. Hence, it is preferable for small local jurisdictions simply to tax their immobile factors directly and avoid at least the excess burden of the tax.

In addition, Dehejia and Genschel (1999) use the standard prisoners' dilemma to address the problem of why does collective action fails under asymmetric tax competition. They could not find obvious why it should be more difficult to stabilize and maintain cooperation in taxation, than in money or trade. The argument is that the prisoners' dilemma is a misleading metaphor for tax competition because it suggests that all competing states suffer from competition and therefore share mutual interest in tax cooperation. Prisoners' dilemma is right when assumes a deserting problem, but it is erroneous in suggesting that states will always share a mutual interest on solving this problem cooperatively. Nevertheless, this is not completely valid. Small states can actually gain from tax competition and may be reluctant to support cooperation, only if states are of about equal initial size will they share a preference towards universal tax cooperation. Thus, the situation changes from a symmetric prisoners' dilemma to a game where one actor with prisoners' dilemma preferences (the initially large country) faces another actor with deadlock preferences (the initially small country). For the small state, cooperation is harmful, they are better off competing. Thus if competing countries differ in size, as they are likely to, the real issue for tax cooperation is not defection ex-post but disagreement ex-ante about the desirability cooperation.

Tax Exporting and Imperfectly Mobile Capital

According to Iregui (2001), tax exporting refers to the shifting of tax burdens from domestic residents to non-residents of the taxing jurisdiction.[15] In the small jurisdiction version of the basic Z-M tax competition model with perfectly competitive markets, tax exporting is not an issue. However, with either large jurisdictions or

[15] Exporting can be achieved indirectly by taxing imports or through intergovernmental transfer mechanisms. In general, tax exporting can be achieved directly, as is often the case for travelers, by taxes that are paid explicitly or predominantly by non-residents. Hotel room taxes, car rental taxes and surcharges are appealing to policymakers because they are paid predominantly by non-residents.

imperfectly competitive markets, local governments may be able to export some of the burden of a tax on capital income to foreigners. For example, Mintz (1994) notes that one common argument for taxing capital income is to tax economic rents earned by foreigners, and Huizinga and Nielsen (1997) note that increasing globalization implies that foreign ownership of domestic companies, and thus the potential for tax exporting, are likely to increase over time. The potential for tax exporting creates a tendency for inefficient overprovision of public services, as consumers perceive a reduced price for public services. The empirical importance of these factors, however, is unclear. In addition, Sørensen (2004) argues that foreign ownership of domestic firms would have to be implausibly large for the tendency toward overprovision of public services due to the potential for tax exporting to outweigh the downward pressure on service levels from tax competition. Nevertheless, another potential efficiency-enhancing role for tax competition is to limit tendencies for overprovision of public services due to the potential for tax exporting an effect that would be negated with tax harmonization.

Within this context, Eijffinger and Wagner (2001) studied whether financial integration can increase taxes, by analyzing the tax competition and tax exporting effects, and assuming imperfect capital mobility. On the one hand, financial integration increases capital mobility, and thus the incentive for countries to compete for capital, this is the tax competition effect. On the other hand, a tax exporting effect is present when financial integration increases foreign ownership of firms and capital, and allows for exportation of source taxes. Both effects have opposite implications for capital taxes. Their empirical results suggest the presence of an excessive taxation due to the assumption of imperfectly mobile capital. Thus, the tax exporting effect counteracts the tax competition effect.

Sørensen (2000) addresses the tax exporting issue and uses it as an explanation for why effective tax rates have not changed much in OECD countries as economic integration has increased. The potential for this type of tax exporting, however, depends on the extent of cross-ownership of assets, which may itself be influenced by tax policies.

Zodrow's and Mieszkowski's (1983) work also show that if jurisdictions are large enough to possess some monopsony power in the union-wide capital market (each jurisdiction faces a less than perfectly elastic supply of capital), then the optimal tax on mobile capital is positive, as each jurisdiction is able to export some of its tax burden to non-resident capital owners. Such tax exportability, which provides an incentive for inefficient overexpansion of the public sector, tends to offset the bias toward underprovision of local public services attributable to the taxation of mobile capital.

Trade and Tax competition

The standard Z-M tax competition model has only a single good and ignores inter-jurisdictional trade. Wilson (1987) incorporates interregional commodity trade into the tax competition analysis adding a second good and a system of numerous identical regions. The model of property taxation by regional governments causes regions to specialize in the production of a single traded good. In equilibrium, some regions choose a relatively low tax rate on capital and produce the capital-intensive good, whereas other regions choose a relatively high tax rate and produce the labor-intensive good. No region produces both goods, because then a tiny reduction in its tax rate would discontinuously eliminate all production of the labor-intensive good, creating only capital-intensive production in its place. Once again, the diversity in tax rates is really inefficient, since there are no ex ante differences between regions to justify it. Thus, Wilson (1987) results demonstrate that regions containing identical individuals and production possibilities choose different tax rates and produce different traded goods, and that the inefficiencies resulting from taxing mobile capital cannot be adequately described as an underprovision of goods.

Within this perspective, Janeba and Wilson (1999) allow for both commodity trade and capital mobility between competing regions and the rest of the world. They reconsider the question of whether tax competition for mobile capital leads to tax rates on capital that are too low or too high from the combined viewpoint of the competing regions. Their model assumes that the country's central government sets the external trade policy by choosing tariffs on imports, that the tax on capital is chosen either by the central government of the home country or by the country's regional governments, and that the economy's import-competing industry imports capital. The key result of the analysis is that whether the capital taxes are too low or high depends on the degree of external trade protection. When the country's central government is free to set the tariff, tax competition leads to inefficiently low tax rates. But in the absence of a tariff, tax rates can be too high. In particular, regions may choose to subsidize capital in equilibrium as a means of inducing favorable terms-of-trade effects, but the subsidy (i.e., a negative tax) will then be too low because an increase in a single region's subsidy benefits other regions by reducing their relative quantities of subsidized capital.

Tax competition, Public Expenditure, and Economic Position

Zodrow and Mieszkowski's (1986) work pays careful attention to the public goods provision, but neglects the composition of it. Keen and Marchand (1997) base their study on Zodrow-Mieszkowski's (1986) model and continue with the discussion that tax competition leads to inefficient levels of public goods and tax rates. Their premise is whether the composition of the public goods under tax competition is efficient or not. The model assumes identical and small countries, a fixed capital supply but mobility between jurisdictions, creating scope for tax competition among them. The model incorporates two stereotypical forms of public spending into a model of fiscal competition; one concerning broadly to consumption items as recreational facilities or social services; and the other refers broadly to items such as infrastructure or general training expenditures. The results propose that a lack of coordination within the model of interjurisdictional tax competition may lead not only to inefficient levels of aggregate public expenditure but also to systematic inefficiencies in the composition of that expenditure. Tax competition leads to overprovision of public inputs in infrastructure, such as business centers and airports, and to underprovision of items that directly affect consumer welfare such as social services (parks and libraries), and since it is not in the interest of any country to undertake such a rebalancing unilaterally it emerges a case for some coordination of spending policies even in the absence of tax rate coordination. Their policy arguments imply the existence of a case for international coordination not only of tax bearing on internationally mobile cases but also of domestic public expenditures.

Following Keen and Marchand (1997), Solanko's (2001) model analyzes the regional tax competition for a mobile capital between identical regions in a transition economy. The study examined the effects of regional tax and commodities competition in a simplified transition economy with several regions and two distinct sectors, an old state sector and a new private sector, each receiving a different tax treatment. The model assumes that: (1) the old sector has a low productivity compared with the new sector; (2) the regional decision-makers are not entirely benevolent, but instead seek to maximize a weighted average of the utility of their citizens and their private benefit; (3) the decision makers are the owners of the old sector production; and (4) the regional governments use rent taxation and capital tax on new sector capital to finance the provision on pure public goods. Solanko's arguments imply that tax competition may be at least partially beneficial in the case of a transition country starting from a centrally planned socialist economy. The results show that in the very early stage of transition when the share of the old sector is overwhelming, consumers in a transition economy may be better off in a competitive equilibrium. The decision maker, however, would prefer to coordinate their tax policies. Also in early transition, when regional competition would be socially beneficial, it is least likely to appear. As the total amount of rents from the old sector is positively correlated with total amount of production in the less efficient sector, it is precisely in early transition that the decision makers have least interest in engaging in a competition for mobile capital. The authors conclude that the transition feature incorporated in a classical tax competition model make regional tax competition less harmful, and consequently make coordination less beneficial.

In addition, Qian and Roland's (1998) work also on transition economies and tax competition indicates that in a transition economy, decentralization combined with regional competition for mobile capital reduces subsidies to local state enterprises, and thus is potentially beneficial for the transition process.

Public Good Spillovers and Tax Competition

The basic tax competition model assumes that the public services provided by the independent regions have no cross-boundary spillover effects. Nonetheless, some public goods may have important positive or negative spillovers. The standard result in the case of positive spillovers is that these lead to underprovision of public services as the region providing the service ignores its external benefits. Within this line, Bjorvatn and Schjelderup (2002) show that if public services are financed with taxes on mobile capital, then positive spillovers dampen tax competition. The intuition is that when the government of an independent region is considering a tax reduction to attract mobile capital, it will also recognize that the capital outflow from other regions will be accompanied by a reduction in their public service levels, which will have a negative effect on the welfare of the citizens of the taxing state. Indeed, in the case of a pure international public good, these two effects are perfectly offsetting, and the incentive for tax competition is eliminated.

Alternatively, Rauscher (1995) considers a single plant which potentially invests in one of several potential locations which compete in terms of emission taxes.[16] Here, investment causes negative spillovers between states as pollution spreads across borders.

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[16] Emission taxes involve tax payments that are directly related to the measurement or estimation of the pollution caused.

Since states ignore the pollution costs to their neighbors, individually optimal state taxes will be less than nationally optimal taxes. While the host state can benefit from FDI due to the taxes it collects, it can also suffer greater environmental damage from local production. If the first effect dominates, emission taxes are too low in the tax competition equilibrium and there is excessive environmental damage. If the second effect dominates, taxes will be too high and may in fact be so high that the firm does not invest. In Davies' (2005) setting, since the firm generates positive spillovers, state taxes will be too high relative to the nationally optimal tax. Also, since there is no cost to being the host (other than the taxes necessary to secure the firm), taxes will always be lower with competition than without it. Finally, without pollution costs, it will never be optimal to set taxes so high that the firm decides not to enter.

State Tax Competition

Contrary to the basic tax competition model, recent studies have discussed the welfare enhancing conditions of the state tax competition scheme. For instance, work by Wilson and Janeba (2005) studies tax competition between two countries that are divided into regions. The model considers a world economy in which the central governments of two countries provide public goods financed by taxes on mobile capital.[17] Competition for this mobile capital leads to inefficiently low taxes and public good levels, as in the basic Z-M tax competition model. Unlike the basic model, however, there exists a variety of public goods and, therefore, the possibility for the central governments to decentralize the provision of some, but not all, public goods. From a single country's viewpoint, both

[17] Their framework uses a two stage game. In the first stage, the strategy variable for each country is the division of the provision of a range of public goods between the central and regional governments. In the second stage, the central and regional governments choose their tax rates on capital.

horizontal and vertical externalities are involved in the provision of public goods by regional governments (i.e., state, local, or provincial governments). When a single regional government lowers its tax rate, it not only attracts capital away from other regions (the horizontal externality), but also expands the central government's tax base by attracting additional capital into the country (the vertical externality). As a result, regional governments may under or over provide public goods, depending on the relative sizes of these two externalities. Wilson and Janeba (2005) demonstrate that the central government can control these relative sizes by manipulating the division of public good provision between the two levels of government. In so doing, it can influence the degree to which the country as a whole competes with the other country for scarce capital. In other words, decentralization emerges endogenously as a tool for gaining a strategic advantage over a rival country in a tax competition game. The authors also show that the uncoordinated decisions to decentralize by the two competing countries can be welfare-improving for both of them. In contrast to standard tax competition models, the decentralized provision of public goods can therefore play a welfare-enhancing role.

Work by Davies (2005) presents a general equilibrium model in which a single, monopolistic firm chooses a single host from multiple states whose costs differ due to differing factor endowments. The framework considers competition in taxes on the firm's domestic factor. States set tax rates to maximize the welfare of their own constituents while the federal government sets a national labor tax rate to maximize national welfare. Due to the price externality, whichever state hosts the multinational enterprise without competition sets a high tax in the absence of federal intervention. While the federal government can make a correction for this, it involves federal subsidies for the host state's labor. Such subsidy may not be possible because it requires the politically difficult task of taxing non-host states to subsidize factor markets in the host state. Furthermore, without competition, the firm may locate in an inefficient location, reducing national welfare.

Tax competition, thus, offers two potential improvements in national welfare. First, the state which generates the largest surplus as a host always wins the multinational enterprise under tax competition eliminating location inefficiencies. Second, incentives offered by other states constrain the winning state's tax, reducing the need for federal subsidies. If federal subsidies are not politically viable, the nationally optimal tax burden can be reached only under tax competition. Thus, in contrast to the warnings put forth by the Z-M model, tax competition can improve national welfare. [18]

In addition, Black and Hoyt (1989) also model subsidy (negative tax) competition between states for a firm under perfect information. They find that, since subsidies can induce labor migration and lower the average cost of providing a public good, allowing states to compete results in an efficient firm location.

Regarding local taxes, the work of Heyndels and Vuchelen (1998) test whether there is a mimic of local tax rates among Belgian municipalities. Their hypothesis initiates from the question that a jurisdiction tax policy may be influenced by other jurisdictions' tax policies. Their findings indicate that tax rates are indeed copied among neighboring municipalities, suggesting that the mimicking behavior is a characteristic of decision making within the context of a decentralized government.

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[18] Davies' results are comparable to Walz and Wellisch (1996) who consider competition for a mobile, oligopolistic firm when expenditures on a public input are the policy instrument. They too find that although competition may be inefficient, its problems can be corrected by allowing the federal government to intervene using the same tool available to the states. However, they do not endogenize tax rates nor do they compare this result to the solution without competition.

Leviathan Models and Political Economics

All the literature summarized thus far assumes that independent governments act to maximize the welfare of their residents or landowners. The strongest challenge to the notion that tax competition reduces welfare comes from Leviathan models in the public choice literature. This literature argues that state politicians and government officials act to maximize their own objectives which are typically positively related to the size of the government budget or are at least heavily influenced by rent-seeking special interest groups. The basic idea, as developed by Brennan and Buchanan (1980), is that the total size of government would be excessive in the absence of fiscal competition. The basic argument is that the government is responsible for the provision of the infrastructural and institutional framework in which economic activities take place. If it is inefficient, for example, if it provides low-quality services but charges high taxes, mobile factors are driven out of the country. This leads to a decline in income and employment of the immobile factors. Thus, the voters will be worse off and they will punish the government by electing other parties or candidates. But since the government is interested in being re-elected, it is forced to act and increase the jurisdiction's attractiveness to mobile factors of production. This requires lower taxes and better public services. Thus, the part of the budget spent by the public sector for its own well-being must shrink. There are additional incentives for government officials to reduce waste in government, and hence, the Leviathan is controlled. Under such circumstances, tax competition potentially serves an important beneficial role in that it may limit the tendency of local governments to overexpansion.

Further investigation was carried out by Rauscher (1997, 1998), and Edwards and Keen (1996) who formally examine various Leviathan models where governments are partially concerned with maximizing the size of the public sector. For instance, Edwards and Keen (1996) construct a model similar to the basic Z-M tax competition model, but assume that state government officials act to maximize a function that includes both the welfare of their residents, and their own welfare, which is assumed to be directly related to revenues diverted to their own purposes, that is government waste. They argue that such a representation embodies a reasonable compromise between the more extreme views that governments act only to maximize the welfare of their citizens or only to maximize revenues.

Within this context, Besley and Smart (2002) relax the assumption of purely benevolent government that seek to maximize the public welfare. They argue that far from being benevolent, governments aim to maximize revenues which politicians use for their own ends. They take the public choice possibility that tax competition between governments may indeed raise welfare. Their main question is whether subjecting the government to greater competition will raise or lower the welfare of voters. The study comprehends two types of competition. The first is a standard notion of competition for mobile tax bases which raises the marginal cost of public funds and constrains the size of the government. The second is a competition where voters in one jurisdiction make use of comparative performance evaluation, conditioning their voting behavior on policy outcomes in other jurisdictions. Their results show that if competition is due to resource mobility across jurisdictions, without any shift in the political equilibrium, welfare must be lower. If the politicians take rents, then the voters would prefer that they did so using efficient forms of taxation. Nonetheless, once endogeneity of the political equilibrium is taken into account, then tax competition may indeed be welfare improving. Overall, they find that competition is most likely to be welfare improving for voters when the prospect of selecting a good politician is high. This is because the screening benefits from competition are likely to dominate any adverse incentive effects.

Parry (2001) examines the possible magnitude of the welfare effects of tax competition in a model that generalizes the Zodrow-Mieszkowski model by allowing for Leviathan behavior. In particular, he allows government officials to care not only about the welfare of residents, but also about tax revenue per se. Extending the analysis of Wildasin (1989), Parry identifies production and preference parameters including local demand and substitution elasticities for capital and for local public goods, numbers or size of jurisdictions, and the potential magnitude of Leviathan behavior. The findings suggest that although the introduction of Leviathan behavior produces a wide range of outcomes, with taxes and spending either too low or two high, the welfare losses from tax competition appear to be quite modest over a range of values of relevant parameters.

Nonetheless the different welfare conclusions, Leviathan models and the Zodrow-Mieszkowski models both agree that tax competition lowers the size of government.

A different welfare enhancing theory comes from Bond and Samuelson (1986). They suggest that tax competition can improve welfare when potential locations have private information about their costs. By offering tax holidays, locations provide signals to the firm about their costs. This allows the firm to choose the most efficient location for its investment, improving global efficiency.

Regarding the inclusion of political economy on tax competition, Biglaser and Mezzetti (1997) study how regions compete to attract large firms. Their starting point is the observation that some U.S. states seem to offer tax packages to firms that often exceed the economic value of firm's instate investment project. They assume that when preparing a bid, legislators take into account both the public's interest and the bid's impact on their probability of re-election. Since politicians value their re-election, their bid for investments is distorted away from the value of the project to voters and may result in an inefficient location of firms in the sense that legislators give away too much of the taxpayers money in order to attract firms.

Persson and Tabellini (1992) make use of political economy to study a two-country model where each government levies a source tax on mobile capital to finance government transfers. This model generates the usual effect. A fall in the cost of investing abroad (i.e., increasing competition) puts downward pressure on tax rates. At the same time, however, there is a second, political effect in place since policy is chosen by a policymaker who represents the preferences of the median voter. Tax competition is shown to make the median voter select a more leftist government, whose distributional preferences call for higher taxes on capital, and this partly mitigates the tendency of tax competition to lower taxes on capital.

Economic Geography

A completely different strand of literature is the new economic geography literature, which analyzes the relationship between trade integration and industrial location. In a series of seminal papers by Krugman (1991), Krugman and Venables

(1995), and Venables (1996), it is shown how economic integration may lead to increased concentration of industrial production. This literature is based on the Spence (1976), and Dixit and Stiglitz (1977) framework of increasing returns to scale and monopolistic competition, together with trade costs. A key feature is that these models display hysteresis in location, meaning that once production has agglomerated in a region it tends to get stuck there because of demand and supply linkages. These linkages are an important explanation for the industrial clusters that can be observed in many real world regions such as the manufacturing belt of the U.S. A consequence of this is that mobile factors may not respond to marginal changes in tax rates if they are locked in by the existence of an industrial cluster. This stands in stark contrast to a standard neo-classical framework, where a marginal tax change in a region leads to a marginal movement of factors.

Few attempts have been made to date to address issues of tax competition in an economic geography framework, among those are papers by Kind, Midelfart-Knarvik, and Schjelderup (1998), Forslid and Ottaviano (1999), Baldwin and Krugman (2002), and Andersson and Forslid (2003). An important exemption is Ludema and Wooton (2000). In a framework with a homogeneous good, oligopoly and moving costs, the authors focus on the effects of integration on the intensity of tax competition. The conclusion indicate that integration interpreted as decreasing trade costs, contrary to popular notions, attenuates tax competition; and that integration interpreted as increased labor mobility has mixed effects. A key finding of Ludema and Wooton is that the inertia resulting from concentration of the mobile factor in one region gives, essentially, rise to a rent that is taxable. This latter conclusion is borne out also in Kind, Midelfart-Knarvik, and

Schjelderup (1998); more precisely they show that a country hosting an agglomeration may find it optimal to levy a source-based tax on capital income.

Recent Empirical Work

Most of the empirical work surveyed by Brueckner (2003) concentrates on tax competition between governmental units within a country. Several recent papers in this literature such as Besley and Rosen (1998), Goodspeed (2000, 2002), Hayashi and Boadway (2001), and Esteller-Moré and Solé-Ollé (2001) investigate Stackelberg behavior of the central government vis-à vis a lower level governments within a country. A small empirical literature has recently begun to attempt estimating tax reaction functions of national governments which compete against other national governments.[19] For instance, Devereux, Lockwood, and Redoano (2002) and Besley, Griffith, and Klemm (2001) estimate Nash reaction functions for OECD countries. Both studies find a positively sloped Nash reaction function, but do not consider the possibility of Stackelberg behavior as suggested by Gordon (1992).

Altshuler and Goodspeed (2002) estimate the tax reaction functions of national governments competing with other national governments, both, for a pure Nash model and for a model in which the U.S. can act as a Stackelberg leader while the European countries compete with each other in a Nash way. They follow Gordon (1992) who sets a strategic model of tax competition that allows for one large country to act as a Stackelberg leader. They allow the followers to be Nash competitors with each other, and the Nash competitors to be followers in a Stackelberg game with a large country. The

[19] Tax reaction functions are equations which indicate whether any particular government will change a tax rate in response to changes in other countries' tax rates.

European countries would act as Nash competitors with each other, while the United States would be the Stackelberg leader.

The basic estimating equation for the Nash game between countries is:

$$\tau_{i,t} = \beta \sum_{j \neq i} w_{ij} \tau_{j,t} + X_{i,t}\theta + d_i \phi + d_t \varphi + \varepsilon_i \qquad (3)$$

where i indexes countries and t indexes time; τ is the tax rate measure; X_i is a vector of exogenous control variables such as GDP per capita, total government spending (as a percentage of GDP) and the lagged value of the personal and corporate tax measure; β, θ, ϕ and φ are estimated parameters (being θ a vector of estimates); ε is an error term; and w is a weighting matrix whose weights are assigned based (inversely) on the distance between the own country and all countries for which interactions are assumed. One such scheme assigns a weight of one to contiguous countries (states, counties, etc.) and zero to all others (Besley & Case, 1995). These weights are normalized to add to one. In this specification they estimate the model for both capital and personal tax competition.

Alternatively, the authors explored the possibility that European tax havens view the United States differently than do other European countries. Following Hines and Rice (1994), Altshuler and Goodspeed (2002) classified Ireland, Luxembourg, and Switzerland as tax havens. Thus, d_i represents a set of country fixed effects with a value of one for the countries above. Furthermore, it was possible that the U.S. Tax Reform Act of 1986 combined with the relaxation of capital controls in Europe and technological advances resulted in European nations treating the U.S. as a Stackelberg leader after 1986. To do this the authors included a dummy variable d_t that equals one for observations prior to and including 1986 and an interaction term between this variable and the U.S. tax rate. The estimated coefficient showed the difference (if any) between the responsiveness of corporate tax rates to U.S. tax changes before and after the U.S. Tax Reform Act of 1986.

The authors turned to a specification that incorporates a Stackelberg leader and in which they allow the followers to be Nash competitors with each other. The basic estimating equation for the followers in this game is:

$$\tau_{i,t} = \beta\sum_{j\neq i} w_{ij}\tau_{j,t} + X_{i,t}\theta + \tau_{L,t-1}\eta + d_i\varphi + T_t\psi + \varepsilon_i \tag{4}$$

where i indexes the follower countries; $\tau_{L,t-1}$ is the lagged tax rate of the leader; η and ψ are estimated coefficients; and T is a time trend. The data was extracted from the OECD's Revenue Statistics from 1968 to 1996, and sample of countries included are all the European OECD's countries with the exception of Czech Republic, Hungary, Poland, Portugal, Iceland, and the Slovak Republic.

The empirical results provided evidence that European countries interact strategically with their neighbors to set capital tax rates but not to set labor tax rates and follow the lead of the United States in setting capital tax rates after 1986, the year of the major U.S. tax reform. In fact, their results suggested that the tax rates of non-tax haven European countries are more responsive to changes in U.S. rates than to their own neighbor's rates. However, they found no evidence that either the haven or non-haven countries reacted to the tax changes of the United States before 1986, the year of a major U.S. tax reform.

A paper by Brueckner and Saavedra (2001) researched property-tax competition among local governments. They estimated the reaction function of the representative community, which relates the community's property-tax rate to its own characteristics and to the tax rates in competing communities. The estimation uses cross-section data on property taxes and other socio-economic variables for 70 cities in the Boston metropolitan area before (1980) and after (1990) Proposition $2\frac{1}{2}$.[20]

Their theoretical model is drawn from the literature on tax competition, in which local jurisdictions choose property-tax rates taking into account the migration of mobile capital in response to tax differentials. The reaction functions were estimated using the techniques of spatial econometrics, with a non-zero slope coefficient providing evidence of strategic interaction in the choice of tax rates. The econometric specification used a spatial lag model on which a weight matrix aggregates the property-tax rates in competing communities into a single variable.

The authors estimate the reaction function:

$$t_i = \phi \sum_{j \neq i} w_{ij} t_j + Z_i \theta + \varepsilon_i \tag{5}$$

where t_i represents the natural logarithm of the total property tax rate; Z_i is a vector containing the socio-economic characteristics of community *i*, such as the natural logarithm of the per-capita income, of the per-capita state aid, of the population with 16 years of education, of the population proportion of Afro-American, of the lagged per capita levy, and the annual rate of population growth; and *w* represents a weight matrix

[20] The Proposition $2\frac{1}{2}$ is a property-tax limitation measure that took effect in 1981.

that takes into account the geographical distances from a given community to its competitors, as well as the population sizes.

The results of the study showed empirical evidence on property-tax competition among local governments. The 1980 results suggested that strategic tax competition occurred in the Boston metropolitan area in the pre-tax-limitation era. Interestingly, the evidence showed that tax competition persisted, although in a less pervasive manner, after Proposition $2\frac{1}{2}$ despite the restrictions imposed by this tax limitation measure.

In this context Devereux, Lockwood, and Redoano (2002) tested whether OECD's countries compete with each other over corporate taxes and allowance rates in order to attract investment. The study examined whether there was any empirical evidence for such international competition in taxes on corporate income using data from 21 countries between 1983 and 1999.

The authors developed two models which helped clarify the nature of corporate tax competition. In the first model, firms are mobile, but countries are small relative to the world capital market. In this case, countries compete only in statutory corporate tax rates. In the second, firms are immobile, and countries are large relative to the world capital market. In this case, countries compete only in allowance rates.[21] For each of the two models, they developed fiscal reaction functions. They also allowed for a wide variety of specifications in the empirical work, i.e., they allowed tax reaction functions to be non-linear, and that the adjustment to equilibrium to be instantaneous or dynamic.

[21] The statutory tax rate is the tax rate established by the government. The marginal effective tax rate is measured by the difference between the pre-tax and after tax rates of return on the investment. On the other hand, the average effective tax rate is measured by dividing actual taxes paid by an independent measure of income.

The theoretical analysis generated symmetric reaction functions of the form $T_i = R(T_j)$ where T_i denotes the tax rate (whether statutory, average effective, or marginal effective tax rate) in country *i*, and T_j is country *j* tax rate. The theoretical model assumed two symmetric countries. Allowing for *n* countries that may be different, and introducing time subscripts, the reaction functions were written more generally as:

$$T_{i,t} = R_i\left(T_{-i,t}, X_{it}\right) \qquad i=1,2,\ldots\ldots n \tag{6}$$

where $T_{-i,S} = \left(T_{1S}, T_{1S}, \ldots T_{i-1S}, T_{i+1S}, \ldots\ldots T_{nS}\right)$ denotes the vector of tax rates of all other countries at time *s*, and X_{it} is a vector of other control variables that may affect the setting of the tax in country *i*, such as the relative size of each economy, measured as GDP_{it}/GDP_{jt} where *j* is U.S., the total public consumption as a percentage of GDP, the lagged sum of inward and outward foreign direct investment as a percentage of GDP, the proportion of population below 14 years old, the proportion of population over 65 years old, the proportion of population living in urban areas, the population density, and the highest marginal income tax rate.

More explicitly, the system of equations estimated could be expressed as:

$$T_{it} = \alpha + \beta T_{1t-1} + \gamma_1 A_{is} + \gamma_2 D_{is} + \gamma_3 D_{is} A_{is} + \eta' X_{it} + \eta_i + \eta_t + e_{it} \tag{7}$$

where $D_{is} = \begin{cases} 1 & if \quad T_{iS} > A_{iS} \\ 0 & if \quad T_{iS} < A_{iS} \end{cases}$ and $i = 1,\ldots.n.$

and where η_i is a country fixed effect, η_t is a period fixed effect, and e_{it} is an error term.

Observe that $A_{i,t}$ is defined as $A_{i,t} = \sum_{j \neq i} w_{ij} T_{jt}$, where w_{ij} is a weights matrix. The weights should be large when tax competition between countries *i* and *j* is likely to be strong. In the case of local property taxes, the obvious choice (and one that works well in practice (see Brueckner, 2000) is to use geographical weights, where w_{ij} is inversely related to the distance between jurisdictions *i* and *j*. A local government is likely to respond more readily to changes in the tax rates of neighboring governments than it would to rates in a different part of the country. However, in this case, the degree of tax competition between two countries may depend not only (or at all) on geographic proximity of countries, but also their relative size and the degree to which they are open to international flows.

On the other hand, D_{is} is a dummy indicating whether country *i*'s tax rate is above or below the weighted average in period *s*. Thus, they allow for two possibilities: simply being above the average may change the intercept of the reaction function; and being above the average may change the way T_{it} responds to changes in the weighted average of the other taxes.

The authors found evidence that countries compete over all three measures of taxes, the effective marginal tax rate, the average effective tax rate, and the statutory tax rate, but particularly over the statutory and effective average tax rates. This is consistent with the belief that the typical location decision of a multinational is a mutually exclusive discrete choice between two locations.

They also found evidence of non-linear reaction functions. Specifically, countries with relatively high tax rates tend to respond more strongly to changes in tax rates in other countries. Alternatively, countries react more strongly to changes in other countries tax rates when their own tax is above the average. Finally, they found rather weaker evidence that countries compete over effective marginal tax rates.

Chen, Martinez-Vazquez, and Wallace (1998) researched foreign direct investment outflows from five developed home countries to four host rival countries in Southeast Asia, as well as the responsiveness of FDI to tax policies of each pair of host and home countries and those of potentially competing host countries. Their work consists in an research of whether host countries are interdependent in the sense that production costs, including taxes in other host countries, affect the inward FDI to a particular host country. A particular point in this study that sets a difference from others' works, is that the authors included the impact of the home country tax rate into the analysis. The estimation and analysis allowed not only for the roles of the tax systems of each pair of home and host countries on FDI, as conventionally done in the literature, but also for the potential role played by the tax systems of competing host countries.

Their model for FDI from home country *i* into host country *j* (F_{ij}) is represented by:

$$\Delta F_{ij}=\alpha_{ij} + \beta_{ij1}\Delta\tau_i + \beta_{ij2}\Delta\tau_j + \beta_{ij3}\Delta(t_i-\tau_{j,}) +\beta_{ij4}\Delta\tau_{jo}+ \beta_{ij5}\Delta w_j+ \beta_{ij6}\Delta w_{jo} +\beta_{ij7}\Delta e_j +\beta_{ij8}\Delta e_{jo} +\beta_{ij9}\Delta p_j + \beta_{ij10}\Delta p_{jo} +\varepsilon_{ij} \quad (8)$$

where ΔF_{ij} is the annual change of FDI from home country *i* (five countries) into host country *j* (four Southeast Asian countries); ε_{ij} is the random disturbance term; τ_i is the effective tax rate in home country *i*; τ_j is the effective tax rate in host country *j*; t_i is the statutory tax rate in home country *i*; τ_{jo} is the average effective tax rate in the other three host countries; w_j is the hourly compensation cost in host country *j*; w_{jo} is the average hourly compensation in the other three host countries; e_j is the number of months of imports covered by international reserves in host country *j*; e_{jo} is the average number of months of imports covered by international reserves in the other three host countries; p_j the export price index in host country *j*; and p_{jo} is the average export price index in the other three host countries. The model was estimated using cross section and annual time series data covering 20 pairs of countries over 18 years (1972-1989).

The results showed that FDI flows tend to be negatively related to the rate of effective taxation in the host country and this effect appear to be more pronounced for FDI coming from home countries with territorial or exemption systems. Foreign direct investment into any host country is sensitive to the tax system of potentially competitive host countries. The results showed that the tax policies of developing countries can put them in competition with each other for FDI.

Continuing with this review, Bénassy-Quéré, Fontagné, and Lahrèche-Révil (2001) work reject the recent literature on economic geography which has underscored the significance of tax differentials as determinants of foreign direct investment. As previously explained, economic geography theory affirms that size effects and agglomeration economies represents the most important determinant for the FDI location, and that corporate tax competition does not necessary lead to a race to the bottom. To challenge this argument, Bénassy-Quéré, Fontagné, and Lahrèche-Révil establish a theoretical and empirical framework based on a panel data of bilateral FDI flows across 11 OECD countries over the 1984-1996 period.

Their empirical specification can be expressed as:

$$FDI_{ijt} = \beta_0 ETAX_{ijt} + \beta_1 NTAX_{ijt} + \beta_2 FDI_{ij,t-1} + \beta_3 SGDP_{ij,t-1} + \beta_4 SGDP_{ij,t} + \beta_5 SGDP_{ij,t+1} \beta_6 GDP_{jt} + \beta_7 Open_{ijt} + \beta_8 DGDP_{ijt} + \beta_9 Dist_{ijt} + \beta_{10} D6 + \beta_{11} D11 + \varepsilon_{ijt} \quad (9)$$

where FDI_{ijt} represents the bilateral foreign direct investment inflow from country *j* to country *i* ; $ETAX_{ijt}$ is the difference between *i* and *j* effective taxes on corporate income standardized by the corresponding operating surplus in GDP percentage; $NTAX_{ijt}$ is the difference between *i* and *j* statutory tax rates; GDP is the Gross Domestic Product of country *j* (investor); $Open_{ijt}$ is the sum of bilateral exports and imports over the GDP of the investing country defined as: $Open_{ijt} = \frac{X_{ijt} + M_{ijt}}{2GDP_{it}}$; $DGDP_{ijt}$ represents the market size difference between GDPs of countries *i* and *j* defined as:

$DGDP_{ijt} = 1 + \frac{w \ln w + (1-w)\ln(1-w)}{\ln 2}$, where $w = \frac{GDP_{it}}{GDP_{it} + GDP_{jt}}$; $Dist_{ijt}$ represents the great arc cycle distances between *i* and *j* economic centers; and $SGDP_{ijt}$ represents a measure of market potential which accounts for both internal transportation costs in the host country and transportation costs between the host country and the regional market, including internal transportation costs in each foreign market. The variable $SGDP_{ijt}$ is defined as: $SGDP_{it} = \frac{GDP_{it}}{d_{iit}} + \sum_h \frac{GDP_{ht}}{d_{iht}}$ if $i,h \in$ Europe, and $SGDP_{it} = \frac{GDP_{it}}{d_{iit}}$ if *i*=Japan, USA. $d_{ih} = \sum_{k \in i} \left(\sum_{k' \in h} z_{k'} d_{kk'} \right) z_k$; $z_k = \frac{GDP_k}{GDP_i}$; $z_{k'} = \frac{GDP_{k'}}{GDP_h}$; and $d_{kk'}$ is the distance between regions *k* and *k'*.

Alternatively, *D6* represents a dummy for the bilateral FDI flows from UK to USA in 1995; and *D11* is a dummy for the bilateral FDI flows from USA to Japan in 1990.

The empirical results imply that, although market potentials such as agglomeration economies and size effects do matter, tax differentials also play a significant role. This provides empirical evidence that corporate tax differentials among countries are significant in determining the FDI flows of investors. Nonetheless, an implication of the results is that tax competition cannot be excluded, although it may not lead to a race to the bottom.

Rizzo's (2002) work investigates the concept of transfers using a tax competition framework. The study is based on the notion that transfers are normally needed to compensate or equalize for the loss of revenue or social welfare due to the mobility resources that happens from tax competition. The aim of the paper is to investigate if the states of a federation receiving a compensation transfer modify their tax rate choice with respect to states which are not given any transfer. Rizzo's model was developed as a tax rate reaction function, described as:

$$t_{st} = \alpha_s + \beta_t + \delta_1 h_{st} + \delta_2 v_{st} + \delta_3 EXPE_{st} + \vartheta x_{st} + \theta z_{st} + \varepsilon_{st} \tag{10}$$

where t_{st} represents the cigarette tax rate for province *s* and year *t*; α_s are the state fixed effects; and β_t is a vector of 2 dummy variables defined as: β_{11} equal to one when the tax rate is higher than the Canadian neighbors' tax, and β_{12} a dummy equal to one when equalization holds. The x_{st} is a vector of province specific time varying shocks such as population of province *s* in year *t*, density of population (calculated as the fraction of population over the area of the province), ratio of individuals who are between 5 and 17 years of age, ratio of individuals over 65 years of age, unemployment rate, and real per capita income. Variable h_{st} represents the tax rates average for province *s* in year *t* of the neighboring provinces of province *s*; v_{st} is the tax rates average for province *s* in year *t* of the neighboring U.S. states of province *s*; and $EXPE_{st}$ represents the ratio of the total expenditure on GDP for province *s* in year *t*. On the other hand, z_{st} is a vector of neighboring variables such as U.S and Canadian province neighbors' income, U.S. and Canadian province neighbors' grant, U.S. and Canadian province neighbors' income tax, U.S and Canadian province neighbors' unemployment rate; and finally ε_{st} represents the error term. The model was estimated for Canada and United States using a panel data at a province level from 1984 to 1994.

The results indicated that a decrease of Canadian neighbors' average tax rate, h_{st}, would produce a significant decrease in the tax rate of province *s*, and that the province with a higher tax rate than its neighbor reacts more heavily to a neighboring change in tax, than in the case that it would have had a lower tax rate than its neighbor.

Other empirical studies that rely on the tax competition model to motivate the estimation of tax reaction functions include Brett and Pinkse (1997, 2000) who focus on local property taxes in Canada; Buettner (2001) who studies the local business tax in

Germany; and Hayashi and Boadway (2001) who focus on provincial corporate income taxes in Canada.

Summary

The literature on tax competition has continuously attempted to demonstrate the disadvantages and advantages of competing through taxes. Since its beginnings with the Tiebout (1956) hypothesis, to the recent theories of the Leviathan (Brennan and Buchanan, 1980), there is no common consensus regarding the favorable or damaging actions of tax competition. What is true is that foreign direct investment inflows represent a favorable environment for economies, and that one way to attract it is to provide fiscal incentives to firms; fiscal incentives in the form of tax holidays, reduced tax rates, or increased depreciation among other factors.

Recent research has demonstrated the existence of tax competition along a geographical region or areas. Subdivisions of this topic are now in study by numerous authors. An example of these subdivisions is the study presented by Altshuler and Goodspeed (2002) on which they have established a form of behavior of countries' tax policies, be it Stackelberg or Nash behavior. Nonetheless the extensive literature of tax competition, a global or world-wide tax competition framework, the topic of this dissertation, has not been analyzed so far in the literature.

CHAPTER 4

THEORETICAL MODEL

As shown in the last chapter, most of the literature concerning tax competition has commonly focused on a regional basis, that is, countries located near each other along a given geographical area or region compete on tax incentives in order to attract foreign direct investments.[22] This study differs from the past literature in the sense that our focus is on global instead of regional corporate tax competition. More formally, global or world-wide tax competition can be defined as uncooperative tax policy reactions between governments of different countries of the world not necessarily near each other geographically, but in similar economic conditions and with the purpose to influence the allocation of a mobile tax base world-wide. In other words, global tax competition is thought as a tax competition among different countries of the world without providing a significant importance to the geographical location of them, but considering their economic position. For the purpose of this study, export oriented foreign capital investment was referred to as the internationally mobile tax base. For countries in similar economic conditions we assume economies that fall in a given interval of gross national product per capita. The reason to use gross national product per capita as a proxy for economic proximity regards the need for a reliable and given parameter that permits a standard classification of the economies. This classification has been already developed

[22] The incentives can take the form of preferential tax rates, tax holidays, tax discounts, or increased depreciation.

by the World Bank as low income, lower middle income, upper middle income, and high income economies.[23]

The basic mechanics of tax competition and the firms' decision can be described as follows. Firms undertake their decision of where to invest examining many possible locations in terms of costs, economic activity, infrastructure, etc., and narrowing their focus to a handful of potential sites. After that, these potential locations bid against one another by (if they decide to do so) offering firm specific tax reductions and other incentives to the firm to ensure that they become the host.

Thus, world-wide tax competition is possible by internalizing transportation costs, distance, and skills, among other factors, within the firms' decision of where to invest, and most important, on the governments' decisions.

World-wide tax competition is also possible by the inclusion of export oriented firms on which the purpose is to find and use particular and specific resources at a lower real cost in foreign countries, and then export the output produced to the home country or third countries.[24] For this type of firms, resource endowments are commonly considered as one of the most important investment location factors. The amount and availability of these factors can make the country in question more, or less competitive in terms of other countries. For this reason, the literature has repeatedly attempted to evaluate if a tax policy could compensate, in terms of competitiveness, for obstacles in the business

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[23] The classification of the world economies is provided in World Bank (2003, 2004). This is fully explained in the next Chapter.

[24] On the other hand, market oriented investments aim to set up enterprises in a particular country to supply goods and services to the local market. This kind of FDI may be undertaken to sustain or protect existing markets or to exploit or promote new markets. Market size, prospects for market growth, and the degree of development of host countries are very important location factors for market-oriented FDI. The general implication is that host countries with larger market size, faster economic growth and higher degree of economic development will provide more and better opportunities for these industries to exploit their ownership advantages and, therefore, will attract more market-oriented FDI.

environment and attract multinational companies.[25] The result depends on whether the firms are market or export oriented. Work by Reuber (1973), Guisinger (1985), and Coyne (1994), indicate that the impact of tax rates on investment decisions is generally higher on export oriented companies than on those seeking the domestic market. Their reasoning showed that export oriented firms operate in highly competitive markets with very slim margins, and that these firms are often highly mobile, and more likely to compare taxes across alternative locations (Wells, 1986). From their work it can be concluded that taxes are an important part of export oriented firms' cost structure, and that these companies can easily move to take advantage of more favorable tax regimes. Hence, in this case tax incentives compensate for resource obstacles making the country more attractive to investors, and consequently more competitive.

Taking into account the above arguments, and acknowledging transportation costs, distance, and skills, among several factors within the firms' decisions and governments' reactions, a tax competition model can be constructed. The model we build here is based on the Devereux, Lockwood, and Redoano (2002) framework, but we expand their framework to allow for a third country, workers, two types of entrepreneurs and capital, geographical distance between countries, transportation costs, labor skills, and technology skills.[26] The aim of the model then, is to understand the forces that generate competition between countries' fiscal policies and after that generate some

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[25] Reuber (1973) argued that all multinational corporations are not the same, and that they respond differently to special types of incentives, depending on their motivations. Reuber studied 80 investment projects; among export oriented projects, fiscal incentives (including accelerated depreciation, tax holidays, and duty remission) were said to have been important in 48% of the investment decisions, while among investments directed to the domestic market, 56% of responses named protection as the most important factor.

[26] We take into account the geographical distance as well as the economic distance in the model. The first is internalized in the theoretical model in the form of geographical distance between the FDI host country and the FDI home country. The second, economic distance, refers to the fact of considering the economic fundamentals of each country within the theoretical model.

testable predictions. The interest of the model is to find optimal tax rates that will serve as reaction functions of the governments' fiscal policy instruments. The logical specification of the model follows a three stage framework.

Theoretical Model

Consider a model with three countries on different geographical areas, labeled 1, 2, and 3, $i = 1, 2, 3$. Countries 1 and 2 face similar economic conditions, and compete to attract capital from country 3.[27] There are two unit measures of "export seeking" corporations in country 3 that would like to invest in 1 or 2 depending on their profitability.[28] The output produced in each host country can be sold in the world market or returned to the investor's home country. For this study the latter will be assumed. There is also a unit measure of immobile home producing corporations established in each country, 1 and 2, that produce a private good x. Note that this type of firms will attend the national market, that is, they will produce the "nationally consumed" products.

In summary, there would be two types of corporations, the export oriented firms that will direct their output only to country 3 (returned to the investors' home country), and the home producing firms that will only attend the local market. Additionally, we will assume that the goods produced by both firms are neither substitutes nor complements.

[27] Countries 1 and 2 will be the FDI hosts and can not become FDI home countries. On the other hand, country 3 will be the FDI home country and can not become a FDI host.
[28] Throughout the model, the export seeking corporations coming from country 3 are denominated as "export oriented entrepreneurs." Note that the goods produced by these types of firms are returned to the investors' home country or directed to the international market if assuming no exports or imports between countries 1 and 2. The goods produced will not be sold in the home producing country local market.

Both types of firms, home producing and export oriented, use two production factors to fabricate x: capital *K*, and labor *L*. Labor is the internationally immobile factor in both types of firms and capital is immobile for home producing firms and perfectly mobile for export oriented firms.[29] The total export oriented capital supply of both countries is assumed to be fixed at $\overline{K}_3$, while the total home producing capital supply of both countries is assumed to be fixed at $\overline{K}_1$ and $\overline{K}_2$, respectively. There is no unemployment and there are no moving or transaction costs for the export oriented firms.

The production technology exhibits constant returns to scale and is described by an homogeneous production function, $F(\gamma K, \varphi L)$, where $\gamma > 0$ and $\varphi > 0$ represent the technological and labor skills, respectively. The intensive form of the production function $F(\gamma K, \varphi L)$ is written $F(k_i, \gamma_i, \varphi_i)$, where k_i is capital per worker.[30] Expressing the production function in the intensive form, we have $F'(k) > 0$ and $F''(k) < 0$. Both countries, 1 and 2, are assumed to be small relative to the size of the capital market, so the cost of capital r is equal in both countries to the international capital cost.

Governments finance the provision of a public good g_i in each country through a corporate income tax rate, with a statutory rate of t_i, where $0 \leq t_i \leq 1$. Governments also set a rate of allowance a_i in order to reduce the taxes paid and provide incentives to the firms, where $a_i \geq 0$. Higher values of a_i are preferred by the firms since they indicate higher fiscal incentives, in other words, governments make use of higher rates of

[29] Labor is assumed to be "internationally" immobile, but mobile within a given country.
[30] The production function $F(\gamma K, \varphi L) = Lf(\upsilon k)$ with $\upsilon = \gamma\varphi$ and $k = K / L$. Similarly to the intensive form, $F'(K) > 0$ and $F''(K) < 0$.

allowance in order to encourage firms to invest.[31] There are no taxes on labor or the capital stock. Thus, there are two mechanisms by which the governments can affect the location decision of firms and their investment, the statutory corporate income tax rate and the rate of allowance, (t_i, a_i).Thus, higher tax revenues are obtained by attracting foreign direct investment but lower tax revenues also result from lower t_i and higher a_i.

It is crucial to assume there is a proactive government, meaning a government that reacts to deficiencies or improvements in its economy by proposing, in a reasonable period of time, diverse policies in order to stabilize, correct, or improve the economic situation of its country. Without this assumption, a non-proactive government would not provide the required framework for fiscal competition, neither regional, nor global. Additionally, another necessary assumption is that governments do not discriminate against domestic capital or home country investors, this implies that the same statutory corporate income tax rate, t_i, and rate of allowance, a_i, are applied to the home producing firms and to the export oriented firms. It is also assumed that home countries use a territorial system of taxation and do not offer any credit for the taxes paid abroad.[32]

There are four types of individuals in countries 1 and 2: workers, capitalists, home producing entrepreneurs, and export oriented entrepreneurs. We make a difference between capitalists and entrepreneurs (or firms) since we need to separate the latter into market oriented and export oriented. According to Reuber (1973), Guisinger (1985), and Coyne (1994), the second type of firms have shown to be more sensitive to changes in tax rates. Hence, the model seeks to internalize that behavior.

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[31] For the case of equity finance, *a* represents the percentage of investment deductible from profit. On the other hand, *a* can also reflect the benefits of interest deductibility in the presence of debt financed investment.
[32] This assumption is meant to simplify the theoretical model.

For simplicity in the model we seek that wages stay fixed, thus we assumed a labor supply with the characteristic of perfect elasticity (it has a zero slope).[33] We previously suppose no unemployment, so at the entry of export oriented firms to home producing countries labor demand could increase; with a perfectly elastic labor supply, an increase at the labor demand would not provoke a change in wages.

Export oriented entrepreneurs denoted as type *b* come from country 3, while home producing entrepreneurs are denoted as type *c*. The sum of the four types of individuals in each case yields the total country population. Capitalists and workers preferences are denoted by a quasi-linear utility function of the form $u(x, g) = x + v(g)$ on which *x* is the private good bought with the agent's total income (there are no savings),[34] and *g* is the public good where the function $v(g)$ is increasing and strictly concave, $v'(g) > 0$, and $v''(g) \leq 0$. On the other hand, entrepreneurs preferences (of both home producing and export oriented) are denoted by a similar utility function of the form $u(y, g) = y + v(g)$, where the function $v(g)$ has the same properties as before. The variable *y* denotes the entrepreneurs' (home producing and export oriented) after tax income, but only in the case of the home producing entrepreneurs it will be entirely used to buy a private good.

Additionally, since there are no savings, it is assumed that capitalists, as well as home producing entrepreneurs, obtained their capital and firms through inheritance, in

[33] If we assume a positive sloped labor supply, when increasing the labor demand due to the export oriented firms' entry to the FDI host country, wages should increase since workers would not accept working for the export oriented firms for lower wages than those that they already have. In turn, this could be translated into an increase in the labor costs for the home producing firms, and therefore their utility would be affected negatively (holding other variables constant) by the entry of export oriented firms. For simplicity, this model tries to isolate that effect by assuming to work on the perfectly elastic part of a labor supply curve.

[34] The statement that there are no savings can be questionable at first sight; however, this is assumed to develop the model in a simple form and to acknowledge that workers do not become capitalists, and that capitalists do not become home producing entrepreneurs. The model could be extended to include savings in a later work.

such a way that capitalists would not become entrepreneurs, nor entrepreneurs will become capitalists. The model is developed in a static form.

Each government chooses the parameters of the corporate tax system that maximize social welfare, which is assumed to be the sum of utilities of the types of individuals, taking as given the tax systems outside the country. The variables are measured in real terms.

The order of events is formulated in four stages which are described as follows:
(1) Governments in both countries choose their corporate tax instruments;
(2) Entrepreneurs make relocations decisions; (3) Entrepreneurs purchase capital inputs and hire workers; and (4) Production, consumption and exports take place. Although the four stages are important, our interest relies on the first three, with primary concern of what happens at stage 1. The model will be solved backwards since we are assuming that governments change their tax package decision after observing the levels of the current production, consumption, investment and location of firms (export oriented) under the present tax package.

In what follows we offer a more detailed description of the income and utility of the four participants of the model, workers, the two kinds of entrepreneurs, and capitalists.

Participants of the Model

Type I. Capitalists

For home producing entrepreneurs there is a unit measure of capitalists in each country, 1 and 2. They receive the return for their capital endowment equal to $r\kappa_i$, where

κ_i is the individual endowment of capital in country *i*. κ_i is defined as the total capital stock of country *i* divided by the number of capitalists of country *i*.[35] Variable *r* is defined as the price of capital.

$$\kappa_i = \frac{\overline{K}_i}{s_i} \tag{11}$$

where $\overline{K}_i$ is the capital stock of country *i*, while s_i represents the number of capitalists in country *i*. Notice that the individual endowment of capital is only used by the home producing companies, k_i^c, since this type of capital is immobile. So, using both conditions:

$$k_i^c = \kappa_i = \frac{\overline{K}_i}{s_i} \tag{12}$$

where the home producers use of capital per capita equals the capital stock divided by the number of capitalists in country *i*.[36] Capitalists income can be denoted as rk_i^c, while the consumption of the private good can be expressed as x_i^k. Since we previously assumed that the private good was bought with the agent's total income, then $x_i^k = rk_i^c$. Hence,

[35] Note that κ_i can not be denoted as the per capita stock of capital since it only takes into account the owners of capital within the country and not the whole population.
[36] Note that the superscript "*c*" is used to denote the home producers, while "*b*" is used to represent the export oriented entrepreneurs.

country's *i* capitalists utility is given by the private good x_i^k and by the capitalists value of the public good $v(g_i)$. Hence:

$$u(x_i, g_i)^k = rk_i^c + v(g_i) \tag{13}$$

Alternatively, the total fixed stock of capital available for export oriented producers $\overline{K}_3$ is defined as the sum of the capital stock for export oriented producers in countries 1 and 2.

$$k_1^b + k_2^b = \overline{K}_3 \tag{14}$$

where k_1^b and k_2^b represent the stock of capital for export oriented entrepreneurs in countries 1 and 2. The total stock of capital available for export oriented producers come exclusively from country 3, $\overline{K}_3$. The income from capital of country 3 is assumed to come entirely from the export oriented entrepreneurs. We do not specify the utility for the capitalists in country 3 since they are not a part of the social welfare functions of the FDI host countries 1 and 2.

Type II. Workers

There is a unit measure of workers residents in country *i* that receive a return for their labor equal to w_i. The wage is completely transformed into consumption of *x*, since as previously stated, agents consume all their income and there are no taxes on labor income.[37] Hence, $x_i^w = w_i$.

Following Brueckner and Saavedra (2001) wages for the home producing firm are determined by:[38]

$$w_i^c = F(k_i^c, \gamma_i, \varphi_i) - k_i^c F'(k_i^c) \tag{15}$$

Wages in the home producing firm are defined as output per worker minus the payment to capital in terms of its marginal product and the amount of capital per worker. On the other hand, the export oriented firm wages are given by:

$$w_i^b = (1-\theta_i)\left(F(k_i^b, \gamma_i, \varphi_i) - k_i^b F'(k_i^b)\right) \tag{16}$$

where θ_i represents the marginal cost of transportation, described in Equation 30 below.

From the above and acknowledging that the fraction of the labor supply on which we are working on this model has the characteristic that it is perfectly elastic, thus the following condition is obtained in order to maintain a simple equilibrium:[39]

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[37] Consumption assumptions are important since the model aims to maximize the social welfare function of the country on which the individuals are taken into account. The utility of each type of individual acknowledges the consumption of the private and the public good.

[38] See Appendix B, Workers and Wages section.

[39] For simplicity, we assume that the labor market has a negative sloped demand curve and a labor supply composed of a perfectly elastic initial part and a positive sloped consequent part. The model is developed in the perfectly elastic initial part of the curve. If assuming a positive sloped labor supply, when the labor demand increases due to the export oriented firms' entry to the FDI host country, wages should increase in order to maintain equilibrium in the labor market. The latter could be transformed, first into an increase in the utility of workers; and second into an increase in the labor costs for the home producing firms affecting negatively their utility (holding other variables constant). So, in order to maintain simplicity and do not deal with workers and home producers utility shifts due to export oriented firms entrance to a country, this

$$w_i = w_i^{\,c} = w_i^{\,b} \tag{17}$$

Note that if $w_i^{\,c} > w_i^{\,b}$ workers would not sell their labor for lower payments than those they are already receiving. In other words, workers would not accept working for the export oriented firm since the wages the latter is offering are lower than those of the home producing firm. The export oriented firms must offer “at least” w^c to the workers if they want to attract them. Therefore, it is assumed that the wage paid is equal in both types of firms, home producer and export oriented in order to maintain equilibrium.[40]

Assembling the above, workers utility is defined as the sum of their income plus their value of the public good, which is described as:

$$u(x_i, g_i)^w = w_i + v(g_i) \tag{18}$$

Type III. Home Producing Entrepreneurs

There are two types of entrepreneurs residing in countries 1 and 2. Type *c* are the home producing entrepreneurs, and type *b* are the export oriented entrepreneurs. Home producing entrepreneurs’ goal, each of whom owns a firm, is to reach the highest possible after tax profits since their income comes exclusively from the profit made by their

model tries to isolate such effect by assuming a perfectly elastic initial part and a positive sloped consequent part of the labor supply; and then, working on the first one. See Figure A.1 in Appendix A.

[40] Note from Appendix B, Workers and Wages section, Equations B7, and B10 that if $w_i^c = w_i^b$ and since $\theta \neq 0$, then $k_i^c = k_i^b \sqrt{(1-\theta)}$.

firms.[41] They face wages equal to w_i; total cost of capital used equal to rk_i^c; a statutory corporate tax rate equal to t_i, and an allowance rate equal to a_i.[42] Hence, the after tax profits of home producing firms located in country *i* can be expressed as:[43]

$$\Pi_i^c = (1 - t_i)\Gamma_i \tag{19}$$

where:

$$\Gamma_i = \left(F(k_i^c, \gamma_i, \varphi_i) - w_i - z_i r k_i^c\right) \tag{20}$$

$$z_i = \frac{(1 - t_i a_i)}{(1 - t_i)} = (1 + m_i) \tag{21}$$

$$m_i = \frac{t_i(1 - a_i)}{(1 - t_i)} \tag{22}$$

where $(1 - t_i)\Gamma_i$ indicates the after tax profits of the home producing firm in country *i*; γ_i represents the technology skills in country *i*; φ_i are the labor skills; w_i is the wage; *r* is the cost of capital; z_i is defined as one plus the effective marginal tax rate; and m_i

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[41] Despite of the differences between the terms entrepreneurs and firms, these will be used indifferently along this dissertation.

[42] See Appendix B, Home Producing Entrepreneurs section.

[43] Also, note that the home producing entrepreneurs' after tax profit with a tax system (t_i, a_i) can be written in a form such as: $\Pi_i^c = (1 - \lambda_i^c)(F(k_i^c, \gamma_i, \varphi_i) - w_i - rk_i^c)$ where $\lambda_i^c = \dfrac{t_i\left(F(k_i^c, \gamma_i, \varphi_i) - w_i - a_i r k_i^c\right)}{F(k_i^c, \gamma_i, \varphi_i) - w_i - rk_i^c}$ and λ_i^c represents the average effective tax rate for the home producing firms.

represents the effective marginal tax rate (EMTR) on new investment in function of the statutory corporate tax rate and the rate of allowance.[44]

Home producing entrepreneurs maximize the after tax profits in order to reach the "optimal" decision of how much to invest. Hence:

$$(1-t_i)\underset{k_i^c}{Max}\left[F(k_i^c,\gamma_i,\varphi_i)-w_i-z_i r k_i^c\right]=(1-t_i)\Gamma(\gamma_i,\varphi_i,w_i,z_i,r) \qquad (23)$$

Now, using Equations 20 and 23 the first order condition can be extracted which is simply the net of tax return to capital for the home producing firm:[45]

$$F'(k_i^c,\gamma_i,\varphi_i)=z_i r \qquad (24)$$

According to the above, and using Equation 21, m_i indicates the aspect of the tax system that determines the scale of a firm's operation, that is the choice of capital per worker, k_i^c, in any country, other things equal.

Solving for k_i^c in Equation 24, the "optimal" decision of how much to invest will depend on γ, φ, *r*, and *m*, for the case of the home producing firm:

$$k_i^c = k(\underset{-}{m_i},\underset{-}{r},\underset{+}{\gamma_i},\underset{+}{\varphi_i}) \qquad (25)$$

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[44] Note that $z_i=(1+m_i)$; $\frac{dz_i}{dm_i}>0$; $\frac{dz_i}{da_i}<0$; $\frac{dz_i}{dt_i}\begin{cases}>0 & if \quad a<1\\ <0 & if \quad a>1\end{cases}$; see Appendix B, Home Producing Entrepreneurs section.

[45] See Appendix B, Home Producing Entrepreneurs section.

Note that the signs below the variables represent the relation between capital per worker, k_i^c, and the variable in question, that is, the first derivative of k_i^c with respect to the variables in question.

Thus, the after tax income for the home producing entrepreneur can be expressed as:

$$y_i^c = (1-t_i)\Gamma_i(\gamma_i, \varphi_i, w_i, z_i, r) \tag{26}$$

While the home producer entrepreneur's utility is composed by the sum of the home producer after tax income plus his value of the public good.

$$u(y_i, g_i)^c = (1-t_i)\Gamma_i + v(g_i) \tag{27}$$

Type IV. Export Oriented Entrepreneurs

Recall that export seeking corporations coming from country 3, or export oriented entrepreneur's decision of where to invest would depend on which country would they expect to obtain the higher after tax profits for their investments. Again, it must be assumed that their income comes exclusively from the profit made by their firms.[46]

[46] Again, this could be a questionable assumption but it is a measure to simplify the analysis. In fact, in order to evaluate the profitability of an export oriented firm located in a given location of the world we should treat each firm separately from their parent (no cross subsidies), thus the profitability of each firm will depend only on the profits made by themselves in the country of residence and not on the whole multinational firm. In this sense, a corporation will be profitable depending on their own costs and benefits that would be in function of the world's location of the firm.

The after tax profits of the export oriented firms located in country *i* can be expressed as:[47]

$$\Pi_i^b = (1 - t_i)\Psi_i \tag{28}$$

where

$$\Psi_i = \left(F(k_i^b, \gamma_i, \varphi_i) - w_i - h_i - z_i r k_i^b\right) \tag{29}$$

on which Ψ_i takes into account the marginal effective tax rate, $z_i = 1 + m_i$; and h_i represents the transportation costs depending on the output produced and on the distance between the producing country and the target country, D_i. Note that h_i refers to the transportation costs from country *i* to country 3.

$$h_i = \vartheta_i D_i + \theta_i F(k_i^b, \gamma_i, \varphi_i) \tag{30}$$

on which ϑ_i represents a fixed coefficient of the distance between countries *i* and 3, where $\vartheta_i > 0$. Alternatively, θ_i represents the marginal cost of transportation, where θ_i is defined to be variable between countries, and $0 < \theta_i < 1$.[48]

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[47] See Appendix B, Export Oriented Entrepreneurs section.

[48] Following Hummels (2001), ocean shipping services are generally charged as US dollars per ton and may also include some minimal loading or unloading expenses. Ocean freight rates also include a charge for a fixed trade route. On the other hand, air cargo rates are assumed to be a function of the volume traded and the distance between the port of shipping and the port of entry. The formula presented here is assumed to be a simplification of the transportation costs commonly observed in reality. Equation 30 includes a

Before the export oriented firms have decided where to invest, the decisions of how much to invest in either location would depend on the "optimal" capital per worker that will maximize the after tax profit. The "optimal" capital per worker decision in each location is needed since entrepreneurs must evaluate which location, given the tax package (t_i, a_i), provides the highest after tax profits.

Export oriented entrepreneurs maximize their after tax profits in order to reach the "optimal" decision of how much to invest. Hence:[49]

$$(1-t_i)\underset{k_i^b}{Max}\left[F(k_i^b,\gamma_i,\varphi_i)-w_i-h_i-z_i r k_i^b\right]=(1-t_i)\Psi(\gamma_i,\varphi_i,w_i,\theta_i,D_i,\vartheta_i,z_i,r) \quad (31)$$

From Equation 31 the after tax return to capital for the exporting firm is represented by:[50]

$$(1-\theta_i)F'(k_i^b,\gamma_i,\varphi_i)=z_i r \quad (32)$$

where the decision of how much to invest will depend on γ, φ, r, θ, and m, for the case of the export oriented firm. Thus:[51]

$$k_i^b = k(\underset{-}{m_i},\underset{-}{r},\underset{-}{\theta_i},\underset{+}{\gamma_i},\underset{+}{\varphi_i}) \quad (33)$$

variable factor determining a cost per volume, and a fixed factor determining the cost per kilometer or mile transferred.

[49] See Appendix B, Export Oriented Entrepreneurs section.

[50] Note that one of the differences between the net return to capital for the home producing firm and the net return to capital for the exporting firm is provided by the marginal cost of transportation $(1-\theta_i)$.

[51] See Appendix B, Export Oriented Entrepreneurs section.

where an increase of country's *i* EMTR m_i, marginal cost of transportation θ_i, and international cost of capital *r*, lead to a decrease in the export oriented capital invested in country *i*. To the contrary, an increase in the technological and labor skills in country *i* increases the level of export oriented capital in country *i*.

Now, since capital is mobile in the case of export oriented firms, net returns must be equalized across countries 1 and 2. Therefore:

$$\frac{1}{z_1}(1-\theta_1)F'(k_1^b,\gamma_1,\varphi_1) = r = \frac{1}{z_2}(1-\theta_2)F'(k_2^b,\gamma_2,\varphi_2) \tag{34}$$

An additional condition is that the export oriented total capital stock is fixed, hence, export oriented capital per capita of country 1 plus export oriented capital of country 2 must be equal to the total export oriented capital stock $\overline{K}_3$. Thus:

$$\overline{K}_3 = k_1^b + k_2^b \tag{35}$$

Now, the optimal value of k_1^b in terms of the competing country's variables and in function of the total export oriented capital of country 3 can be expressed as:[52]

$$k_1^b = k(\underset{-}{z_1}, \underset{+}{z_2}, \underset{-}{\theta_1}, \underset{+}{\theta_2}, \underset{+}{\gamma_1}, \underset{-}{\gamma_2}, \underset{+}{\varphi_1}, \underset{-}{\varphi_2}, \underset{+}{\overline{K}_3}) \tag{36}$$

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[52] The signs below the variables represent the relation between the capital per worker and the variable in question. See Appendix B, Export Oriented Entrepreneurs section.

where an increase of country's 1 EMTR, m_1, and marginal cost of transportation θ_1, as well as in the labor and technological skills of country 2, φ_2 and γ_2, respectively, lead to a decrease in the export oriented capital invested in country 1. To the contrary, a raise of country's 2 EMTR m_2, and marginal cost of transportation θ_2, as well as in the technological and labor skills of country 1 and in the total export oriented capital supply of country 3, lead to an increase in the level of export oriented capital in country 1.[53]

Note from Equations 28 and 29 that the exporting firms' after tax profit in a country with a tax system (t_i, a_i) can be written:

$$\Pi_i^b = \left(1-\lambda_i^b\right)\left(F(k_i^b,\gamma_i,\varphi_i)-w_i-h_i-rk_i^b\right) \tag{37}$$

where

$$\lambda_i^b = \frac{t_i\left(F(k_i^b,\gamma_i,\varphi_i)-w_i-h_i-a_i rk_i^b\right)}{F(k_i^b,\gamma_i,\varphi_i)-w_i-h_i-rk_i^b} \tag{38}$$

where λ_i^b indicates the effective average tax rate (AETR) for an export oriented entrepreneur, which is represented by the taxes paid as a percentage of true economic profit. For that reason, ceteris paribus, λ_i^b could represent the element of the tax system that determines the location of the firm, as indicated by Devereux, Lockwood, and Redoano (2002). That is, if export oriented firms located in country 2 observe that they will pay a high AETR in country 1, they will not consider moving from country 2 to

[53] As previously stated, $z_i = (1+m_i)$, or 1 plus the EMTR of country *i*.

country 1, and vice versa. In this case it implies a comparison between λ_1^b and λ_2^b for export oriented firms, other things equal. However, assume a comparison of the form $\lambda_2^b = \frac{t_2\left(F(k_2^b,\gamma_2,\varphi_2)-w_2-h_2-a_2rk_2^b\right)}{F(k_2^b,\gamma_2,\varphi_2)-w_2-h_2-rk_2^b}$ against $\lambda_1^b = \frac{t_1\left(F(k_1^b,\gamma_1,\varphi_1)-w_1-h_1-a_1rk_1^b\right)}{F(k_1^b,\gamma_1,\varphi_1)-w_1-h_1-rk_1^b}$, in which $\mu = \lambda_1^b - \lambda_2^b$, then if $\mu < 0$ country's 2 export oriented entrepreneurs will move to country 1 since the AETR in country 1 is lower than the AETR in country 2. Nonetheless, consider a situation in which $a_1 = a_2 = 1$, and $t_1 = t_2$, but $\gamma_1,\varphi_1 \neq \gamma_2,\varphi_2$, in this case the comparison will end with $\mu = 0$ which indicates that no export oriented entrepreneur of country 2 will consider moving to country 1, since the AETR's in both countries are the same. However, this comparison is incorrect since indeed the AETR's are the same, but the technology and labor skills are not, leading to different after tax profits in each country since the level of investment per capita, *k*, would be different in each location. The latter will imply a different location decision for a firm. So, a simple comparison of AETR's in isolation without controlling for other determinants of foreign direct investment can lead to the wrong conclusion concerning the final location choice of firms.

After recognizing this problem, export oriented firms' most preferable location to invest could be determined by the following conditions:

Define:

$$q = [(1-t_1)(\Psi_1)] - [(1-t_2)(\Psi_2)] \tag{39}$$

Hence:

a. If $q > 0$ then $(1-t_1)(\Psi_1) > (1-t_2)(\Psi_2)$ and therefore firms located in country 2 will find country 1 more profitable and will decide to move to country 1.

b. If $q < 0$ then $(1-t_1)(\Psi_1) < (1-t_2)(\Psi_2)$ and therefore firms located in country 1 will find country 2 more profitable and will decide to move to country 2.

The above conditions imply that a positive value of q, ($q > 0$), leads to capital flight from firms in country 2 towards country 1; to the contrary, a negative value of q, ($q < 0$), indicates a capital flight from firms on country 1 towards country 2. Thus, in order to obtain the fraction of entrepreneurs that will leave country 2 towards country 1, and using Equation 39 it is necessary to define the following:

$$\Omega = \frac{q}{(1-t_2)(\Psi_2)} = \frac{(1-t_1)(\Psi_1)}{(1-t_2)(\Psi_2)} - 1 \tag{40}$$

where Ω is assumed restrained to $\Omega = [-1,1]$ since a positive value of Ω represents the fraction of export oriented entrepreneurs located in country 2 that will relocate and invest in country 1; to the contrary, a negative value of Ω represents the fraction of export oriented entrepreneurs located in country 1 that will leave and invest in country 2.[54] On the other hand, $(1+\Omega)$ represents the total export oriented entrepreneurs investing in country 1, including investors from country 1 and country 2.[55] It results important to

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[54] Units are considered perfectly divisible and can be expressed in fractions.
[55] Note that (1-Ω) represents the number (fraction) of export oriented entrepreneurs investing in country 2.

recall that there are two unit measures of export oriented entrepreneurs in country 3 that would like to invest in countries 1 and/or 2.[56]

Thus, the number of export oriented entrepreneurs investing in country 1 is determined by:[57]

$$(1+\Omega)=\frac{(1-t_1)(\Psi_1)}{(1-t_2)(\Psi_2)} \tag{41}$$

Given the restraining conditions assumed for Ω, then $0 \leq (1+\Omega) \leq 2$, since there are two unit measures of export oriented entrepreneurs. The latter indicates that the export oriented entrepreneurs investing in country 1 could go from 0, to the total number of entrepreneurs including country 2 and country 1, that is 2. Since the conditions regarding the "optimal" capital per capita and the number of entrepreneurs investing in country 1 are already obtained, what follows is to assemble the export oriented entrepreneurs' after tax income given a tax system (t, z). Thus, the total export oriented entrepreneurs' after tax income for country *i* can be expressed as:

$$y_i^b = (1+\Omega)(1-t_i)\Psi_i \tag{42}$$

Note that country 1 total export oriented entrepreneurs' include export oriented entrepreneurs' from country 1 and those coming from country 2.

[56] For simplicity in the model we assumed two unit measures of export oriented entrepreneurs; however, these two unit measures could represent a given number of firms, i.e., 1,000 export oriented firms.
[57] See Appendix B, Condition of Investment section.

Finally, country *i* total export oriented entrepreneur's utility is determined by their after tax income and their value for the public good.

$$u(y_i, g_i)^b = (1+\Omega)(1-t_i)\Psi_i + (1+\Omega)v(g_i) \tag{43}$$

After a description of the incomes and utilities of the types of individuals has been given, the next section establishes the three central stages of the model in a backward form.

Stages of the Model

Stage 3: Entrepreneurs Purchase Capital Inputs and Hire Workers

The maximum profit of a home producing entrepreneur given a tax system (t, z) is:

$$(1-t_i)\underset{k_i^c}{Max}\left[F(k_i^c, \gamma_i, \varphi_i) - w_i - z_i r k_i^c\right] = (1-t_i)\Gamma(\gamma_i, \varphi_i, w_i, z_i, r) \tag{44}$$

Countries, 1 and 2, home producing entrepreneurs optimal investment is determined by:[58]

$$k_1^c = k(\underset{-}{m_1}, \underset{-}{r}, \underset{+}{\gamma_1}, \underset{+}{\varphi_1}) \tag{45}$$

[58] See Appendix B, Home Producing Entrepreneurs section.

$$k_2^c = k(\underset{-}{m_2}, \underset{-}{r}, \underset{+}{\gamma_2}, \underset{+}{\varphi_2}) \tag{46}$$

Alternatively, the maximum profit of an export oriented entrepreneur, given a tax system (t, z) is:

$$(1-t_i)\underset{k_i^b}{Max}\left[F(k_i^b, \gamma_i, \varphi_i) - w_i - h_i - z_i r k_i^b\right] = (1-t_i)\Psi(\gamma_i, \varphi_i, w_i, \theta_i, D_i, \vartheta_i, z_i, r) \tag{47}$$

Where the optimal value of k_1 can be expressed as:[59]

$$k_1^b = k(\underset{-}{z_1}, \underset{+}{z_2}, \underset{-}{\theta_1}, \underset{-}{D_1}, \underset{-}{\vartheta_1}, \underset{+}{\theta_2}, \underset{+}{\gamma_1}, \underset{-}{\gamma_2}, \underset{+}{\varphi_1}, \underset{-}{\varphi_2}, \underset{+}{\bar{K}_3}) \tag{48}$$

and the optimal value of k_2 is given by:

$$k_2^b = k(\underset{+}{z_1}, \underset{-}{z_2}, \underset{+}{\theta_1}, \underset{-}{\theta_2}, \underset{-}{D_2}, \underset{-}{\vartheta_2}, \underset{-}{\gamma_1}, \underset{+}{\gamma_2}, \underset{-}{\varphi_1}, \underset{+}{\varphi_2}, \underset{+}{\bar{K}_3}) \tag{49}$$

Regarding the number of workers hired, firms will hire workers until the payment for their labor equals the value of the marginal productivity for labor. Hence, from Equations 15 and 16:[60]

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[59] See Appendix B, Export Oriented Entrepreneurs section.
[60] See Appendix B, Workers and Wages section.

$$F'(L_i^c) = w_i^c = \left(F(k_i^c, \gamma_i, \varphi_i) - k_i^c F'(k_i^c)\right) = w_i \tag{50}$$

$$F'(L_i^b) = w_i^b = (1-\theta_i)\left(F(k_i^b, \gamma_i, \varphi_i) - k_i^b F'(k_i^b)\right) = w_i \tag{51}$$

We assume that both, the wage that the home producing entrepreneur pays, w_i^c, and the export oriented entrepreneur wage, w_i^b, are equal since there is perfect mobility of workers within a country.[61] If an export oriented entrepreneur wishes to set up a plant in a given country he would "at least" pay the workers the same wage that they are earning in the home producing firm. Workers, generally, will not be tempted to leave their job for a lower wage.[62] Hence, wages are assumed to be equal to w_i.

Following Equations 50 and 51, labor demand is determined by:

$$L_i^c = L\left(w_i^{-1}\right) = L\left\{\left[\left(F(k_i^c, \gamma_i, \varphi_i) - k_i^c F'(k_i^c)\right)\right]^{-1}\right\} \tag{52}$$

$$L_i^b = L\left(w_i^{-1}\right) = L\left\{\left[(1-\theta_i)\left(F(k_i^b, \gamma_i, \varphi_i) - k_i^b F'(k_i^b)\right)\right]^{-1}\right\} \tag{53}$$

[61] See Type II. Workers, above.

[62] Workers, generally, take into account several factors in their decision to leave their job. A few of such factors are higher wages, better work conditions, and distance traveled from home to their job, among others. These factors can be exchanged by one another in the sense that a worker could accept a lower wage but with better work conditions. In this context, the model presented in this chapter assumes that workers take their decisions regarding the wage they earn, and not on other factors that depend considerably on the utility of each worker.

Stage 2: Entrepreneurs make Relocations Decisions

Entrepreneurs take relocation decisions following the condition given by:

$$(1+\Omega)=\frac{(1-t_1)(\Psi_1)}{(1-t_2)(\Psi_2)} \tag{54}$$

where

$$\frac{d(1+\Omega)}{dt_1}=\frac{d\Omega}{dt_1}=\frac{-\Psi_1}{(1-t_2)\Psi_2}+\underset{+}{\frac{(1-t_1)}{(1-t_2)\Psi_2}}\underset{+}{\frac{d\Psi_1}{dk_1^b}}\underset{-}{\frac{dk_1^b}{dz_1}}\underset{?}{\frac{dz_1}{dt_1}}<0 \tag{55}$$

assuming $\left|\frac{\Psi_1}{(1-t_2)\Psi_2}\right|>\left|\frac{(1-t_1)}{(1-t_2)\Psi_2}\frac{d\Psi_1}{dk_1^b}\frac{dk_1^b}{dz_1}\frac{dz_1}{dt_1}\right|$ in the case that $\frac{dz_1}{dt_1}<0$.

Similarly,

$$\frac{d(1+\Omega)}{da_1}=\frac{d\Omega}{da_1}=\underset{+}{\frac{(1-t_1)}{(1-t_2)\Psi_2}}\underset{+}{\frac{d\Psi_1}{dk_1^b}}\underset{-}{\frac{dk_1^b}{dz_1}}\underset{-}{\frac{dz_1}{da_1}}>0 \tag{56}$$

and

$$\frac{d(1+\Omega)}{dz_1}=\frac{d\Omega}{dz_1}=\underset{+}{\frac{(1-t_1)}{(1-t_2)\Psi_2}}\underset{+}{\frac{d\Psi_1}{dk_1^b}}\underset{-}{\frac{dk_1^b}{dz_1}}<0 \tag{57}$$

The above intuitively indicates that an increase in the corporate tax rate of country 1 will decrease the number of entrepreneurs investing in country 1, other things equal. Likewise, an increase in the EMTR of country 1 will lead to a decrease in the total number of entrepreneurs investing in country 1. Alternatively, an increase on the fiscal incentives, that is an increase on the allowance rate, will provoke an increase on the number of entrepreneurs investing in country 1, other things equal. Hence, the relocation decision is provided by Equation 54.

Stage 1: Governments in both Countries choose their Corporate Tax Systems

Governments finance the provision of a public good g_i in each country through a statutory corporate income tax rate, t_i, and the allowance rate a_i.[63] The government can tax the home producer entrepreneurs and the $(1+\Omega)$ export oriented entrepreneurs' resident in the country, and can tax both their rents and their use of capital. So, the government budget constraint for country *i* can be expressed as:[64]

$$g_i = (1+\Omega)\left[t_i\Psi_i + (z_i - 1)rk_i^b\right] + \left[t_i\Gamma_i + (z_i - 1)rk_i^c\right] \qquad (58)$$

The objective of government of country *i* is to reach the optimal tax instruments that will maximize the social welfare, which is simply the sum of utilities of the four types of residents in the country, subject to the location decision condition.[65]

[63] Governments' revenues are used completely to finance the provision of the public good *g*.
[64] See Appendix B, Government Budget Constraint section.
[65] The utilitarist type of Social Welfare Function used in this work is assumed given its simplicity to work with at an algebraic level, but also, since we want to provide the same weight to the preferences of each individual, that is, we do not want to discriminate against or in favor of any of the individuals of the model. It can be put into discussion that social planners could not assign a same weight to the nationals' social

Taking into account country 1, its Social Welfare Function can be written as:

$$SWF_1 = u_1^w + u_1^k + u_1^c + u_1^b \tag{59}$$

or

$$SWF_1 = w_1 + v(g_1) + r\kappa + v(g_1) + (1 - t_1)\Gamma_1 + v(g_1) + (1 + \Omega)(1 - t_1)\Psi_1 + (1 + \Omega)v(g_1) \tag{60}$$

which by simplification:[66]

$$SWF_1 = w_1 + r\kappa + (4 + \Omega)v(g_1) + (1 - t_1)\Gamma_1 + (1 + \Omega)(1 - t_1)\Psi_1 \tag{61}$$

Suppose that the utility of the public good $v(g_i)$ is linear in g_i in such a form that $v(g_i) = \phi g_i$, where $\phi > 0$.[67] It is assumed that *g* is an impure public good which is rival and non-excludable since it leads to perfect crowding but on the other hand an exclusion payment mechanism is difficult to implement.

Therefore, the government will maximize Equation 61 subject to Equation 54 with the control variables being the statutory corporate tax rate, t_i, and the EMTR simplified by using z_i. In addition, assume that the social welfare function is strictly

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welfare than to the no-nationals, or in fact that the differences in weight could also be applied within the nationals. This kind of observation could be represented in the model by assigning a different weight to each type of individual; however, we maintain a no discriminatory approach between the types of individuals in the model.

[66] Note that the Social Welfare Function of country 1 internalized the number (fraction) of export oriented entrepreneurs investing in country 1, that is $(1 + \Omega)$.

[67] For straightforwardness in the mathematical calculations we could assume that $\phi = 1/(\text{Types of individuals})$. However, for the case of symbolic calculations the term ϕ is left that way.

quasi-concave in t_1 and z_1.[68] The government SWF maximization internalizes both types of entrepreneurs after tax income since greater after tax income for the home producing entrepreneurs would imply greater consumption of the home produced good; while a greater after tax income for the export oriented entrepreneurs will increase the attractiveness of the country to additional export oriented investors which would come into the country and hire new workers.[69]

For competition between the two recipient countries for FDI, we assume Nash-Cournot behavior.[70] Hence, government of country 1 chooses taxes t_1 and z_1 to maximize SWF_1 subject to the location condition of $(1+\Omega)$ and assuming t_2 and z_2 as fixed. Note that country 2 behaves in a similar form. Hence, the maximization problem is given by:

$$\underset{t_1, z_1}{Max}\ SWF_1 = w_1 + rk_1^c + v(g_1)(4+\Omega) + (1-t_1)\Gamma_1 + (1+\Omega)(1-t_1)\Psi_1 \qquad (62)$$

$$\textit{Subject to:} \quad (1+\Omega) = \frac{(1-t_1)(\Psi_1)}{(1-t_2)(\Psi_2)}$$

Consequently, the first order conditions can be expressed as:

$$\frac{dSWF_1}{dt_1} = \frac{d(w_1 + rk_1^c)}{dt_1} + \frac{dy_1^c}{dt_1} + \frac{dy_1^b}{dt_1} + \frac{dv(g_1)}{dt_1}[4+\Omega] + \frac{dSWF_1}{d\Omega}\frac{d\Omega}{dt_1} = 0 \qquad (63)$$

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[68] Note that by obtaining the optimal values of t_1 and z_1 the optimal value of the allowance rate, a_1, could be additionally obtained using the definition of z_1.

[69] In reality, foreign direct investments could cause positive externalities to the countries on which they decide to locate. Externalities such as technology and the know-how could be spread on the location and workers, respectively.

[70] The approach used in this study assumes a Nash-Cournot behavior, in which each government considers the taxes of all other rival governments and sets its own tax system in a way that maximizes its social welfare function. All governments choose the tax systems simultaneously. In equilibrium, each government sets its tax system at its social welfare maximizing point, given the tax systems of all the other governments, thus they would not find it optimal to choose a different tax package. This is an approach we have applied in detail to the corporate tax competition for FDI framework.

$$\frac{dSWF_1}{dz_1} = \frac{d\left(w_1 + rk_1^c\right)}{dz_1} + \frac{dy_1^c}{dz_1} + \frac{dy_1^b}{dz_1} + \frac{dv(g_1)}{dz_1}\left[4+\Omega\right] + \frac{dSWF_1}{d\Omega}\frac{d\Omega}{dz_1} = 0 \qquad (64)$$

Intuition indicates that by solving the previous conditions for t_1 and z_1 it is possible to obtain the optimal statutory tax rate t_1^* for country 1, and the optimal EMTR for country 1, $m_1^* = z_1^* - 1$. Furthermore, the optimal allowance rate a_1^* is obtained by substituting t_1^* and z_1^* into Equation 21.

Nonetheless, as argued by Devereux, Lockwood, and Redoano (2002), governments will not find efficient and optimal to use the tax on capital, m_1, and the allowance rate, a_1. The intuition is that a capital tax, or the allowance rate, causes double distortion in that it causes outward migration of firms and an inefficient use of capital by the remaining firms, whereas a corporate income tax distorts only location decisions. So, it is not desirable to use a double distorting capital tax. Hence, $z_1^* = 1$, and $m_1^* = 0$.

In order to show the above let's assume that $0 < t_i < 1$ and that $z_1^* = 1$. Hence, from Equation 63:[71]

$$\frac{dSWF_1}{dt_1} = \begin{bmatrix} \frac{d\left(w_1 + rk_1^c\right)}{d\Omega} + \frac{dx_1^c}{d\Omega} + 2(1-t_1)\Psi_1 \\ + \phi\left[t_1\Psi_1 - (1-t)\Psi_1 - \frac{dx_1^c}{d\Omega}\right]\left[4+\Omega\right] + \frac{dSWF_1}{d\Omega} \end{bmatrix} \frac{d\Omega}{dt_1} = 0 \qquad (65)$$

[71] See Appendix B, Government Maximization Problem section.

and from Equation 64:

$$\frac{dSWF_1}{dz_1} = \begin{bmatrix} \frac{d\left(w_1 + rk_1^c\right)}{d\Omega} + \frac{dx_1^c}{d\Omega} + 2(1-t_1)\Psi_1 \\ +\phi\left[t_1\Psi_1 - (1-t)\Psi_1 - \frac{dx_1^c}{d\Omega}\right][4+\Omega] + \frac{dSWF_1}{d\Omega} \end{bmatrix} \frac{d\Omega}{dz_1} = 0 \qquad (66)$$

Note that $\left.\frac{dSWF_1}{dt_1}\right|_{z_1=1} = 0$ implies that $\left.\frac{dSWF_1}{dz_1}\right|_{z_1=1} = 0$, and hence the optimal z_1 is 1, which indicates that the optimal allowance rate (a_1) is also 1, and the optimal EMTR (m_1) is zero. Consequently, if the government of country 1 chooses a statutory corporate tax rate that is positive, then it will find optimal to choose $z_1^* = 1$, and $a_1^* = 1$, without regard to the tax policy of country 2.[72] Additionally, since $z_1^* = 1$ and substituting this value into Equations 20 and 29, Γ_1 is now considered the before tax profits for the home producing entrepreneurs, while Ψ_1 represents the before tax profits of the export oriented entrepreneurs.

Since the optimal EMTR, m_1, is already solved, it is now the turn to obtain the optimal statutory corporate tax rate. By solving for t_1 in Equation 66, the reaction function for country 1, or the optimal statutory corporate tax rate, t_1^*, can be expressed as:[73]

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[72] See Appendix B, Government Maximization Problem section.
[73] See Appendix B, Optimal Statutory Corporate Tax Rate section. Note that the signs below the variables in the optimal statutory tax rate represent the empirical relation between the statutory corporate tax rate of country 1 and the variables in question.

$$t_1^* = t\left(\underset{+}{t_2}, \underset{-}{\theta_1}, \underset{-}{D_1}, \underset{-}{\vartheta_1}, \underset{+}{h_2}, \underset{-}{r}, \underset{+}{\gamma_1}, \underset{+}{\varphi_1}, \underset{-}{\gamma_2}, \underset{-}{\varphi_2}, \underset{-}{w_1}, \underset{+}{w_2}, \underset{+}{\overline{K}_3}\right) \tag{67}$$

where the optimal rate of allowance, effective marginal tax rate, and average effective tax rates, for both home producing and export oriented firms, are represented by $a_1^* = 1$; $z_1^* = 1$; and $\lambda_1^{b^*} = \lambda_1^{c^*} = t_1^*$. Nonetheless, Devereux, Lockwood, and Redoano (2002) have indicated that an optimal $z_1^* = 1$ does not hold in their data. Generally, z_1^* exceeds 1 for equity financed investment. Their reasons concern the treatment of losses; that by giving full relief for all expenditure (when it is incurred) implies that governments may end up subsidizing loss making investments. Nonetheless, naturally, they are unwilling to do this. An option may be to pick a lower value for a_1 and consequently a higher value of z. In such circumstances, the government will impose a positive EMTR, and then tax capital as well as economic rent. Alternatively, governments can still compete for firm location by choosing an appropriate statutory tax rate.

Note from the reaction function (Equation 67) the pattern of tax competition when a decrease in the statutory corporate tax rate of country 2 leads to a decline in the statutory corporate tax rate of country 1. This effect comes as a result of the relative loss of competitiveness of country 1 at the reduction of country's 2 tax rate.

Similarly, a decrease in country's 2 wages and transportation cost as well as in country's 1 technology and labor skills lead to a decrease in the statutory corporate tax rate of country 1. Intuitively, these actions will make country 1 relatively less attractive to investors than country 2, hence, country's 1 authority will direct their efforts to reduce their statutory corporate tax rate.

Alternatively, an increase in country's 1 wages and transportation costs, and country's 2 technology, and labor skills, lead to a decrease in the statutory corporate tax rate of country 1. A raise in these variables will make country 1 less attractive to foreign investors, so in order to compensate for this loss of competitiveness, government 1 decides to decrease its optimal statutory corporate tax rate, t_1^*.

A positive change in the international cost of capital *r* leads to a decline in the optimal statutory corporate tax rate of country 1. An increase in *r* indicates a raise in the opportunity cost of capital making country's 3 investors reevaluate their investment positions in country 1 and 2. Hence, to compensate for the change in *r*, fiscal incentives are needed in order to continue to attract foreign investors to countries 1 and 2, as a consequence a decrease in t_1^* occurs.

Finally, an increase in the export oriented fixed capital supply will induce to an increase in the t_1^*. Intuitively, the slight positive relationship obeys to a wider margin of movement of the statutory corporate tax rate. More supply of capital will be available and consequently it will be distributed between countries 1 and 2. It must be remarked that the magnitude of the change is relatively small, but of course it would depend on the size of the capital increase.

The intention of the model is to obtain a reaction function so as to observe or measure the level of corporate tax competition between 2 countries; hence Equation 67 provides that function. Nonetheless, it is also possible to solve the model simultaneously for country 1 and 2 in order to reach the Cournot-Nash equilibrium. For that, it is first necessary to obtain the optimal statutory corporate tax rate for country 2, t_2^*, this is done by maximizing the Social Welfare Function of country 2 subject to the location condition $(1-\Omega)$. Hence:[74]

$$\underset{t_2, z_2}{Max}\ SWF_2 = w_2 + rk_2^c + v(g_2)(4-\Omega) + (1-t_2)\Gamma_2 + (1-\Omega)(1-t_2)\Psi_2 \qquad (68)$$

$$\textit{Subject to:} \quad (1-\Omega) = 2 - \frac{(1-t_1)(\Psi_1)}{(1-t_2)(\Psi_2)}$$

Thus, the optimal statutory corporate tax rate for country 2, or country's 2 reaction function, is given by:

$$t_2^* = t\left(\underset{+}{t_1}, \underset{-}{\theta_2}, \underset{-}{D_2}, \underset{-}{\vartheta_2}, \underset{+}{h_1}, \underset{-}{r}, \underset{-}{\gamma_1}, \underset{-}{\varphi_1}, \underset{+}{\gamma_2}, \underset{+}{\varphi_2}, \underset{+}{w_1}, \underset{-}{w_2}, \underset{+}{\bar{K}_3} \right) \qquad (69)$$

where similarly to country's 1 reaction function, it indicates that a decrease in country's 1 corporate tax rate will lead to a decline in corporate tax rate of country 2. Furthermore, country's 2 optimal rate of allowance is $a_2^* = 1$, the effective marginal tax rate is $z_2^* = 1$, and the average effective tax rates, for both home producing and export oriented firms are given by $\lambda_2^{b^*} = \lambda_2^{c^*} = t_2^*$.

Now, substituting Equation 69 into Equation 67, the Cournot-Nash equilibrium of the corporate tax rate for country 1 is given by:

$$t_1^* = t\left(\underset{-}{\theta_1}, \underset{-}{D_1}, \underset{-}{\vartheta_1}, \underset{+}{\theta_2}, \underset{+}{D_2}, \underset{+}{\vartheta_2}, \underset{-}{r}, \underset{+}{\gamma_1}, \underset{+}{\varphi_1}, \underset{-}{\gamma_2}, \underset{-}{\varphi_2}, \underset{-}{w_1}, \underset{+}{w_2}, \underset{+}{\bar{K}_3} \right) \qquad (70)$$

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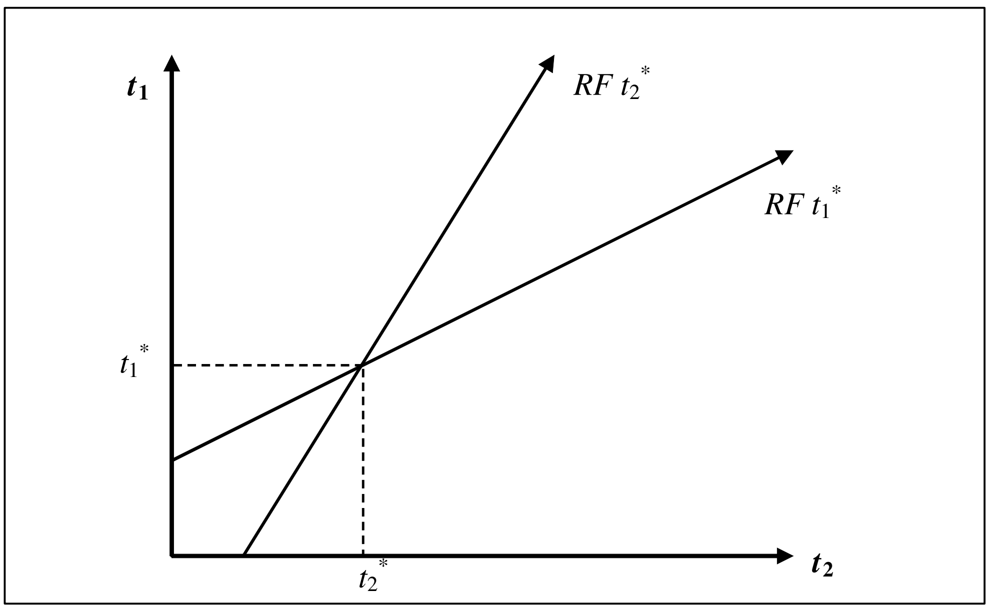
74 See Appendix B, Reaction Function of the AETR section.

and for country 2:

$$t_2^* = t\left(\underset{+}{\theta_1}, \underset{+}{D_1}, \underset{+}{\vartheta_1}, \underset{-}{\theta_2}, \underset{-}{D_2}, \underset{-}{\vartheta_2}, \underset{-}{r}, \underset{-}{\gamma_1}, \underset{-}{\varphi_1}, \underset{+}{\gamma_2}, \underset{+}{\varphi_2}, \underset{+}{w_1}, \underset{-}{w_2}, \underset{+}{\overline{K}_3}\right) \tag{71}$$

Both reaction functions, Equations (67) and (69), can be represented in Figure 1. Note that both have a positive slope.

Figure 1
Reaction Functions for Countries' 1 and 2 Corporate Tax Rates



Note that RFt_i^* indicates the reaction function for country *i*, and t_1^* and t_2^* represent the Cournot-Nash equilibrium, when the countries' fundamentals are the same, Table 1 scenario 1.

As observed previously, the optimal statutory corporate tax rate for both, countries 1 and 2, depends on the countries' fundamentals; that is on the labor and technological skills, wages, and transportation costs, among other factors. Assuming that these factors are considered within the before tax profits of the home producing entrepreneurs (Γ_i) and export oriented entrepreneurs (Ψ_i), it is possible to note that given different countries fundamentals, the resulting optimal statutory corporate tax rates of each country will be different.[75] Hence, Table 1 shows the different scenarios for the Cournot-Nash Equilibrium when taking into account different amounts for Γ_i and Ψ_i.

Table 1
Policy Implications for Different Cournot-Nash Equilibriums for Optimal Statutory Corporate Tax Rates

1) If $\left.\begin{matrix}\Psi_1 = \Psi_2 \\ \Gamma_1 = \Gamma_2\end{matrix}\right\} \Rightarrow t_1 = t_2$	4) If $\left.\begin{matrix}\Psi_1 = \Psi_2 \\ \Gamma_1 < \Gamma_2\end{matrix}\right\} \Rightarrow t_1 < t_2$	7) If $\left.\begin{matrix}\Psi_1 < \Psi_2 \\ \Gamma_1 < \Gamma_2\end{matrix}\right\} \Rightarrow t_1 < t_2$
2) If $\left.\begin{matrix}\Psi_1 > \Psi_2 \\ \Gamma_1 = \Gamma_2\end{matrix}\right\} \Rightarrow t_1 > t_2$	5) If $\left.\begin{matrix}\Psi_1 = \Psi_2 \\ \Gamma_1 > \Gamma_2\end{matrix}\right\} \Rightarrow t_1 > t_2$	8) If $\left.\begin{matrix}\Psi_1 < \Psi_2 \\ \Gamma_1 > \Gamma_2\end{matrix}\right\} \Rightarrow t_1 ? t_2$
3) If $\left.\begin{matrix}\Psi_1 < \Psi_2 \\ \Gamma_1 = \Gamma_2\end{matrix}\right\} \Rightarrow t_1 < t_2$	6) If $\left.\begin{matrix}\Psi_1 > \Psi_2 \\ \Gamma_1 > \Gamma_2\end{matrix}\right\} \Rightarrow t_1 > t_2$	9) If $\left.\begin{matrix}\Psi_1 > \Psi_2 \\ \Gamma_1 < \Gamma_2\end{matrix}\right\} \Rightarrow t_1 ? t_2$

Note: The sign "$\Rightarrow$" means leads to.

For example, starting from a situation where $\Psi_1 = \Psi_2$ and $\Gamma_1 = \Gamma_2$, the statutory corporate tax rates of both countries, 1 and 2, tend to be equal. To the contrary, if $\Psi_1 < \Psi_2$ and $\Gamma_1 = \Gamma_2$, the before tax profits of the export oriented entrepreneurs in country 1 would be smaller than those in country 2; hence, country 1 should offer a

[75] Recall that since $z_1^* = 1$, Γ_1 from Equation 20 is now considered the before tax profits for the home producing entrepreneurs, and Ψ_1 from Equation 29 represents the before tax profits of the export oriented entrepreneurs.

smaller statutory corporate tax rate than country 2 in order to attract export oriented firms.[76]

On the other hand, it is of course possible to solve the model in terms of the AETR, λ. So, regarding the corporate average effective tax rate reaction functions, several equations must be redefined, among those, the location decision constraint, Equation 54. Recall from previous assumptions that governments do not discriminate against domestic capital or home country investors, this implies that the same statutory corporate income tax rate, t_i, and rate of allowance, a_i, are applied to the home producing firms and to the export oriented firms. Hence if governments compete through AETRs to attract export oriented entrepreneurs they would have to take into account the transportation costs since this type entrepreneur acknowledges the costs of transportation in the profit valuation. Thus, governments would compete through the export oriented AETRs, λ_i^b. Furthermore, this framework serves in a better way for an empirical investigation since both, the statutory corporate income tax rate, t_i, and rate of allowance, a_i, are internalized within λ_i^b.[77]

Export oriented entrepreneurs' after tax income in terms of AETRs is represented by:

$$y_i^b = (1+\Omega)(1-\lambda_i^b)\Lambda_i \tag{72}$$

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[76] For the case of policy implication number 4 in Table 1, when home producing entrepreneurs in country 1 have smaller before tax profits than in country 2, the statutory corporate tax rate in country 1 tends to be smaller than in country 2 in order to incentive national investment. A similar approach applies to policy implication number 5. The sign "?" in policy implications 8 and 9 implies that the setting of the optimal statutory corporate tax rate of each would depend on the magnitudes of the differences between Ψ_1 and Ψ_2, and Γ_1 and Γ_2.

[77] See Appendix B, Reaction Function of the AETR section.

where Λ_i is defined as the export oriented before tax income as:

$$\Lambda_i = \left(F(k_i^b, \gamma_i^b, \varphi_i^b) - w_i^b - rk_i^b - h_i^b\right) \tag{73}$$

In addition, home producing entrepreneurs' after tax income in terms of AETRs is redefined as:

$$y_i^c = \left(1 - \lambda_i^c\right)\Sigma_i \tag{74}$$

where Σ_i is the home producing entrepreneurs' before tax income given by:

$$\Sigma_i = \left(F(k_i^c, \gamma_i^c, \varphi_i^c) - w_i^c - rk_i^c\right) \tag{75}$$

The new location decision constraint depending on AETRs is represented by:

$$1 + \Omega = \frac{\left(1 - \lambda_1^b\right)\Lambda_1}{\left(1 - \lambda_2^b\right)\Lambda_2} \tag{76}$$

where Ω has the same qualities and conditions as before.

Alternatively, the new government constraint in terms of AETRs is categorized by:

$$g_i = (1+\Omega)\lambda_i^b \Lambda_i + \lambda_i^c \Sigma_i \tag{77}$$

Now, the government search for the optimal λ_1^b that would maximize the social welfare function subject to the new form of the location decision constraint, Equation 76, and taking into account Equations 72, 74, and 77. Thus:

$$\underset{\lambda_1^b}{Max}\ SWF_1 = w_1 + rk_1^c + v(g_1)(4+\Omega) + y_1^c + y_1^b \tag{78}$$

$$Subject\ to: \quad (1+\Omega) = \frac{(1-\lambda_1^b)\Lambda_1}{(1-\lambda_2^b)\Lambda_2}$$

Hence, the first order condition is expressed as:

$$\frac{dSWF_1}{d\lambda_1^b} = \frac{d(w_1^b + rk_1^c)}{d\lambda_1^b} + \frac{dy_1^c}{d\lambda_1^b} + \frac{dy_1^b}{d\lambda_1^b} + \frac{dv(g_1)}{d\lambda_1^b}[4+\Omega] + v(g_1)\frac{d\Omega}{d\lambda_1^b} = 0 \tag{79}$$

Solving for λ_1^b the corporate AETR reaction function for country 1 is given by:

$$\lambda_1^b = \lambda\left(\underset{+}{\lambda_2^b}, \underset{-}{\lambda_1^c}, \underset{-}{h_1}, \underset{+}{h_2}, \underset{-}{r}, \underset{+}{\gamma_1}, \underset{+}{\varphi_1}, \underset{-}{\gamma_2}, \underset{-}{\varphi_2}, \underset{-}{w_1}, \underset{+}{w_2}, \underset{+}{\bar{K}_3}\right) \tag{80}$$

where a decrease in the AETR of country 2, λ_2^b, will lead to a decrease in the AETR of country 1. In addition, a decrease in country's 1 technology and labor skills as well as in country's 2 wages and transportation cost lead to a decline in the average effective tax rate of country 1. Intuition indicates that a negative change in these variables lead to a decrease in country's 1 competitiveness relatively to country 2, hence, in order to compensate for this loss of competitiveness country's 1 corporate AETR, λ_1^b, must be reduced.

On the other hand, an increase in country's 1 wages and transportation costs, and country's 2 technology, and labor skills, lead to a decrease in the AETR for export oriented entrepreneurs of country 1. A positive alteration in these variables will make country 1 less attractive to foreign investors, so in order to compensate for this loss of competitiveness, government 1 decides to decrease its AETR, λ_1^b.

Alternatively, there are two theories to evaluate a change in the international cost of capital. First, an increase in the international cost of capital *r* does not provoke any change on the AETRs, neither λ_1^b nor λ_2^b, since every country will face the same change in *r*, and therefore the decisions of the AETR are left unaltered (assuming that the AETRs are computed as in Equation 38 and holding all other variables constant). Second, an increase in *r* indicates a raise in the opportunity cost of capital making country's 3 investors reevaluate their investment positions in country 1 and 2 and perhaps making them evaluate to take their capital and invest it in the financial sector. Hence, to compensate for the change in *r*, fiscal incentives are needed in order to continue to attract foreign investors to countries 1 and 2, as a consequence a decrease in AETR occurs. Given the second conjecture closer similarity to reality, it will be the one assumed along this dissertation.

Aside from previous assumptions, an interesting observation from Equation 80 is that a high home producing AETR for country 1 leads to a low export oriented AETR for the same country. Intuitively, a high λ_1^c will act as a type of cross subsidy to λ_1^b, in such a way that a country, having a high λ_1^c, could find optimal to reduce its λ_1^b in order to attract more foreign direct investment. In this context, a country could charge a higher corporate tax rate to the immobile tax base, and a lower corporate tax rate to the mobile tax base.

Finally, a decrease in the export oriented fixed capital supply will induce a decline in the AETR in order to attract the scarce export oriented FDI.

As expressed in the optimal statutory corporate tax rate exercise, it is possible to solve the model simultaneously in terms AETR's in order to reach the Cournot-Nash equilibrium. Then:

$$\underset{\lambda_2^b}{Max}\ SWF_2 = w_2 + rk_2^c + v(g_2)(4+\Omega) + y_2^c + y_2^b \tag{81}$$

$$\textit{Subject to:} \quad (1-\Omega) = 2 - \frac{(1-\lambda_1^b)\Lambda_1}{(1-\lambda_2^b)\Lambda_2}$$

Hence, the optimal export oriented AETR for country 2 is given by:

$$\lambda_2^b = \lambda\left(\underset{+}{\lambda_1^b}, \underset{-}{\lambda_2^c}, \underset{-}{h_2}, \underset{+}{h_1}, \underset{-}{r}, \underset{-}{\gamma_1}, \underset{-}{\varphi_1}, \underset{+}{\gamma_2}, \underset{+}{\varphi_2}, \underset{+}{w_1}, \underset{-}{w_2}, \underset{+}{\overline{K}_3}\right) \tag{82}$$

Thus, by substituting Equation 82 into Equation 80 the Cournot-Nash equilibrium of the corporate tax rate for country 1 is given by:

$$\lambda_1^b = \lambda\left(\underset{-}{\lambda_2^c}, \underset{-}{\lambda_1^c}, \underset{-}{h_1}, \underset{+}{h_2}, \underset{-}{r}, \underset{+}{\gamma_1}, \underset{+}{\varphi_1}, \underset{-}{\gamma_2}, \underset{-}{\varphi_2}, \underset{-}{w_1}, \underset{+}{w_2}, \underset{+}{\overline{K}_3}\right) \tag{83}$$

while for country 2:

$$\lambda_2^b = \lambda\left(\underset{-}{\lambda_1^c}, \underset{-}{\lambda_2^c}, \underset{-}{h_2}, \underset{+}{h_1}, \underset{-}{r}, \underset{-}{\gamma_1}, \underset{-}{\varphi_1}, \underset{+}{\gamma_2}, \underset{+}{\varphi_2}, \underset{+}{w_1}, \underset{-}{w_2}, \underset{+}{\bar{K}_3}\right) \tag{84}$$

The optimal average effective corporate tax rate for both, countries 1 and 2, depends on the countries' fundamentals, that is on the labor and technological skills, on the wages, and on the transportation costs of countries, 1 and 2. In this context, by assuming that these factors are internalized in the before tax profits of the home producing entrepreneurs, Σ_i, and in the before tax profits of the export oriented entrepreneurs, Λ_i, the results of the different scenarios for the Cournot-Nash Equilibrium will be given by:

Table 2
Policy Implications for Different Cournot-Nash
Equilibriums for Optimal Corporate AETRs

1) If $\left.\begin{matrix}\Lambda_1 = \Lambda_2 \\ \Sigma_1 = \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b = \lambda_2^b$	4) If $\left.\begin{matrix}\Lambda_1 = \Lambda_2 \\ \Sigma_1 < \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b < \lambda_2^b$	7) If $\left.\begin{matrix}\Lambda_1 < \Lambda_2 \\ \Sigma_1 < \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b < \lambda_2^b$
2) If $\left.\begin{matrix}\Lambda_1 > \Lambda_2 \\ \Sigma_1 = \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b > \lambda_2^b$	5) If $\left.\begin{matrix}\Lambda_1 = \Lambda_2 \\ \Sigma_1 > \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b > \lambda_2^b$	8) If $\left.\begin{matrix}\Lambda_1 < \Lambda_2 \\ \Sigma_1 > \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b \,?\, \lambda_2^b$
3) If $\left.\begin{matrix}\Lambda_1 < \Lambda_2 \\ \Sigma_1 = \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b < \lambda_2^b$	6) If $\left.\begin{matrix}\Lambda_1 > \Lambda_2 \\ \Sigma_1 > \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b > \lambda_2^b$	9) If $\left.\begin{matrix}\Lambda_1 > \Lambda_2 \\ \Sigma_1 < \Sigma_2\end{matrix}\right\} \Rightarrow \lambda_1^b \,?\, \lambda_2^b$

From the above it is possible to observe that given different countries fundamentals that affect the before tax profits of the home producing entrepreneurs and the before tax profits of the export oriented entrepreneurs, the resulting optimal statutory corporate tax rates of each country will be different.

Theoretical Model's Global Tax Competition Framework

As defined previously, global or world-wide tax competition is thought simply as tax policy reactions between governments of different geographical areas of the world but in similar economic conditions. It is possible to extract this description and apply it to the theoretical model in such a form that the model itself can provide insights of a global tax competition framework. Hence, observe from Table 2 that if countries face the same economic conditions or economic fundamentals (that is similar wages, transportation costs, technology, or labor skills, or in fact that the mix of them provides comparable advantage before tax incomes) the average corporate effective tax rates of the competing countries are equal. On the other hand, if the economic fundamentals are worse off for country 1, its government must compensate to the export oriented entrepreneurs by offering them a lower AETR, and then make country 1 attractive and competitive. Also note the same analysis applies to Table 1.

It can be noted from Equations 67 and 80 that the effect of a change in the statutory corporate tax rate or AETR of country 2, over the statutory corporate tax rate or AETR of country 1, respectively, will be greater the closer (in terms of income) that the economies of both countries are. To the contrary, the more distant in terms of income the countries are, the smaller the effect of a change in the statutory corporate tax rate or AETR of country 2 over country 1. This can be denoted by:

$$\left.\frac{dt_1^*}{dt_2}\right|_{\Gamma_1>\Gamma_2} < \left.\frac{dt_1^*}{dt_2}\right|_{\Gamma_1\approx\Gamma_2} \tag{85}$$

and

$$\left.\frac{d\lambda_1^{b^*}}{d\lambda_2^b}\right|_{\Lambda_1>\Lambda_2} < \left.\frac{d\lambda_1^{b^*}}{d\lambda_2^b}\right|_{\Lambda_1\approx\Lambda_2} \tag{86}$$

where the sign "$>$" in $\Lambda_1 > \Lambda_2$ denotes "greater than." This finding comes hand in hand with the definition of global corporate tax competition given at the start of the chapter.

Additionally, from the theory we could think of global or world-wide tax competition if the geographical (from the FDI home country to the FDI host country) and economic distances (discussed above) for both, host country and competing country, are taken into account and affect the determination of the optimal statutory corporate tax rate.

So, the model provides us with some predictions regarding the relationship between geographical distances and the optimal corporate tax rates, t_1^*. First, the theoretical conclusions of the model indicate that, among different variables, the geographical distance between the home country and the host country represents a significant factor taken into account by both the optimal statutory corporate tax rate and the optimal AETR. Governments' policymakers consider the distance from country 1 to country 3 when deciding country's 1 optimal statutory and average effective tax rates. Hence:

$$\frac{dt_1^*}{dD_1} < 0 \tag{87}$$

where a greater distance between a host country and the investors' home country leads to a host country's lower optimal statutory tax rate. The intuition behind this argument is that governments' policymakers will tend to provide a form of compensation to the export oriented entrepreneurs' profit since the costs of transportation will be high given the greater distance between countries.

Second, the model indicates that country's 2 parameters (the competitor) also affect country's 1 fiscal policy mechanisms decisions. Hence, distance from country 2 to country 3, whether being greater or smaller, affects the optimal tax rate of country 1. A smaller distance from country 2 to country 3 will provide country's 1 policymakers a lower margin to modify their optimal tax rates, that is, that a smaller D_2 will tend to decrease the optimal statutory and average effective tax rates for country 1. Therefore:

$$\frac{dt_1^*}{dD_2} > 0 \tag{88}$$

Third, the magnitude of the reaction of a country's optimal tax rate to another country's change in its tax rate takes in to account the distance between both countries to the investor's home country. The theoretical model indicates that the slope of the reaction function is greater when $D_1 > D_2$ than when $D_1 < D_2$. Thus, the magnitude of the change in the optimal tax rate of a host country will be greater at the presence of a change in the competing host country tax rate, when the host country is located further from the investors' home country than the competing host country. This can be expressed as:

$$\left.\frac{dt_1^*}{dt_2}\right|_{D_1<D_2} < \left.\frac{dt_1^*}{dt_2}\right|_{D_1>D_2} \tag{89}$$

A similar condition can be extracted from the marginal cost of transportation, θ_1 and θ_2:

$$\left.\frac{dt_1^*}{dt_2}\right|_{\theta_1<\theta_2} < \left.\frac{dt_1^*}{dt_2}\right|_{\theta_1>\theta_2} \tag{90}$$

which implies that the slope of the reaction function of the statutory tax rate depends, among different factors, on the marginal cost of transportation of country's 1 and country's 2.

Extracted from the above is the conclusion that the theoretical model indeed provides an indication that world-wide or global tax competition is possible. Governments, theoretically, take into account the geographical distance from its country to the investors' home country but also consider the distance of the competing host countries to the investors' country when deciding their optimal statutory corporate tax rates. Competing countries' distance is considered when offering tax compensations or incentives to the export oriented entrepreneurs. Also, it is very important that countries with similar economic conditions and with the purpose of attracting FDI will affect each others policies, while countries' policies in dissimilar income conditions would be affected in a less significant form. Hence, the model itself highlights the possible presence of global tax competition.

Summary

The theoretical model in this dissertation assumes a benevolent government who intents to provide a high quality public good to its community. The quality of the public good will improve as more tax revenues are obtained. Higher tax revenues are obtained by attracting foreign direct investment. The nature of the FDI is export oriented as exposed by Reuber (1973), Guisinger (1985), and Coyne (1994), in such a form that the output produced in each host country would be returned to the investor's home country. The objective of the benevolent government is to find the optimal tax instruments that will maximize the social welfare of its country. Reaction functions for the corporate tax rate, the rate of allowance, the average effective tax rate and the marginal effective tax rate are sought in this maximization. Nonetheless, the model indicates that if governments decide a statutory corporate tax rate that does not causes a double distortion then the optimal allowance rate must be equal to one while the EMTR must be equal to zero in order to maintain optimality. Hence, the model is able to provide an optimal statutory corporate tax rate and an optimal average effective tax rate where both serve as reaction functions given their dependence on competing countries' fundamentals. Given the difficulty to obtain reliable data on the statutory corporate tax rates, the marginal effective average tax rates, and the allowance rates, the empirical specification of the model will be based on the average effective tax rate reaction function, Equation 80. Country *i's* export oriented optimal AETR, λ_i^b, depends on the competing country export oriented AETR, λ_j^b; on the host country and competing host country transportation costs, h_i, and h_j, respectively; on the international capital cost r; on the host country and competing host country technology skills, γ_i, and γ_j, respectively; on the host country and competing host country labor skills, φ_i, and φ_j, respectively; on the host country and competing host country wages, w_i, and w_j, respectively; on the host country home producing AETR, λ_i^c; and on the total supply of foreign capital, $\overline{K}_3$.

Commonly, countries that are far way from each other are typically considered as non-reactionary since distance puts a barrier between their responses. Nonetheless, the theoretical model presented in this section provides an insight to the fact that governments, when competing for export oriented FDI, take into account the geographical distance of their competing countries to the investors' home country, as well as the income distance between each other, at the time of deciding their optimal statutory corporate tax rate.

CHAPTER 5

EMPIRICAL MODEL AND METHODOLOGY

The previous chapter provides a theoretical model for the presence of a significant level of global or world-wide corporate tax competition among countries. Crucial assumptions had to be made in order to develop the model properly. Conspicuous among these is the one related to the kind of firms there are; in particular we assume these are export oriented type firms as suggested by Reuber (1973), Guisinger (1985), and Coyne (1994). It is clear that without this assumption the theoretical model could not have an appropriate logic.

Several issues arise from the theoretical model in relation to testing the hypothesis of global (corporate tax) competition scheme among countries.

1. Does the optimal corporate tax rate of a country depend significantly on the corporate tax rates of other countries?
2. Does the significance of global corporate tax competition depend on the fact that the "economic" distance of a country with its competitors is similar?
3. Does the level of corporate global or world-wide tax competition depends significantly on the transportation costs (proxied by the geographical distance) between the host country and the investors' home countries?
4. Does the significance of global corporate tax competition depend on the geographical distance among the host countries?

Additionally, there are further questions that we may want to consider when analyzing the global corporate tax competition framework.

5. Can the similarity or disparity of trade policies between countries affect significantly the setting of a country's optimal corporate tax rate?
6. Do countries tend to reduce their corporate tax rate in order to increase the amount of foreign direct investment inflows depending on their position of foreign direct investment attraction relative to other countries?
7. Do countries compensate by offering lower AETRs if their technological skills are lower than those of their competitors?
8. Finally, do countries compensate by offering lower AETRs if their wages are higher than those of their competitors?

Hence, to answer these questions this section will provide a brief description of the type and measures of corporate taxes we use, the empirical specification of the theoretical model, the data sources, the specification of the variables and their computation, and the econometric methodology used along this investigation.

The Empirical Model

The model to be estimated represents an approximation of Equation 80 in Chapter 4. Nonetheless, in order to make Equation 80 estimable we would need to transform it in several ways. First, given the data availability restraint, it is not possible to estimate Equation 80 for the framework previously established. Furthermore, some merging of parameters is necessary given the large number of variables taken into account. Thus, the real cost of capital, r_i, is internalized within the average effective tax rate for the export oriented entrepreneurs, λ_i^b.[78] The transportation costs, h_i, are approximated by the average geographical distance between the host country and the foreign direct investment home country, D_i, internalized in W_3, fully explained below. The total fixed stock of capital available for export oriented producers $\overline{K}_3$ is decomposed into FDI inflows to host countries and incorporated in a variable denoted as fd_i. The labor skills φ_i are internalized in the constructed variable L_i denoting wages. There is another variable that, according to the literature, is taken into account in the real world when the entrepreneurs decide the location of an export oriented firm, that is openness to trade which will be denoted as op_i.[79] The computation of four variables, L_i, fd_i, op_i and the technology skills γ_i will be explained in further below. Furthermore, in reality two additional variables could affect the AETR behavior: (1) the government expenditure denoted by GE_i, which implies that higher government spending could require additional funding from taxes which could be translated into an increase in the AETR;[80] and (2) the movements of the exchange rate (appreciation or depreciation), ER_i, i.e., an appreciation of the national currency against the U.S. dollar implies that U.S. dollars are worth less in a given country; hence the costs of maintaining an export oriented firm increases relatively, as a consequence, the country's government could compensate by providing

[78] See Equation 38 for an algebraic interpretation, and Devereux, Griffith, and Klemm (2001) for a theoretical interpretation.
[79] Given that the model relies on the export oriented FDI, a trade openness variable will be taken into account in the framework, this will measure how the FDI home countries will invest given the trade policies of the host countries. See Bénassy-Quéré, Fontagné, and Lahrèche-Révil (2001).
[80] Note that an increase of government spending raises the need for higher tax revenues which could put some pressure for an increase at the corporate AETR. However, this does not necessarily occur since the tax system of a country could manage several cross subsidies between taxes or simply increase its indebtedness that could leave the corporate AETR unchanged. Nonetheless, government spending enters the equation in order to measure the significance of its possible effect on the corporate AETR.

tax incentives (observable through its AETR) to the export oriented firms if they want the firm to stay at their current location. Government expenditure will be measured in GDP terms. The exchange rate will be computed as percent changes at the exchange rate, which in turn it will be calculated as US dollars per one unit of the national currency. Consequently, an appreciation of the national currency will be defined as an increase in the ER_i; by contrast a depreciation of the national currency will be seen as a decrease at the ER_i . Recall that wages and labor depend on labor market conditions rather than on governments' policymakers' decisions, and others such as infrastructure, skills and technology can not be changed in the short run, so corporate taxes are the only control variable left that can be changed.

In addition, for representing the model in the real world, we need to make Equation 80 estimable, and for that, it is necessary to assume that $\lambda_i^b = \lambda_i^c = \tau_i$ given the complexity and lack of data that would be needed for estimating two different AETRs for a single country (within a wide sample of countries). Hence, Equation 80 is redefined as:

$$\tau_i = \tau\left(\underset{+}{\tau_j}, \underset{+}{\gamma_i} \, \underset{-}{L_i} \, \underset{+}{fd_i}, \underset{+}{op_i}, \underset{+}{GE_i}, \underset{-}{ER_i}\right) \tag{91}$$

The theoretical model of the previous chapter generated symmetric corporate tax reaction functions of the form $t_i = t(t_j)$ and $\lambda_i^b = \lambda(\lambda_j^b, \lambda_i^c)$ where t_i represents the statutory corporate tax rate and λ_i the export oriented average effective tax rate of country *i*. Nonetheless, as described previously, the empirical form of the model will be based on Equation 91 with a symmetric corporate average tax rate of the form $\tau_i = \tau(\tau_j)$.

The empirical approach approximates in a linear form the corporate AETR reaction function.

Following Altshuler and Goodspeed (2002), Revelli (2000), Brueckner (2003), and Brueckner and Saavedra (2001), the empirical version of Equation 91 may be written as:

$$\tau_{i,t} = \alpha \sum_{i \neq j} \omega_{ij} \tau_{i,t} + \beta_0 \gamma_{i,t} + \beta_1 L_{i,t} + \beta_2 fd_{i,t} + \beta_3 op_{i,t} + \beta_4 ER_{i,t} + \beta_5 GE_{i,t} + \varepsilon_{i,t} \qquad (92)$$

where $\tau_{i,t}$ indicates the AETR of country *i* at time *t*, and ω_{ij} represent a set of weights that aggregate the average effective tax rates in other countries into a single variable, which has a scalar coefficient α. The four constructed variables $\gamma_{i,t}$, $L_{i,t}$, $op_{i,t}$, and $fd_{i,t}$ represent the technology skills, wages, openness to trade and foreign direct investment of country *i*, respectively.[81] Variable $ER_{i,t}$ indicates the exchange rate for country *i* at time *t*, while $GE_{i,t}$ denotes the government expenditure for country *i* at time *t*. Finally, $\varepsilon_{i,t}$ represents the error term. Hence, Equation 92 represents a linear approximation of the nonlinear reaction function presented in Chapter 4.

Additionally, Equation 92 can be rewritten in matrix form as:

$$\tau_t = \alpha W \tau_t + X_t \beta + \varepsilon_t \qquad (93)$$

[81] The four variables $L_{i,}$ γ_i, fd_i and op_i, will be defined further in the chapter.

where τ_t is a vector of corporate average effective tax rates (*i* and *j* jointly) at time *t*; $X_t^{'} = [\gamma_t \quad L_t \quad fd_t \quad op_t \quad ER_t \quad GE_t]$ is a vector containing the technological skills γ_t, the wages L_t, the openness to trade, and the foreign direct investment of both, the home country and the competing countries, and the exchange rates and the government expenditure for country *i*; ε_t is the error vector; and *W* represents the weight matrix.[82] In the present context, the slope of the reaction function is given by $d\tau_{i,t} / d\tau_{j,t} = \alpha\omega_{ij}$. *Thus, a positive and statistically significant value of* α *proves our hypothesis of the presence of world-wide or global corporate tax competition among countries*. Similarly, a statistically different from zero (significant) value of the β parameters will imply that skills, whether technological or labor, wages, FDI and openness to trade will affect the governments' decision of the tax package represented by the AETRs.

Second, we explore extending the above static model into a dynamic one that can be estimated (one more attached to the governments' tax setting current practices). Note that in the literature, Equation 93 is the representation of a spatial autoregressive, or spatial lag, econometrics model. However, we will follow the approach of Nicita and Olarreaga (2000), Hayashi and Boadway (2001), Richard, Tulkens and Verdonck (2001), and Cavlovic and Jackson (2003) substituting the independent variables $\tau_{i,t}$ and $X_{i,t}$ by their one period lagged values $\tau_{i,t-1}$ and $X_{i,t-1}$.

In this sense, an estimation problem arising from the theoretical model in Chapter 4 concerns the condition that the optimal values of the corporate tax rates for each country are set in each period, that is, countries react to one another at the same time

[82] Note that the diagonal elements of the weight matrix W are zero and that a representative off-diagonal element is ω_{ij}.

regarding their optimal decision of their Nash equilibrium values (the continuously setting of corporate tax rates). Devereux, Lockwood and Redoano (2002 p. 21) indicate that this simultaneity or endogeneity seems improbable even in game theory, since the Nash equilibrium might be interpreted as the result of several steps of adjustment. As a consequence, a straightforward adjustment that produces testable reaction functions is to assume that the government in each country establishes the corporate tax rate as the best response to the previous period's corporate tax rates in other countries. Therefore, $\tau_{i,t}$ from the independent variables would replaced by $\tau_{i,t-1}$.

Intuitively, in the real world, governments do not behave automatically nor immediately; they have several restraints when accepting new fiscal policies. For example, in the case of democratic governments, as in the majority of the sample, a change in the statutory corporate tax rate or an increase of a tax incentive has to be prepared, analyzed, and evaluated by policy makers, but must importantly, the changes have to be accepted by the congress. In such a case, the proposals of decreasing the corporate tax rates or providing corporate tax incentives would have to pass several tests within the congress of the country limiting the time of action and delaying the process. Hayashi and Boadway (2001) refer to this aspect as reasonable since governments decisions must internalize the time between studying other governments' tax rates and incentives, and revising and modifying their own. Furthermore, the Nash equilibrium on which taxes are set continuously implicates an approach of perfect availability of information. It is improbable to believe that governments have perfect availability of information about each other tax decisions (for a theoretical explanation see Elhorst, 2001). Rational expectations theory implies that expectations are formed by incorporating all available information about the problem; in this case, much of the information available for a wide sample of countries such as the one used in this investigation comes from previous period data. Expectations about future data are not always available for every country, neither for policymakers nor for government officials in charge of formulating a tax incentive package.

Taking into account the above argument and recognizing that governments take their tax packages decisions by observing the data available (that is, data that has already been generated), as a consequence, variable X_t must also be lagged one period, becoming X_{t-1}.[83]

In order to make the theoretical model applicable and testable for real world behavior, we follow the approach presented in Hayashi and Boadway (2001) and Cavlovic and Jackson (2003).[84] Thus, the empirical model can be described as:

$$\tau_{i,t} = \alpha W \tau_{i,t-1} + X_{i,t-1}\beta + \varepsilon_{i,t} \tag{94}$$

This model is basically described in Anselin (1999), and Lopez and Chasco (2004) as a "*pure space-recursive model*" and as a "*non-contemporary or lagged spatial dependence model,*" respectively.

[83] This approach assumes a one period lag for governments to internalize the information regarding variables that affect the setting of a corporate AETR. Nonetheless, in Appendix F we also performed different estimations using two and three time lags as an exercise, but those regressions are not the central part of the study.

[84] Devereux, Lockwood, and Redoano (2002) indicate that a disadvantage of the lagged specification is that it is not directly consistent with the theory. Governments are assumed myopic in the sense that they do not anticipate any change in other countries' tax rates either due to changes in underlying economic conditions, or as a result of the other governments' myopic reactions to current taxes. We do not agree with this point of view since, as explained previously, governments do not have perfect availability of information nor perfect sharing of it, and furthermore, their policymakers and law actors and mechanisms do not function immediately, that is, they have by default a lag integrated.

Regarding the econometric problems we face, characteristic of spatial econometric models as explained above, the endogeneity or simultaneity issue is avoided entirely by allowing for the interaction among countries to occur with one time lag.[85] Hence, the estimation of Equation 94 through the Ordinary Least Squares (OLS) method will yield consistent parameter estimates.[86]

A second problem occurs if countries' individual characteristics in X_i are correlated with the error term ε. In this case the estimation of the parameters through Maximum Likelihood (ML) and Instrumental Variables (IV) methods are inconsistent. This correlation could occur if some countries' characteristics, conditions or situations affecting τ are unobserved but they are correlated with observed characteristics. A simple procedure to solve this issue is to use panel data in such a way that all time-invariant country conditions, observed or unobserved, can be symbolized by country specific intercepts. Hence, a fixed-effects estimation approach is needed to make α, from Equation 94, consistent (Revelli, 2000; Devereux, Lockwood & Redoano, 2002).

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[85] In order to have a closer view of the endogeneity of the τ's problem it is necessary to transform Equation 93 solving for τ, that is: $\tau_t = (1-\alpha W)^{-1} X_t\beta + (1-\alpha W)^{-1}\varepsilon_t$. Note that the solution to this equation provides, through interaction among countries, the Nash equilibrium. An important inference from the equation above is that any τ is a function of $(1-\alpha W)^{-1}$ and the error term ε, this correlation implies that parameters estimated through OLS are inconsistent. According to Brueckner (2003), there are two methods widely used in the literature to face this problem. In the first method, followed in Buttner (2001), Revelli (2002a), and Devereux, Lockwood, and Redoano (2002), the estimation of the above equation is made through the Instrumental Variables (IV) approach, in which a frequently used procedure is to regress $W\tau$ on X and WX ($W\tau = f(X, WX)$), and use the fitted values $W\tau^*$ as instruments for $W\tau$. Consequently, the τ_j's are viewed as depending on its associated X_j vector and on X_i. The IV approach yields consistent estimates of the parameters of Equation 93. On the other hand, a second approach implies the estimation of Equation 93 through a Maximum Likelihood (ML), however this process has the peculiarity that it involves a non-linear optimization routine since α enters the equation as a non-linear parameter. Similarly to the IV method, the ML approach also generates consistent estimators for the parameters. Authors that have applied this approach are Brueckner (1998), Saavedra (2000), and Brueckner and Saavedra (2001), among others. There is a different approach from the IV and ML methods for avoiding the endogeneity issue completely. Cavlovic and Jackson (2003), and previously Hayashi and Boadway (2001), elude this problematic by assuming that interaction occurs with a time lag, so that the values on the right hand side of Equation 93 are lagged one or more periods. This last approach is the one used at this study.

[86] See Anselin (1999) and Lopez and Chasco (2004).

Thus, we follow this approach in our econometric estimation.[87] Furthermore, several tests are carried out for validating the presence of fixed individual and time effects.[88]

Finally, a third problem, characteristic of spatial econometric models, is the possible presence of spatial error dependence which can be represented by:

$$\varepsilon = \psi W^{e} \varepsilon + v \tag{95}$$

where W^{e} is a weight matrix, which is often assumed to be equal to W in Equation 94, v is well-behaved error vector, and ψ is an unknown parameter.

The problem of spatial error dependence takes place when ε includes omitted variables that are themselves spatially dependent. If this problem is ignored, estimation of Equation 94 may indicate the presence of strategic interaction, when in reality we are facing a spatial error dependence problem. Thus, in order to address this issue, some authors such as Case et al. (1993), have used the ML estimation method taking into account the error structure in Equation 95. According to Brueckner (2003), this approach is difficult and computational challenging, but also it could lead to problems of magnitude measuring since α and ψ play comparable roles in the model. A second

[87] The econometric estimation is formulated to allow for fixed individual and time effects together and separately, and for panel data alone. According to Anselin (1999), fixed individual effects are non compatible with spatial econometric models, thus the coefficients of the spatial individual fixed effects can not be estimated consistently because the number of observations available for their estimation is limited to *T* observations. Nonetheless, Elhorst (2003) indicates that the inconsistency of the fixed individual effects is not transmitted to the estimator of the slope coefficients in the demeaned equation since this estimator is not a function of the demeaned fixed individual effects. The latter implies that the large sample properties of fixed effects model when *T* is fixed and *N* tends to infinity do apply for the demeaned equation. If the fixed effects model also contains fixed time effects, for short panels when *T* is fixed and *N* tends to infinity, the fixed effects for time periods can be estimated consistently.

[88] See Appendixes C and E.

solution is to apply the IV approach discussed previously since even with spatial error dependence it provides a consistent estimate of α (Kelejian & Prucha, 1998).

A different technique to manage this problem is to rely on hypothesis tests to validate the presence of spatial error dependence. Anselin, Bera, Florax, and Yoon (1996), and later Baltagi, Song, Jung, and Koh (2003), developed several Lagrange robust tests for this topic. These tests have the characteristic of not being skewed or damaged if spatial error dependence is not corrected, but most importantly, they can simply be obtained from the estimation of Equation 94 through OLS.[89] This approach described in Brueckner (2003) is used by Saavedra (2000), and Brueckner and Saavedra (2001).

Thus, taking into account the above arguments into Equation 94, the empirical model can be represented as:

$$\tau_{i,t} = \phi + \alpha W \tau_{i,t-1} + X_{i,t-1}\beta + u_{i,t} \qquad (96)$$

$$u_{it} = \mu_i + \eta_t + \varepsilon_{it} \qquad (97)$$

where μ_i represent the individual fixed effects, η_t indicate the time period effects, and ϕ is the intercept. Following Baltagi, Song, Jung, and Koh (2003) we will also be analyzing the possibility that the following would be present:[90]

[89] See Appendix C.
[90] See Appendix C.

$$\varepsilon_{it} = \lambda W_{NT} \varepsilon_{it} + v_{it} \quad (98)$$

$$v_{it} = \rho v_{it-1} + e_{it} \quad (99)$$

where W_{NT} is the weight matrix assumed equal to the previous defined weight matrixes, λ represents the spatial correlation in the error terms, and ρ is the serial correlation at the error terms. Note that $e_{it} \sim \mathrm{IIN}(0, \sigma_e^2)$, $v_{it} \sim \mathrm{N}(0, \sigma_e^2/(1-\rho^2))$. Baltagi, Song, Jung, and Koh (2003) Lagrange tests imply testing for $H_0^e : \rho = 0$ and $H_0^e : \lambda = 0$, where if λ is statistically different from zero then we are facing a spatial error dependence problem instead of strategic interaction, and if ρ is statistically different from zero then we are in front of serial correlation in the error terms.[91]

Thus, by substituting Equation 97 into Equation 96, the empirical model that will be estimated at this study through the OLS method regards:

$$\tau_{i,t} = \phi + \mu_i + \eta_t + \alpha W \tau_{i,t-1} + X_{i,t-1}\beta + \varepsilon_{it} \quad (100)$$

The description of the computation of the average effective tax rates, the weight matrixes, and other deterministic variables will be presented in the next section.

[91] For a further description see Appendix C.

Theoretical Specification of Computed Variables

The Weight Matrix

The weight matrix W comes within the linear representation of Equation 80, in which the average effective corporate tax rate of country *i* depends on a weighted average of the average effective corporate tax rate of the competing country plus additional deterministic factors. The weights reflect the influence of each competing country tax rate on the own country tax rate. Hence, in principle, we would expect the weights ω_{ij} to be large when corporate tax competition between countries *i* and *j* is estimated to be high. Authors such as Altshuler and Goodspeed (2002) set a weighting scheme according to geographical distance, where ω_{ij} is inversely related to the distance within jurisdictions *i* and *j*.[92] Others such as Devereux, Lockwood, and Redoano (2002) indicate that the degree of tax competition between two countries may not only depend on the geographic proximity of countries, but also in the relative size of the economy against the U.S. economy, and the degree to which they are open to international flows.

This dissertation will use neither of these two approaches, but instead it will rely on four other methodologies. First, an analysis will be made by assuming the same weight for each competing country tax rate in matrix W_1. Its computation is simple since it only represents an average of the number of countries taken into account. For example, if the sample includes 21 countries, the weights will be equal to 0.05 since only 20 countries are taken into account to form the matrix weights.[93] The reason for using this matrix is to evaluate the presence of global (corporate tax) competition in its simplest

[92] See Chapter 3 for a greater insight.
[93] Note that the diagonal elements of the weight matrix are equal to zero.

form, that is, without assigning a given and different weight to each country AETR. This matrix also serves as a benchmark for the other three approaches. Furthermore, it is clear that, in a simple form, we could answer the first question established above regarding the significant dependence of the optimal tax rate of a country on the tax rates of other countries.[94]

Second, as the definition of global corporate tax competition points out, a given country will tend to face greater tax competition against countries that have similar economic conditions. This implies that that the weights ω_{ij} will be high when there is some level of proximity between the countries' GNP per capita. This matrix will be represented by W_2. It will be computed using a similar approach to that in Brueckner and Saavedra (2001), and Altshuler and Goodspeed (2002).[95] Their weighting scheme assigns a weight of one to contiguous countries (states, counties, etc.) and zero to all others. Note that one important difference between their approach and this dissertation is that instead of a geographical distance, this study uses the concept of an economic distance. The weight scheme is based on the proximity of GNP per capita among countries. To use a given, standard and *reliable* parameter for economic proximity, we use the Classification of Economies provided by the World Bank. There, countries are classified in a range of

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[94] See Chapter 5.

[95] The difference between the weighting scheme W_2 and that applied in Devereux, Lockwood, and Redoano (2002) work regards that the latter provides different weights to every country depending on the relative size of their economy against the U.S. economy; the weights are measured as the total GDP of country *i* divided by the total GDP of the U.S. This scheme does not represent a measure for similar economic conditions of countries since there could be a developed country with a similar GDP to a developing country, and this would give a similar ratio of GDP_A/GDP_{US}; however, the developed country would have a low population and the developing country a extremely high population showing great differences in the GDP per capita of the developed and developing countries. Hence, if the condition above is present we would be setting poor, medium income or perhaps rich countries in the same economic condition interval; a situation that misses the principal point of this dissertation. On the other hand, the weights provided for W_2 regard economic proximity and gives equal weights to those countries that fall in a given interval of GNP per capita, without taking as a reference just one given economy, and taking into account the per capita term which reflects in a greater form the similar economic condition term.

low income ($735 or less); lower middle income ($736-$2,935); upper middle income ($2,936-$9,075); and high income ($9,076 or more).[96] The countries that fall in the same interval as the studied country will be given a value of one; the countries that fall one interval above or below the country in question are given a value of 0.75; the countries that fall two intervals above or below the given country are given a value of 0.5; and the ones falling three intervals above or below are given a value of 0.25. Consequently, the weight matrix W_2 will be formed by normalizing the weights so every row will add to one.

As mentioned above, the reason to use this matrix for our framework is to evaluate the presence of global corporate tax competition given its definition in Chapter 4. Regarding the economical distances between the countries, a country could compete with another not depending if they are close to each other geographically, but rather if they are close to each other in terms of economical distance. In addition, by using this matrix it is possible to answer the second question at the start of the chapter. Does the significance of global corporate tax competition depend on the fact that the "economic" distance of a country with its competitors is similar?

Third, in matrix W_3 weights ω_{ij} will be calculated by using the geographical distance as an approximation for transportation costs. In this context, weights ω_{ij} will be greater when host countries have similar geographical distances to the FDI home country.

[96] See World Bank (2004). For operational and analytical purposes, the World Bank's main criterion for classifying economies is gross national product (GNP) per capita. Every economy is classified as low income, middle income (subdivided into lower middle and upper middle), or high income. Low-income and middle-income economies are sometimes referred to as developing economies. The classification includes all World Bank member economies and all other economies with populations of more than 30,000. Economies are divided among income groups according to 2003 GNP per capita, calculated using the World Bank Atlas method. The groups are: low income, $735 or less; lower middle income, $736–$2,935; upper middle income, $2,936–$9,075; and high income, $9,076 or more.

The reason for using this computation is to evaluate if countries that face similar transportation costs (proxied by the geographical distances) to the FDI home country show a higher level of global corporate tax competition. Moreover, question three of the introduction section of this chapter can be solved by this framework. Does the level of corporate global or world-wide tax competition depends significantly on the transportation costs (proxied by the geographical distance) between the host country and the investors' home countries?

Hence, in order to accomplish the above, transportation costs depend on the output produced by the export oriented investing firm and on the geographical distance between the home country and the host country. That is:

$$h_i = h\big(D_i, \theta_i, F(k_i^b, \gamma_i, \varphi_i)\big) \qquad (101)$$

Nonetheless, given the lack of data, the amount of parameters to be estimated and the wide sample of countries, it is not practical to calculate the previous equation. Thus, in order to simplify Equation 101 and make it available for empirical estimation is necessary to assume that the transportation costs will be approximated by the average geographical distance between the foreign direct investor home country and the host country. Consequently, Equation 101 can be re-expressed as:

$$h_i = h\Big(\underset{+}{D_i}\Big) \qquad (102)$$

The average geographical distance was measured using the distance in miles from the host country capital city to the capital cities of United Kingdom, France, Belgium, Spain, Netherlands, Germany, Hong Kong, Canada, United States, and Japan, the top ten FDI home countries.[97]

Matrix W_3 is computed in the following form. First, we obtain the average geographical distance from the top ten FDI home countries to the host countries, x_i (each country of the sample). The second step is to construct an initial matrix with the x_i without making the diagonal elements of the matrix equal to zero. The third step is to calculate y_i defined as the absolute value of the difference of 1 less the ratio of a host country average geographical distance (to the FDI home country) to the country of reference from which we want to obtain the weights, this computation can be extracted from the matrix as $y_i = \left|1 - x_{ij}/x_{ii}\right|_{i \neq j}$, where *i* and *j* are the elements of the matrix. This computation is similar to an scale where $y_i \geq 0$ with indicates that countries that have similar average geographical distances to FDI home countries will face ratios of x_{ij}/x_{ii} closer to one and small y_i's, which with further calculations would provide higher weights to those countries that share similar distances, and to the contrary, host countries that face dissimilar average geographical distances will end up with ratios of x_{ij}/x_{ii} distant from 1 and high y_i's, that will provide lower weights to those countries that share different distances.

[97] See Chapter 2. The distance calculation is done using the web page http://www.indo.com/cgi-bin/dist/, which uses the "geod" program, which is part of the "PROJ" system available from the U.S. Geological Survey at http://kai.er.usgs.gov/pub/.

The fourth step is to calculate the row sum of the y_i, that is $\sum_{i=1}^{N} y_i$. Step five will be to construct a second matrix with the following row values $\left[\sum_{i=1}^{N} y_i \Big/ y_i\right]$. Sixth, we obtain the sum of the row values of the second matrix, that will be $\sum_{i=1}^{N}\left[\sum_{i=1}^{N} y_i \Big/ y_i\right]$, and step seven, we construct matrix W_3 by calculating the weights given by

$$\omega_{ij} = \frac{\left[\sum_{i=1}^{N} y_i \Big/ y_i\right]}{\sum_{i=1}^{N}\left[\sum_{i=1}^{N} y_i \Big/ y_i\right]}.$$ [98]

Note that FDI host countries in different geographical regions could face similar transportation costs, that is, they could share similar geographical distances between them and the FDI home countries.

Finally, a different approach is used in matrix W_4 where we use the geographical distances between the host countries. The reason for it is to evaluate if countries located in a neighboring condition face greater tax competition than those situated far way from each other. Matrix W_4 computation is simple the weights of countries that reside in the same continent are granted a value of 1, and if they are not, a value of zero.[99] Subsequently, the weights ω_{ij} will be formed by the ratio of the value (i.e., 1 or 0) divided by the sum of the row. Furthermore, matrix W_4 serves to resolve question number 4 of the introduction.

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[98] These steps are included in order to normalize the rows of the weight matrix.

[99] Perhaps in a further work it could result interesting to assign the weights of the countries based on a miles distance ratio instead of assigning them to the same continent basis, i.e., Mexico could be assigned a value of 1 in relation to Canada but a ratio of 0.5 in relation to Argentina or Brazil despite their location in the same continent. But again, the approach used in this work tries to maintain simple the complex task of modeling corporate tax competition.

In the four approaches used to calculate the weight matrixes, the weights are normalized to add to one.

Additional Constructed Variables

In order to be able to answer if the optimal tax rate of a country depends significantly on its position of foreign capital attraction relative to other countries, and if the similarity or disparity of trade policies between countries affects significantly the setting of a country's optimal corporate tax rate, an additional identification of variables is needed.

First, it is necessary to define the foreign direct investment inflows variable previously denoted as $fd_{i,t-1}$, in the following form:

$$fd_{i,t-1} = \left(f_{i,t-1} - \overline{f_{j,t-1}} \right) \tag{103}$$

where $\overline{f_{j,t-1}} = W_s f_{j,t-1}$ represents the weighted FDI inflows to competing countries *j*, $f_{i,t-1}$ denotes country's *i* FDI inflows at time *t-1*, and W_s indicates the weight matrix, whether W_1, W_2, W_3, or W_4, used in the regression. Observe that if $fd_{i,t-1} < 0$, country *i* FDI inflows will be smaller than the weighted FDI inflows of its competing countries *j*, and regarding its effects over the AETR it might oblige a decrease in the corporate AETR of country *i* at time *t* since the policymakers and politicians will react with a one period lag.[100]

Intuitively, a country's corporate tax rate at time *t* can be determined in part by the country's own ability to attract FDI in relation to its competing countries attraction of foreign capital. The variable is lagged one period since we are assuming that policymakers, politicians, and law mechanisms do not function immediately, that is, they have by default a lag integrated. In this context, a deviation of country *i* from its competitors weighted FDI attraction at time *t-1* will affect the setting of *i*'s optimal corporate AETR at time *t*. The $fd_{i,t-1}$ variable is measured in million of US dollars per year.

A second variable, openness to trade denoted above as $op_{i,t-1}$ can be described as:

$$op_{i,t-1} = \left(o_{i,t-1} - \overline{op}_{j,t-1} \right) \tag{104}$$

where $\overline{op}_{j,t-1} = W_s o_{j,t-1}$ represents the weighted trade openness of competing countries *j*, $o_{i,t-1}$ denotes country's *i* trade openness at time *t-1*, and W_s indicates the weight matrix, whether W_1, W_2, W_3, or W_4, used in the regression. Observe that if $op_{i,t-1} < 0$, country *i* trade openness will be lower than the weighted trade openness of its competing countries *j*, and regarding its effects over the AETR it might oblige a cut in the corporate AETR of country *i* at time *t*. It is clear that the use of this variable obeys to the fact that countries will face greater tax competition against each other if their trade policies are similar. The

[100] See a further explanation for lagging variables above in the chapter.

trade openness variable will be measured similarly to Bénassy-Quéré, Fontagné, and Lahrèche-Révil (2001) as the ratio of the sum of imports and exports to GDP. Thus, the variable used along this methodology summarizes the trade policies of each country. $op_{i,t-1}$ will be measured in GDP terms.

A third constructed variable which denotes a country's wage deviation from its competitors' wages can be described as:

$$L_{i,t-1} = \left(SL_{i,t-1} - \overline{L_{i,t-1}} \right) \tag{105}$$

where $\overline{L_{j,t-1}} = W_s SL_{j,t-1}$ represents the weighted wages of competing countries *j*, $SL_{i,t-1}$ denotes country's *i* wages at time *t-1*, and W_s indicates the weight matrix, whether W_1, W_2, W_3, or W_4, used in the regression. It results clear that if $L_{i,t-1} > 0$, country's *i* wages will be greater than the weighted wages of its competing countries *j*, resulting in a lost of competitiveness against its competitors, thus it might force a cut in the corporate AETR of country *i* at time *t*. Summing up, countries will face greater tax competition against each other if their wages are similar. The $L_{i,t-1}$ variable is measured in US dollars per year.

Finally, a fourth constructed variable, technological skills $\gamma_{i,t-1}$ denotes the deviation of country's *i* technology skills from its competitors skills. This variable is constructed similarly to the previous three, in such a way that:

$$\gamma_{i,t-1} = \left(\Omega_{i,t-1} - \overline{\Omega_{i,t-1}} \right) \quad (106)$$

where $\overline{\Omega_{j,t-1}} = W_s \Omega_{j,t-1}$ represents the weighted wages of technological skills of competing countries j, $\Omega_{i,t-1}$ denotes country's i technology skills at time t-1, and W_s indicates the weight matrix, whether W_1, W_2, W_3, or W_4, used in the regression. Note that similarly to the last constructed variable, a negative deviation of country's i technology skills from its competitors, $\gamma_{i,t-1} < 0$, it would implicate a cut in the corporate AETR of country i at time t. This fact relates to the idea that countries will face greater tax competition against each other if their technological skills are similar and they would have to compensate for lower technological skills by reducing its AETR. In particular, $\gamma_{i,t-1}$ will be measured as telephone mainlines per 1,000 people.

In conclusion, to test the hypothesis of the presence of a significant level of global corporate tax competition among countries we would need to evaluate the significance of α in Equation 100 using either W_1, W_2, W_3, or W_4. Table A1 from Appendix A provides us with the way of how this study intent to evaluate the hypothesis and answer the eight questions presented at the start of the chapter.

The Tax Rates: Statutory, Average Effective or Marginal Effective?

According to the literature on corporate tax rates, the measurement and capture of a country's corporate tax system has been considered a complex task for macroeconomic empirical work. Three types and measures of corporate tax rates have been used in macroeconomic empirical studies: the statutory corporate tax rate, the corporate marginal effective tax rate, and the corporate average effective tax rate.

The statutory corporate tax rate represents the most visible attribute of a country's corporate tax structure, nonetheless is just one factor among many tax determinants that leads to a significant economic impact in a country.[101] The statutory tax rate plays an important role in the determination of fiscal incentives that promote shifting income between cities, states, and countries. However, regarding its impact on investment incentives, the statutory corporate rate is not a proper measure since it misses the existence of tax holidays, of depreciation schedules, of inflation adjustments, of inventory allowance systems, of availability of credits for investment, and of deductibility of categories of business expenses. Consequently, a large literature has searched for the most accurate methodology able to summarize and acknowledge the previous factors into a common measure that could be useful in macroeconomic studies.

Different combinations of information on tax returns, statutory tax rates, deductions, depreciation rates, and tax codes with data on income distribution, household surveys, and projections of net present values for investment projects, have been proposed by researchers in this area.[102] Nonetheless, again, the complexity of tax credits, exemptions, and deductions that exist in most countries complicate the construction of effective tax rates, marginal and average, useful in macroeconomic modeling. As numerous authors argue, there are considerable suspicions in that marginal and average tax rates, extracted from particular individuals in a household survey or a specific

[101] The statutory corporate tax rate is defined as the corporate tax rate legally established by the tax authority of a country.
[102] See Deveroux, Lockwood, and Redoano (2002) for further explanation on the use of Net Present Values to calculate the average and marginal effective tax rates.

aggregation of incomes based on tax bracket weights, can be equivalent to the aggregate tax rates that affect macroeconomic variables (Frenkel, Razin, & Sadka, 1991; Mendoza, Razin & Tesar, 1994). Furthermore, given the existing methodologies, data availability considerably restricts the computation of corporate average and marginal effective tax rates for time series and cross country data.

Before continuing is necessary to define both of these measures. Marginal effective tax rates, or EMTR, are defined as the difference between the before tax and the after tax rate of return to capital on the last dollar invested. On the other hand, average effective tax rates, or AETR, are the ratio of total taxes paid by the firm to the before tax returns of the firm.

Different currents of thought have highlighted the advantages and disadvantages to each measure. Authors such as Chen, Martinez-Vazquez, and Wallace (1998), and Slemrod (2004) have not used the EMTR given its need for specific tax and firm's information difficult to find and compare, and have opted to use the concept of AETR due to its measure convenience at a macroeconomic level. In contrast, Bird and Chen (2002) have promoted the superiority of EMTR over AETR arguing that the EMTR serves in a much better way for a comparative purpose across different types of assets, business sectors, or countries' tax regimes than the AETR.[103]

There are several arguments identified against the EMTR. First, EMTRs are relatively easy to quantify at a microeconomic level. However computing it at a national or international level results difficult and impractical. Second, the density and diversity of tax deductions, credits, and exemptions make it problematical to infer the actual tax

[103] Whichever line of thought prevails, this study needs to identify the reasons by which one of the effective tax rates, marginal or average, might be chosen for the empirical work.

burden from information on given statutory tax rates. Third, the majority of available methods for computing marginal effective tax rates require data on the distribution of income that should be consistent with social security contributions and income tax schedules and returns. Fourth, tax revenue data and the tax system itself do not conform to the aggregate concepts of a macroeconomic model. Fifth, observable variables used to construct tax rate estimates can be affected similarly by different taxes (Frenkel, Razin, & Sadka, 1991). Sixth, tax systems, especially in decentralized systems, often include different forms of taxation affecting the same tax base. Seventh, the EMTR do not account for how vigorously a particular system of procedure is enforced. Finally, the measure of EMTR complicates further at the international level given the differences in the structure of tax systems and limitations of the information available on tax revenues and income distribution (Easterly & Rebelo, 1993).

Despite the disadvantages of the EMTR approach, Bird and Chen (2002) still favor the use of EMTR instead of AETR.[104] They indicate that the EMTR serve as a better comparative indicator that could provide evidence for a tax distortion within a tax regime and a tax advantage or disadvantage of one tax regime relative to another. EMTR is considered as an ex-ante indicator that reflects the designed, or planned, impact of a formal tax structure. EMTR emphasizes the need to take into account not only statutory tax rates but also other tax provisions (i.e., tax allowances) that may affect the real tax cost. It is an economic concept that measures the impact of formal tax structure on the cost of capital. It is sensitive to the formal tax structure and its interaction with economic indicators and hence an ideal tool for investment oriented policy simulations.

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[104] EMTR measures the incremental amount of taxes payable on the return to the last unit of capital investment under the formal tax system.

In contrast, against AETR, Bird and Chen (2002) specify that it does not represent a relevant indicator when comparing the impacts of tax structures on capital investment since AETR depends on the business performance of the taxpayer and on the quality of the tax administration reflecting the outcome of the interaction between the economy, the formal tax structure, and actual tax administration. The AETR provides a measurement for overall tax burden or revenue changes but lacks a strong economic background.[105]

In favor of AETR, Shah and Slemrod (1991) indicate that the average effective tax rates capture in a better form the aspects of the countries' tax laws. Furthermore, Mendoza, Razin, and Tesar (1994) indicate that the AETR approach is less stringent on data requirements than the EMTR, it takes into account the net effect of existing rules regarding credits, exemptions, and deductions, and moreover, it is consistent with the concept of aggregate tax rates at the national and international level.

To sum up, both lines of thought seem reasonable in their opinions; however the intention of this section is to offer the reader the latest arguments in favor and against the measure of effective corporate tax rates. It is in our best interest to focus on the AETR since it is the most accurate approach for our work. Furthermore, it is impractical to use the EMTR because its measure requires detailed sectoral information on tax provisions, deductions, exemptions, special depreciation structures, and other variables of economic influence, which could have diverse definitions in each country. In addition, it is also not convincing to use the statutory tax rate as a proxy of a country's corporate tax structure since it misses the collection of determinant factors in the corporate tax system of a country.

[105] EMTR and AETR thus need not coincide and do not play the same role in tax analysis. Nonetheless, if tax administration is efficient, it would seem reasonable to expect AETR in the long run and at the macro level to follow the pattern of EMTR.

Now the turn is to choose the most suitable measure of AETR. Authors such as Lucas (1990), Razin and Sadka (1993), Mendoza, Razin and Tesar (1994), and Chen, Martinez-Vazquez, and Wallace (1998) have suggested an alternative estimation method that produces average effective tax rates using data on actual tax payments and national accounts. Their method takes into account the effective overall burden resulting from major taxes and produces measures of tax rates that are consistent with the concept of aggregate tax rates at the national level. The empirical work they have conducted suggests that the resulting average tax rates are useful approximations to the taxes that distort economic decisions in dynamic macroeconomic models.

Chen, Martinez-Vazquez, and Wallace (1998) framework uses Mendoza, Razin and Tesar (1994) proposal for computing average effective tax rates. Their scheme is an extension of the Lucas (1990), and Razin and Sadka (1993) method to compute time series of effective tax rates on consumption, capital income, and labor income using information publicly available from the OECD. The three taxes are measured as ad-valorem estimates by classifying virtually all forms of tax revenue at the general government level into one of the three taxes. Each measure of tax revenue is then expressed as a fraction of a precise estimate of the corresponding tax base. As Razin and Sadka (1993) show, these ad-valorem tax rates reflect specific (or per unit) tax rates faced by a representative agent in a general equilibrium framework.

The main advantage of the Mendoza, Razin and Tesar (1994) method is that is less stringent on data requirements than other methods because it exploits the consistency of available international sources on national accounts and revenue statistics, and hence is much easier to use it to produce time series and cross country samples of tax rates. In addition to its simplicity, the method also takes into account the net effect of existing rules regarding credits, exemptions, and deductions. Nonetheless, the method has the disadvantage that it does not take into account information on statutory tax rates and income distribution per tax bracket, as well as that it does not account for the enforcement of the corporate tax system. Furthermore, a shortcoming from the careful measure of Mendoza, Razin and Tesar (1994) method is that it results unworkable to a wide sample of countries since their source is the OECD's *Revenue Statistics*.

A different approach is proposed by Deveroux, Lockwood, and Redoano (2002). Their methods to calculate effective corporate tax rates, both AETRs and EMTRs, are based on applying the rules of the tax system to a hypothetical investment project. The AETR is defined as to be in function of the fixed pre-tax rate of return, on the discount rate of the marginal share holder in the absence of personal taxes, on the statutory corporate tax rate, on the cost of capital, on the present value of allowances associated with the additional investment expenditure, and on the economic rate of depreciation. This method, as dense as it seems, provides us with an interesting framework to work with at microeconomic level. However, similarly to the Mendoza et al. (1994) methodology, in reality this careful measure is not available for a wide range of countries over many years.

Summing up, both measures of AETRs have a complication in common: they do not support their use within a large sample of countries. It results impractical, complex, and unreliable to calculate these tax rates since every country has its own fundamentals, and besides, developing countries do not have data available to estimate the AETRs by these methods. Thus, we end up analyzing three alternative estimation methods for AETRs.

First, there is the approach in Slemrod (2004), and Altshuler and Goodspeed (2002) which propose an approximation measure for AETRs when facing a large sample of countries. Commonly, AETRs are calculated as the ratio of corporate tax revenues divided by some economic income of corporations. But as mentioned before, obtaining information for a large sample of countries on income from corporations is impractical and for some countries is unreliable. Hence, as Slemrod (2004), and Altshuler and Goodspeed (2002) indicate, the AETR of a country can be approximated by the ratio of Corporate Income Tax Revenues (CITR) to Gross Domestic Product (GDP), in order to be comparable and useful with a large sample of countries. This can be denoted as:

$$\tau_i = \frac{CITR}{GDP} \tag{107}$$

As it can be observed in other computations, every method has one or several difficulties or problems. The inconvenient with this approach is that the denominator of the average tax rate, the GDP, is not a measure of corporate profits; τ_i is a product of an effective rate of tax on corporate income and the base to which it is applied. The AETR approximated by this measure will be higher the more successful the country is at attracting and retaining profitable corporations. This measure as simple as it seems, collects important information regarding the corporate tax system of a country, and in addition it results widely comparable between countries.

Even though this measure has the good feature of being available for a large sample of countries and for many years, it is troublesome for a few reasons.[106] On the one hand, the ratio of CITR to GDP may fluctuate due to economic factors that are unrelated to changes in the underlying corporate tax structure of a country. On the other hand, as with any average effective tax measure, it does not necessarily internalizes the corporate tax incentives to invest in a given country in given year since it is a function of both present and previous investment decisions of firms as well as economic fundamentals. As a result, we have to acknowledge that this method is an imperfect measure of corporate tax burdens. Furthermore, the framework developed by Slemrod (2004) will provide skewed results since countries with strong economies will have greater tax collection than weak economies, and at the limit, what could seem as tax competition would be a comparison of poor tax collector countries and good tax collector countries, and not a world-wide tax competition by itself. The last argument can be transformed into competition among good to good tax collectors and bad to bad tax collectors. This method, hence, throws more information regarding the tax collecting capacity of each country than as a way to measure the corporate average effective tax rates.

Second, a different method for approximating AETRs is used by Grubert and Mutti (2000), and Altshuler, Grubert and Newlon (2001). They calculate the average effective tax rate for manufacturing Controlled Foreign Corporations, or CFCs, incorporated in each country by dividing total income taxes paid by total earnings and profits, both variables extracted from the Statistics of Income bulletin from the Internal

[106] This computation can easily be obtained using the Corporate Income Tax Revenue (CITR) statistic from the International Monetary Fund's "Government Financial Statistics" book. Nonetheless, the CITR statistic obtained from the IMF has the shortcoming that it only takes into account central government data and leaves aside states, counties and municipalities data.

Revenue Service, IRS.[107] Parent corporations must report their CFCs earnings and profits using the definition provided by the U.S. Internal Revenue Code. This measure of earnings and profits is meant to reflect net income, not host country (or domestic U.S.) taxable income, which would be affected by investment incentives such as accelerated depreciation. The first criticism to this approach, and perhaps the most important given the need for a large sample in terms of years, is that the data are only available for an interval of 2 years apart starting in 1982. Furthermore, the latest data available comes from 1998, and as it could be seen in KPMG (1998, 1999, 2000, 2001, 2002, 2003, 2004), the most important changes in the corporate income tax rates start in the year 2000. Hence, the method provided by Altshuler, Grubert and Newlon (2001) for computing the AETR leaves out much information needed for a good fit of the empirical model.

A third method comes from Desai, Foley and Hines (2001, 2002, 2003, 2004). They compute the AETR with data extracted from the Bureau of Economic Analysis (BEA) annual survey of U.S. Direct Investment abroad which provides information on the financial and operating characteristics of U.S. firms operating abroad.[108] Desai et al.

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[107] A CFC is defined as a foreign company where more than 50 percent of which is owned by U.S. shareholders. A U.S. shareholder must own 10 percent or more of the foreign company. More than 75 percent of the CFCs on the form 5471 of the IRS are 100 percent controlled.

[108] The surveys require respondents to file detailed financial and operating items for each foreign affiliate and provide information on the value of transactions between U.S. parents and their foreign affiliates. The International Investment and Trade in Services Survey Act govern the collection of the data and the Act ensures that "use of an individual company's data for tax, investigative, or regulatory purposes is prohibited." Willful noncompliance with the Act can result in penalties of up to $10,000 or a prison term of one year. As a result of these assurances and penalties, BEA believes that coverage is close to complete and levels of accuracy are high. BEA collects sufficient information to link affiliate level data through time to create a panel. U.S. direct investment abroad is defined as the direct or indirect ownership or control by a single U.S. legal entity of at least ten percent of the voting securities of an incorporated foreign business enterprise or the equivalent interest in an unincorporated foreign business enterprise. A U.S. multinational entity (MNE) is the combination of a single U.S. legal entity that has made the direct investment, called the U.S. parent, and at least one foreign business enterprise, called the foreign affiliate. In order to be considered as a legitimate foreign affiliate, the foreign business enterprise should be paying foreign income

(2001, 2002, 2003, 2004) calculate the corporate effective income tax rates by first identifying the affiliates that report positive net income and then taking the ratio of the sum of foreign income taxes to the sum of net income and foreign income taxes for all affiliates in each country and year.

$$\tau_i = \frac{Foreign \quad Income \quad Taxes}{Foreign \quad Income \quad Taxes + Net \quad Income} \tag{108}$$

It results interesting and useful for the purpose of this investigation, that the method developed by Desai et al. takes into account data provided by firms that are involved in the FDI host country, and not information coming from the governments' revenue accounts. This method represents a closer approximation for the average effective corporate tax rate of the export oriented entrepreneurs' theory presented in the last Chapter.

Thus, observing and analyzing the above advantages and shortcomings, we would use the Desai, Foley and Hines (2001, 2002, 2003, 2004) measure for computing the AETRs and then evaluate the hypothesis of the presence of a global corporate tax competition among countries.

Data Sources

Countries of different geographical areas are included in the dataset in order to evaluate the hypothesis of the presence of a global corporate tax competition scheme. The

taxes, have a substantial physical presence abroad, have separate financial records, and should take title to the goods it sells and receive revenue from sales.

empirical approach in this paper is set to estimate Equation 100. In order to achieve this, panel data are collected on the tax regimes and control variables for the largest number of countries for which data is available and that comply with the requirements of the Desai, Foley, and Hines methodology (further on referred as the DFH method).

For computing the average effective corporate tax rate, data are obtained from the Bureau of Economic Analysis annual survey of U.S. Direct Investment abroad from the BEA webpage.[109]

For the vector $X_{i,t-1}$ variables, the host country and competing countries' wages at time *t-1*, $L_{i,t-1}$ and $L_{j,t-1}$, are approximated by the annual average compensation per employee in US dollars for the Majority Owned Foreign Affiliates obtained from the BEA annual survey of U.S. Direct Investment abroad.

The technological skills, $\gamma_{i,t-1}$, is proxied by the telephone mainlines per 1,000 people obtained from the World Bank's World Development Indicators, 2004.

The Foreign Direct Investment, FDI, needed to compute $fd_{i,t-1}$ is obtained from the United Nations Conference of Trade and Development, UNCTAD, database and it is measured in million of US dollars per year.[110]

Trade openness is approximated by the ratio of the sum of the exports and imports to the GDP and the data is obtained from the World Bank's, World Development Indicators, 2004.

Government expenditure is measured as percentage of GDP and the data is extracted from the World Bank's, World Development Indicators, 2004.

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[109] Data are available in the Bureau of Economic Analysis (BEA) website. http://www.bea.doc.gov/bea/surveys/diasurv.htm.

[110] Data are available in the United Nations Conference of Trade and Development (UNCTAD) website. http://www.unctad.org/Templates/Page.asp?intItemID=1584&lang=1

The exchange rate is obtained from the International Monetary Fund's, International Financial Statistics, 2004.

Regarding the geographical distance, it is obtained from the Geod Program which is part of the "PROJ" system available from the U.S. Geological Survey.[111]

Summary

This chapter offers a discussion of the type and measure of corporate tax rate to use, and specification of the variables, their computation and their sources, and serves to state both the empirical and econometrical methodologies used along in this research. Four weight matrixes were described: (1) homogeneous weights; (2) similar economic conditions' weights; (3) similar transportation costs' weights; and (4) geographically neighboring conditions' weights. The average effective corporate tax rate was selected as the most appropriate measure given its properties and suitability to our work. The method selected to approximate the corporate average effective tax rate follows the DFH methodology, which takes the ratio of foreign income taxes to the sum of net income and foreign income taxes. The next chapter presents the empirical results of this dissertation.

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[111] See http://www.indo.com/cgi-bin/dist/.

CHAPTER 6

RESULTS OF THE MODEL: EVALUATING THE PRESENCE OF A GLOBAL CORPORATE TAX COMPETITION SCHEME

This chapter begins with a brief description of the sample used in the study. Next we discuss the estimation results for Equation 100 using the weight matrixes W_1, W_2, W_3, and W_4.

Sample Description and Estimation Assumptions

Sample Description

Given the restrictions imposed by the available data and the methodology we use, the number of countries in the sample is 53, with the time period covering 19 years from 1984 through 2002; thus, the number of observations for the sample is 1007. It is important to note that the number of countries in the sample is greater than the time period since there is not enough data available for years before 1984, and most notably, because we need a large sample of countries to evaluate the possibility of world-wide tax competition, the main interest of this dissertation.

The sample of countries is conformed by: (1) Seventeen countries from America: Argentina, Barbados, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Panama, Peru, Trinidad and Tobago, and Venezuela; (2) Twelve countries from Asia and Oceania: Australia, China, Hong Kong, India, Indonesia, Japan, Republic of Korea, Malaysia, New Zealand, Philippines, Singapore, and Thailand; (3) Eighteen countries from Europe and Central Asia: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Turkey; and (4) Six countries from the Middle East and Africa: Egypt, Nigeria, Saudi Arabia, South Africa, United Arab Emirates, and Israel.

The measurement units of the variables in the dataset can be described as follows: (1) the average effective tax rates, the serially lagged differences at openness to trade, the lagged government expenditure, and the shifts at the lagged exchange rate will be measured as follows: if an AETR is set at 35%, this will be represented as 0.35 in the sample; (2) the serially lagged difference at wages will be measured as US dollars per year; (3) the serially lagged difference at technology skills will be measured as telephones mainlines per 1,000 people; and (4) the lagged difference at FDI inflows will be represented as million of US dollars per year.

Estimating Assumptions

The econometric model is estimated using four approaches: (1) fixed individual and time effects jointly; (2) fixed individual effects only; (3) fixed time effects only; and (4) no fixed effects: simple panel data. The main results are presented at Tables 3, 4, 5, and 6. Each table contains five columns; the first contains the explanatory variables, while the results are presented in the other four. The first column of results presents the estimation of Equation 100 from Chapter 5, allowing for fixed individual and time effects jointly ($\mu_i \neq 0$, $\eta_t \neq 0$):[112]

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[112] Recall from Chapter 5 that μ represents fixed individual effects, and η the fixed time effects.

$$\tau_{i,t} = \phi + \mu_i + \eta_t + \alpha W \tau_{i,t-1} + X_{i,t-1}\beta + \varepsilon_{it} \tag{109}$$

The second column assumes fixed individual effects only, that is $\eta_t = 0$ while $\mu_i \neq 0$, and implies the estimation of:

$$\tau_{i,t} = \phi + \mu_i + \alpha W \tau_{i,t-1} + X_{i,t-1}\beta + \varepsilon_{it} \tag{110}$$

The third column presents the estimation under the fixed time period effects method, that is $\mu_i = 0$ while $\eta_t \neq 0$, thus the model can be represented by:

$$\tau_{i,t} = \phi + \eta_t + \alpha W \tau_{i,t-1} + X_{i,t-1}\beta + \varepsilon_{it} \tag{111}$$

Finally, the fourth column of results assumes no fixed effects, that is $\mu_i = 0$ and $\eta_t = 0$, and refers to the estimation of the following equation:

$$\tau_{i,t} = \phi + \alpha W \tau_{i,t-1} + X_{i,t-1}\beta + \varepsilon_{it} \tag{112}$$

In the four cases, we follow Arellano (1987) approach to present robust serial correlation and heteroskedasticity standard errors estimates, and Baltagi, Song, Jung, and Koh (2003) to present three Lagrange Multiplier tests: one for serial correlation (LM_ρ), one for spatial correlation (LM_λ), and one for serial and spatial correlation in the error terms ($LM_{\rho+\lambda}$) .[113] Additionally, several tests were carried out in order to evaluate the suitability of each method for each weight matrix through a number of *F tests*. These simple Chow tests evaluate the differences between the residual sums of squares (RSS) of each method above, making them compete against each other. The *F tests* are fully developed in Appendix C. Furthermore; we carried out the Hausman test under each of the four weight matrixes in order to corroborate the use of the fixed effects approach instead of the random effects model. This test is fully developed in Appendix E and shows that the fixed effects estimation approach is preferable to the random effects under each of the four weight matrixes.

The following four sections refer to the estimation of the equations above for the four weight matrixes discussed in Chapter 5: W_1, W_2 , W_3 and W_4 , and presents the most appropriate estimation method for each weight matrix. Consequently, after the most appropriate methods are selected, we make a comparison of the four estimation results from the weight matrixes.

Estimation Results using Weight Matrix W_1

The assumed weights for this study reflect the influence of each competing country tax rate on the own country tax rate. In this section, weight matrix W_1 sets the possibility of evaluating the presence of corporate AETR competition by providing the same weight to each competing country's corporate AETR. By not differentiating among weights across countries, the empirical estimation under W_1 makes it possible to examine

[113] See Appendix C for a further description.

whether countries compete against each other without restricting their behavior to a particular geographical region or the economic position of those countries.

Table 3 below presents the results based on the estimation of the equations above under W_1 (equal weights). It shows, also, the values for the *LM tests* and *F tests* developed in Appendix C.

Regarding the most appropriate estimation method under weight matrix W_1, first it is necessary to define each of the Chow tests presented at the results. Hence, F_1 *test* is repeated in each column of Table 3 and it tests the hypothesis of whether all coefficients to be estimated are zero ($H_0 : \alpha = \beta = \mu = \phi = \eta = 0$). On the other hand, F_2 measures different issues for each column. For the first column, F_2 tests whether fixed individual and time period effects are zero ($H_0 : \mu_i = \eta_t = 0$) (it tests RSS from Equation 109 against RSS from Equation 112); for the second column, it tests whether fixed individual effects are zero ($H_0 : \mu_i = 0$); and for the third column, it tests whether fixed time effects are zero ($H_0 : \eta_t = 0$). However, there are two additional *F tests* that only apply to the fixed individual and time effects jointly estimation method. The first one, F_3 tests for individual effects given time effects ($H_0 : \mu_i = 0$, given $\eta_t \neq 0$) (it tests RSS from Equation 109 against RSS from Equation 111). The second, F_4 tests for the presence of time effects given individual effects ($H_0 : \eta_t = 0$, given $\mu_i \neq 0$)(it tests RSS from Equation 109 against RSS from Equation 110).

Table 3
Estimation Results using Weight Matrix W_1.

Explanatory Variables (Expected Signs)		Fixed Effects: Individual and Time (1)	Fixed Effects: Individual (2)	Fixed Effects: Time (3)	No Fixed Effects (4)
$w\,\tau_{i,t-1}$	(+)	0.7638344	0.7508322	1.0128148	0.6363172
		(0.00000)	(0.00000)	(0.00000)	(0.00001)
$L_{i,t-1}$	(-)	1.3071E-06	1.1967E-06	2.3648E-06	2.4548E-06
		(0.13600)	(0.17126)	(0.30602)	(0.27235)
$op_{i,t-1}$	(+)	-0.0531589	-0.0497860	-0.1063855	-0.1064499
		(0.28558)	(0.31282)	(0.00008)	(0.00003)
$\gamma_{i,t-1}$	(+)	0.0001900	0.0002197	-0.0002074	-0.0002065
		(0.29885)	(0.21563)	(0.19890)	(0.20532)
$fd_{i,t-1}$	(+)	-1.1380E-06	-1.0904E-06	-1.3511E-06	-1.4528E-06
		(0.01707)	(0.01943)	(0.07961)	(0.05763)
$ER_{i,t-1}$	(-)	2.6619E-05	7.6403E-06	1.1248E-04	1.3328E-05
		(0.09090)	(0.70977)	(0.24367)	(0.58724)
$GE_{i,t-1}$	(+)	0.2611465	0.2647555	-0.2617789	-0.2254035
		(0.30619)	(0.34265)	(0.50733)	(0.54247)
Constant		--	--	--	0.1540253
		--	--	--	(0.01627)
R^2 *within*		0.22782	0.14065	0.25128	0.19467
RSS		11.64889	11.34608	32.12227	31.26192
F_1		45.68036	25.83195	54.87173	34.49888
		(0.00000)	(0.00000)	(0.00000)	(0.00000)
F_2		22.34489	31.96683	-0.50528	--
		(0.00000)	(0.00000)	(1.00000)	--
F_3		31.39913	--	--	--
		(0.00000)	--	--	--
F_4		-1.34160	--	--	--
		(1.00000)	--	--	--
$LM\,\lambda$		0.36158	0.51570	1.82737	1.61636
		(0.54763)	(0.47268)	(0.17644)	(0.20360)

Numbers in parentheses are p-values obtained using Arellano's (1987) robust serial correlation and heteroskedasticity standard errors.

The results of the F_1 *tests* imply that the null hypothesis for the four cases (columns) was rejected. That is, for the four estimation methods, the coefficients were found to be statistically different from zero when tested together.

Regarding column 1 of the results, F_2 shows that the null hypothesis of $\mu_i = \eta_t = 0$ is rejected indicating that the fixed individual and time effects are non zero when tested together. Test F_3 also rejects the null hypothesis that all individual fixed effects are zero given time effects. Nonetheless, F_4 does not reject the null hypothesis that all time fixed effects are statistically equal to zero given individual effects.

With respect to the fixed individual effects only estimation method, column 2 of the results, F_2 indicates that the null hypothesis is rejected making all the fixed individual effects non zero. In contrast, F_2 from the fixed time effects estimation method, column 3, implies that the null hypothesis was not rejected, making all time period effects statistically not different from zero.

Note that the F_2 *test* from column 3 implies that the no fixed effects estimation method is preferred to the time period fixed effects method. Additionally, F_2 from column 2 implies that the fixed individual and time period effects estimation method is preferred to the no fixed effects approach. Thus, it remains to evaluate two of the approaches, joint fixed individual and time period effects and only fixed individual effects. In order to choose between these two, the decisive criteria will be the lowest RSS. Consequently, the lowest RSS corresponds to the fixed individual effects only estimation method, with a value of 11.34608, while the fixed individual and time effects together approach presents a RSS of 11.64889. Observe also that the highest RSS corresponds to the fixed time effects only estimation method with a value of 32.12227. Thus, the most appropriate estimation method under W_1 corresponds to the fixed individual effects only.[114]

Concerning the results of the model under weight matrix W_1, column 2 shows that the lagged weighted corporate AETR, $W\tau_{i,t-1}$, has a positive, expected and statistically significant effect over an FDI host country corporate AETR, $\tau_{i,t}$.

Intuitively, a decrease of 10 percentage points (0.10) on last year's weighted average corporate AETR of competing countries provokes a negative effect on a given FDI host country corporate AETR at nearly 7.508 percentage points (0.075083217).[115]

This result would seem to indicate that the corporate AETR of a country depends significantly on other countries last year's corporate AETR, when every country is weighted in a similar way. Again note that for this result it does not matter the geographical location of the country; if Argentina is located in America, China in Asia or Nigeria in Africa, they reflect some level of interaction among them regarding the corporate AETR decision.

Looking back to Chapter 5, the empirical estimation under weight matrix W_1 makes it possible to answer question 1 of the referred chapter. Does the optimal corporate tax rate of a country depend significantly on the corporate tax rates of other countries? The answer appears to be yes. According to these results, the optimal corporate tax rate of a country depends significantly, positively and robustly on the previous period

[114] As an exercise without implications to this study, Appendix F shows estimations for each of the four weight matrixes under the individual fixed effects approach using two and three time period lags instead of one.

[115] The sample shows a change in $W\tau_{i,t-1}$ of nearly -10 percentage points (-0.10) in Mexico from 1986 to 1987 using W_1.

corporate tax rates of other countries. This argument show some light regarding the "reasonable" tax competition behavior of the countries from the sample.

The lagged difference wage estimated coefficient, $L_{i,t-1}$, which measures the deviation of the own wages from the weighted wages of competing countries, shows a small, non-statistically significant and non-expected positive effect over the FDI host country corporate AETR, $\tau_{i,t}$. Hence, do countries compensate by offering lower AETRs if their wages are higher than those of its competitors? According to the obtained coefficient when assuming similar weight to each country (under weight matrix W_1), the answer is no. The obtained effect was neither expected nor statistically different from zero; moreover, the magnitude of the effect depends on the fact that the shift on $L_{i,t-1}$ would be large.

The serially lagged openness to trade differences, $op_{i,t-1}$, presents a non-significant at a 95% level and non-expected effect over the corporate AETR. As regards to question 5 from Chapter 5, neither the similarity nor the disparity of trade policies between countries affects significantly the optimal corporate AETR decision of a country.

The result from the lagged technology skill differences $\gamma_{i,t-1}$ shows that the expected theoretical effect is met; however, it was not statistically significant at a 95 percent level. Hence, to answer question 7 of Chapter 5, countries do not compensate by offering lower AETRs if their technological skills are lower than those of their competitors.

Alternatively, regarding the $fd_{i,t-1}$ variable, the result indicates a statistically significant effect over the setting of the corporate AETRs. According to the theory, countries that have a lower FDI inflow than the similarly weighted average of their competitors will push for a decrease in their corporate AETR in order to provide an incentive to attract FDI. Nonetheless, the obtained effect did not match the expectation. Additionally, it must be noted that an increase in last year's FDI inflows difference variable of nearly 1 billion US dollars will encourage a decrease of 0.001090445 points at the setting of the current corporate AETR.[116] Consequently, the size of the effect seems very small at first sight. However, taking into account that differences in FDI inflows could reach values higher than one billion US dollars, the size effect for $fd_{i,t-1}$ turns out to be not that insignificant in magnitude. Hence to answer question six, according to the estimation results for $fd_{i,t-1}$, despite of being significant, countries do not reduce their corporate AETR in order to attract a higher amount of FDI inflows depending on its position of FDI attraction relative to other countries.

Similarly to the majority of the previous results, the serially lagged government expenditure coefficient is not statistically significant at a 95 percent level. The obtained effect matches the expected sign and it is the second in size behind the weighted corporate AETR.

The estimated coefficient for the lagged percent changes at the exchange rate, $ER_{i,t-1}$, was also not significant at a 95 percent level, and it resulted particularly small in magnitude given its measurement units. Regarding the expected effect, an increase at $ER_{i,t-1}$ represents an appreciation of the national currency against the US dollar, hence US dollars are worth less and the costs of maintaining an export oriented firm increases

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[116] Data from the sample under W_1 shows an increase in $fd_{i,t-1}$ in Argentina from 1995 to 1996 of nearly 1 billion US dollars. On the other hand, under W_1 the average increase of $fd_{i,t-1}$ from the sample is 3.64 billion US dollars, while the average decrease is 2.36 billion US dollars.

relatively; as a consequence, the country's government could compensate the raise in costs by providing a lower corporate AETR; that is, an incentive for the firm to stay. This argument exemplifies the negative expected sign for the parameter, but the sign of the coefficient obtained is actually the opposite of what we expected.

As explained above, we followed Arellano (1987) in order to present serial correlation and heteroskedasticity consistent standard errors estimates since serial correlation and heteroskedasticity are assumed of an unknown form. Consequently, we end up just analyzing the *LM test* for spatial error correlation, since we can correct for serial correlation in the errors by using Arellano's approach. Thus, the *LM test* for spatial correlation in the error terms (LM_{λ}) does not rejects the null hypothesis that $\lambda = 0$, that is, it is demonstrated that the spatial correlation in the error coefficient is statistically not different from zero. Hence, there are no spatial dependence in the error terms.[117]

Additionally, since the fixed individual effects turned out to be significant when tested jointly, it implies that there are several deterministic factors inherent to each country different to the ones tested in this section that could explain some part of the corporate AETR.

Summing up, since it turned out that countries react with an effect of 0.75083217 to each others corporate AETR decisions when assuming the same weight, it results important to evaluate if the effect changes signs and significance or if it increases or decreases in size when providing a different weight to each country based on different assumptions.

[117] See Chapter 5 and Appendix C for further description.

Estimation Results using Weight Matrix W_2

Global or world-wide tax competition was described as uncooperative tax policy reactions between governments of different countries of the world not necessarily near each other geographically, but in similar economic conditions and with the purpose to influence the allocation of FDI. The central hypothesis of this study is that countries with similar economic conditions may face greater tax competition than countries within the same geographical area. As described in Chapter 5 previously, matrix W_2 assigns the weights based on the economic conditions of each country; thus, by using W_2 at the estimation we will be able to evaluate the presence of a global tax competition framework.

Table 4 presents the results based on the estimation of the Equations 109, 110, 111, and 112 above under W_2. Furthermore, it presents the values for each of the *LM tests* and *F tests* detailed in Appendix C.

Again, it is necessary to evaluate which estimation method is the most appropriate under weight matrix W_2. The F_1 *tests* results for the four cases (columns) indicate that the null hypothesis – that all coefficients are equal to zero when tested jointly – is rejected.

Regarding the fixed individual and time effects jointly estimation (column 1), the F_2 *test* shows that the null hypothesis of fixed individual and time effects equal to zero must be rejected. Similarly, F_3 *test* result, from the same estimation method, rejects the null hypothesis that all individual fixed effects are zero given the time fixed effects. On the contrary, F_4 result does not reject the null hypothesis that all time fixed effects are zero given individual effects.

Table 4
Estimation Results using Weight Matrix W_2

Explanatory Variables (Expected Signs)		Fixed Effects			No Fixed Effects
		Individual and Time (1)	Individual (2)	Time (3)	(4)
$w\,\tau_{i,t-1}$	(+)	0.7499148	0.7341452	1.0439724	0.7341181
		(0.00000)	(0.00000)	(0.00000)	(0.00002)
$L_{i,t-1}$	(-)	1.5762E-06	1.4611E-06	2.4955E-06	2.6091E-06
		(0.08352)	(0.10722)	(0.29460)	(0.25391)
$op_{i,t-1}$	(+)	-0.0575175	-0.0531708	-0.1052313	-0.1055033
		(0.24125)	(0.27481)	(0.00007)	(0.00001)
$\gamma_{i,t-1}$	(+)	0.0002525	0.0002728	-0.0001545	-0.0001702
		(0.22912)	(0.18186)	(0.42234)	(0.37737)
$fd_{i,t-1}$	(+)	-1.1511E-06	-1.1064E-06	-1.4169E-06	-1.5447E-06
		(0.01454)	(0.01673)	(0.06262)	(0.04328)
$ER_{i,t-1}$	(-)	2.2649E-05	4.8765E-06	1.1284E-04	1.1174E-05
		(0.14275)	(0.81649)	(0.26478)	(0.65258)
$GE_{i,t-1}$	(+)	0.2258508	0.2366965	-0.3123613	-0.2944339
		(0.37486)	(0.39693)	(0.43855)	(0.44115)
Constant		--	--	--	0.1342073
		--	--	--	(0.04680)
R^2 *within*		0.22901	0.14190	0.25507	0.19594
RSS		11.63093	11.32952	31.95935	31.21281
F_1		45.98989	26.10047	55.98490	34.77770
		(0.00000)	(0.00000)	(0.00000)	(0.00000)
F_2		22.34383	31.96125	-0.44068	--
		(0.00000)	(0.00000)	(1.00000)	--
F_3		31.22494	--	--	--
		(0.00000)	--	--	--
F_4		-1.33750	--	--	--
		(1.00000)	--	--	--
$LM\,\lambda$		0.19861	0.30047	1.40118	2.03485
		(0.65585)	(0.58359)	(0.23653)	(0.15373)

Numbers in parentheses are p-values obtained using Arellano's (1987) robust serial correlation and heteroskedasticity standard errors.

Similarly to Table 3, F_2 *tests* from the fixed individual effects only estimation method, column 2, indicates that the null hypothesis (that all the individual fixed effects are zero) is rejected. On the other hand, the result from the F_2 *test* of the time period fixed effects estimation method, column 3, shows that the null hypothesis (that all time period effects are zero) can not be rejected.

The above results for the *F tests* imply the following: (1) that the no fixed effects (simple panel data) estimation method (column 4) is preferred to the time fixed effects only estimation method (column 3), since F_2 result from column 3 implies that the time fixed effects are significantly no different from zero; and (2) that both, individual and time fixed effects jointly (column 1) and individual fixed effects estimation methods (column2) are preferred to the no fixed effects estimation, since the F_2 results from column 1 and 2 suggest that the individual and time fixed effects jointly and the individual fixed effects are significantly different from zero.[118] Thus, we are left with two options for the most appropriate estimation method under weight matrix W_2, column 1 fixed individual and time effects jointly or column 2, fixed individual effects only. In order to make this decision, it is necessary to observe the RSS results from Table 4, which shows that the lowest value for the residual sum of squares comes from the fixed individual effects only estimation method. Therefore, the most appropriate estimation method under W_2 is the individual fixed effects estimation method.[119]

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[118] Appendix E refers to the Hausman specification test and it shows that the fixed effects approach is preferable to the random effects model since the latter presents inconsistent estimates. See Baltagi (2003).
[119] See Appendix F for estimations under the individual fixed effects approach using two and three time period lags as an exercise.

Regarding the results under weight matrix W_2, column 2 shows that the serially lagged weighted corporate AETR $W\tau_{i,t-1}$ affects in an expected, positive and significant form the present corporate, $\tau_{i,t}$. An increase of 1 percentage point (0.01 points) on last year's weighted corporate AETR of competing countries leads to a rise on a given FDI host country corporate AETR of nearly 0.73415 percentage points (0.0073414524).[120] According to this result, countries react today to yesterday's each others corporate AETR decisions when they are in similar economic conditions.

By using weight matrix W_2 it is possible to answer one of the main questions in Chapter 5. Does the significance of global corporate tax competition depend on the fact that the economic distance of a country with its competitors is similar? Similarly, to question 1, the answer appears to be yes. The result obtained from the parameter α, indicates that the countries optimal corporate tax rate of a country depends significantly, positively and robustly on the corporate tax rates of other countries that have a similar economic condition.

Regarding the variable denoting the serially lagged difference wage, $L_{i,t-1}$, the obtained coefficient from column 2 above indicates a not statistically significant effect over the corporate AETR. Also, note that the expected sign was not met. Hence, do countries compensate by offering lower AETRs if their wages are higher than those of its competitors? Similarly to the estimation under W_1, the answer is no. The obtained effect was statistically not different from zero, and did not match the theoretically expected sign.

[120] Data from Venezuela shows a 1 percentage point increase from 1995 to 1996. Under the estimations using W_2, the average increase of the sample is 0.01 points, or 1 percentage point.

The serially lagged openness to trade differences estimated coefficient, $op_{i,t-1}$, shows a non significant at a 95 percent level and non expected effect over the corporate AETR. Looking back to question 5 of Chapter 5; neither the similarity nor the disparity of trade policies between countries affect significantly the optimal corporate AETR decision of a country when the empirical estimation assumes high weights to countries that have similar economic conditions.

The result from the serially lagged technology skill differences shows that the expected theoretical effect is met; nonetheless it was not statistically different from zero. Thus, according to question 7 of Chapter 5, the results from this estimation indicate that countries do not compensate significantly by offering lower AETRs if their technological skills are lower than those of their competitors.

For the serially lagged foreign direct investment differences variable, $fd_{i,t-1}$, the estimated parameter shows a statistically significant but not expected effect. The latter implies that countries that have a lower FDI inflow than the weighted average of their competitors last year, tend to decrease their corporate AETR in order to attract FDI. Consequently, the setting of a country's optimal corporate AETR depends significantly on its position of FDI attraction relative to other countries. Nevertheless, in answer to question 6 from Chapter 5, countries do not decrease their corporate AETR in order to attract a higher amount of FDI inflows in relation to their own FDI inflows differences against their competing countries.

The lagged government expenditure coefficient was not significant at a 95 percent level, but it matched the expected sign. Similarly, the serially lagged percent change at the exchange rate coefficient was not statistically different from zero and the theoretically expected sign was not obtained.

Again, the *LM test* for spatial correlation in the error terms (LM_{λ}) shows that he null hypothesis ($H_0 : \lambda = 0$) can not be rejected, this indicates that the spatial correlation in the error coefficient is statistically not different from zero. There is no spatial error dependence and we are facing spatial interaction.[121]

Similar to the previous section, since the fixed individual effects resulted significantly different from zero when tested jointly; as a consequence, there are several factors natural to each country (not taken into account in this section) that could explain some part of the behavior of the corporate AETR.

Concluding, countries corporate AETRs decisions react positively, significantly and robustly to other countries last year's corporate AETRs when they are competing in regards to economic position or area.

Estimation Results using Weight Matrix W_3

Matrix W_3 evaluates whether countries that face similar transportation costs to the FDI home country show a higher level of global corporate tax competition. For this reason, weight matrix W_3 is constructed providing higher weights when host countries have similar geographical distances from the FDI home country.[122]

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[121] See Chapter 5 and Appendix C for further description.
[122] The computation of this weight matrix is fully described in Chapter 5.

Table 5
Estimation Results using Weight Matrix W_3

Explanatory Variables (Expected Signs)		Fixed Effects: Individual and Time (1)	Fixed Effects: Individual (2)	Fixed Effects: Time (3)	No Fixed Effects (4)
$w\,\tau_{i,t-1}$	(+)	0.5663070	0.4582160	0.7185726	0.5165254
		(0.00000)	(0.00000)	(0.00000)	(0.00001)
$L_{i,t-1}$	(-)	2.8020E-06	2.5383E-06	2.8493E-06	2.7078E-06
		(0.00125)	(0.00355)	(0.24199)	(0.26228)
$op_{i,t-1}$	(+)	-0.0617623	-0.0617646	-0.0975845	-0.0998978
		(0.20466)	(0.20692)	(0.00001)	(0.00000)
$\gamma_{i,t-1}$	(+)	0.0002186	0.0002420	-0.0001730	-0.0001626
		(0.22068)	(0.18475)	(0.21358)	(0.23885)
$fd_{i,t-1}$	(+)	-8.9758E-07	-8.7453E-07	-9.5760E-07	-1.2225E-06
		(0.03152)	(0.04151)	(0.22091)	(0.10322)
$ER_{i,t-1}$	(-)	1.6076E-06	-1.1462E-05	7.2841E-05	1.7585E-06
		(0.91919)	(0.61681)	(0.38405)	(0.95057)
$GE_{i,t-1}$	(+)	0.2678937	0.2565451	-0.2617015	-0.2708811
		(0.35600)	(0.43388)	(0.36162)	(0.31301)
Constant		--	--	--	0.2046791
		--	--	--	(0.00104)
R^2 *within*		0.19652	0.11345	0.24415	0.19640
RSS		12.12108	11.70512	32.42785	31.19494
F_1		37.86909	20.19826	52.81396	34.87938
		(0.00000)	(0.00000)	(0.00000)	(0.00000)
F_2		20.88407	30.32346	-0.71726	--
		(0.00000)	(0.00000)	(1.00000)	--
F_3		29.93036	--	--	--
		(0.00000)	--	--	--
F_4		-1.77114	--	--	--
		(1.00000)	--	--	--
$LM\,\lambda$		1.18176	0.00019	15.38701	3.96442
		(0.27700)	(0.98892)	(0.00009)	(0.04647)

Numbers in parentheses are p-values obtained using Arellano's (1987) robust serial correlation and heteroskedasticity standard errors.

The results from the empirical estimation of Equations 109, 110, 111, and 112 under W_3 are presented in Table 5 above. Moreover, it shows the values for each of the *LM tests* and *F tests* detailed in Appendix C.

As in the two previous subsections, it would be required to analyze which estimation method is the most suitable for weight matrix W_3. The F_1 *tests* results for the four cases were rejected, which indicate that all coefficients are significantly different from zero when tested jointly.

As regards of the fixed individual and time effects jointly estimation (column 1), the null hypothesis of fixed individual and time effects significant equal to zero was rejected (F_2 *test*). In the same way, F_3 *test* result, from the same estimation method, rejects the null hypothesis that all individual fixed effects are zero given the time fixed effects. In contrast, F_4 shows that the null hypothesis that all time fixed effects are zero given individual effects can not be rejected.

The F_2 *test* from column 2, the fixed individual effects only estimation method, shows that the null hypothesis was rejected, hence, all the individual fixed effects are significant different from zero.

Alternatively, column 3 F_2 *test* result shows that the null hypothesis that all time period effects are not different from zero can not be rejected.

A deeper analysis show that the lowest RSS indicator comes from the fixed individual effects only estimation method. Consequently, taking into account the *F tests* results and the RSS from the four estimation methods presented at Table 5, the most appropriate estimation method under weight matrix W_3, is again the fixed individual effects only approach, column 2.

The coefficient for the serially lagged weighted corporate AETR effect, $W\tau_{i,t-1}$, matches theoretically the expectation and it is significant different from zero. Intuitively, a decrease of 10 percentage points (0.10 points) on last year's weighted corporate AETR of competing countries encourages a reduction on any given FDI host country (from the sample) corporate AETR of nearly 4.582 percentage points (0.045821595 points).[123] Hence, does the level of corporate global or world-wide tax competition depends significantly on the transportation costs (proxied by the geographical distance) between the host country and the investors' home country? The answer appears to be yes; countries react today significantly to yesterday's each others corporate AETR decisions depending upon the transportation costs between the host country and the investors' home countries.

The serially lagged difference wage estimated coefficient, $L_{i,t-1}$, from column 2 above shows a statistically significant effect over the corporate AETR. Intuitively, it would be expected that an increase at the lagged difference at wages (which implies that at country's wages could be increasing in comparison to its competitors weighted wages) would encourage a reduction in any given country corporate AETR in order to compensate for the loss of competitiveness attributed to the differences at wage variable. Nonetheless, the obtained effect was not the expected, and the magnitude of it depends considerably on the amount of the change of the serially lagged difference at wage

[123] The sample shows a decrease of 10 percentage points in Argentina from 1987 to 1988, in Turkey from 1988 to 1989, and in Costa Rica from 1984 to 1985, among others.

variable. For example, the sample average increase is 2,536 US dollars; this would cause an increase in the AETR of nearly 0.64 percentage points (0.00643858 points).[124]

Therefore, do countries compensate by offering lower AETRs if their wages are higher than those of its competitors? Once more the answer is no, but for different reasons. Despite of being significant at a 95 percent level, the theoretically expected effect was not met.

The result for the serially lagged openness to trade differences, $op_{i,t-1}$, shows that the effect was not statistically different from zero, and its sign does not match the expected. Hence, on the topic of question 5 of Chapter 5, the similarity of trade policies between countries does not affect significantly the optimal corporate AETR decision of a country.

The serially lagged technology skill differences coefficient was not significant at a 95 percent level, but it matched the theoretical expected effect. Therefore, regarding question 7 of Chapter 5, countries do not significantly compensate by offering lower AETRs if their technological skills are lower than those of their competitors.

In relation to the $fd_{i,t-1}$ coefficient, the obtained result was statistically different from zero; however it did not achieve the expected sign. Therefore, despite that the $fd_{i,t-1}$ coefficient resulted significant at 95 percent level, countries do not decrease their corporate AETR in order to attract FDI inflows depending on its position of FDI attraction relative to other countries.

Regarding the serially lagged government expenditure coefficient, the results show that the expected sign was met; nonetheless it was not significant at a 95 percent

[124] On the other hand, the sample average decrease of the serially lagged difference at wage variable is 2,370.6 US dollars.

level. Similarly to the estimation under weight matrixes W_1 and W_2, the magnitude of the effect was the second behind the estimated parameters of the serially lagged weighted corporate AETR.

Additionally, the serially lagged percent change at the exchange rate coefficient was not statistically different from zero (at a 95 percent level). Even so, the theoretically expected sign was achieved. Thus, similarly to the two previous estimations for $ER_{i,t-1}$ using different weight matrixes, the obtained effect was extremely small in magnitude.

About the *LM test* for spatial correlation in the error terms (LM_{λ}), the obtained result indicates that the null hypothesis can not be rejected. The spatial correlation in the error coefficient is significantly equal to zero. Thus, there is no spatial dependence in the error terms. [125]

Note that since the fixed individual effects resulted statistically significant when tested together, there are several deterministic factors from each country not examined in this section that could explain the corporate AETR behavior.

Summing up, countries corporate AETRs decisions depend significantly in other countries last year's corporate AETRs when they have similar geographical distances between them and the FDI home countries.

[125] See Chapter 5 and Appendix C for further description.

Estimation Results using Weight Matrix W_4

The empirical estimation under weight matrix W_4 test whether geographical neighboring countries face greater tax competition than those located far away from each other. This matrix serves to answer if global corporate tax competition depends significantly on the geographical distance among the host countries; i.e., question four from Chapter 5.[126]

Similarly to the three previous sections, it is necessary to get the most appropriate empirical estimation method under weight W_4. According to the estimations' results from the fixed individual and time effects, fixed individual effects, time period effects and no fixed effects illustrated in Table 6 below; the F_1 *tests* from the four methods show a rejection of the null hypothesis that the coefficients were statistically not different from zero when tested together. In column 1 of Table 6, the F_2 statistic rejects the null hypothesis that fixed individual and time effects were significantly equal to zero ($\mu_i = \eta_t = 0$). In the same way, the F_3 *test* rejects that all individual fixed effects are zero given time effects ($\mu_i = 0$, $\eta_t \neq 0$). On the contrary, F_4 does not reject the null hypothesis that all time fixed effects are zero when given the individual effects.

With respect to the fixed individual effects only estimation method, the F_2 test result implies that the null hypothesis was rejected. Thus, the fixed individual effects are significant different from zero. Quite the reverse occurs for the F_2 test from the fixed time effects estimation method, column 3, where its result show that all time period effects are significantly equal to zero.

[126] For a further description of how to compute this weight matrix see Chapter 5.

Table 6
Estimation Results using Weight Matrix W_4

Explanatory Variables (Expected Signs)		Fixed Effects: Individual and Time (1)	Fixed Effects: Individual (2)	Fixed Effects: Time (3)	No Fixed Effects (4)
$w\,\tau_{i,t-1}$	(+)	0.6835585	0.6216420	0.7742964	0.5477322
		(0.00000)	(0.00000)	(0.00000)	(0.00064)
$L_{i,t-1}$	(-)	1.8529E-06	1.6562E-06	1.6019E-06	1.4610E-06
		(0.05646)	(0.08325)	(0.44416)	(0.46422)
$op_{i,t-1}$	(+)	-0.0377291	-0.0374149	-0.1183671	-0.1185545
		(0.38076)	(0.39408)	(0.00000)	(0.00000)
$\gamma_{i,t-1}$	(+)	0.0002730	0.0002750	-0.0000954	-0.0001038
		(0.12607)	(0.12404)	(0.47412)	(0.41489)
$fd_{i,t-1}$	(+)	-9.6939E-07	-9.7184E-07	-1.1581E-06	-1.3538E-06
		(0.03903)	(0.03858)	(0.17891)	(0.10477)
$ER_{i,t-1}$	(-)	8.9367E-06	-7.4192E-06	8.4045E-05	-6.7628E-06
		(0.54716)	(0.73030)	(0.33339)	(0.81392)
$GE_{i,t-1}$	(+)	0.2306899	0.2390679	-0.4914919	-0.3774506
		(0.37827)	(0.41233)	(0.08474)	(0.14491)
Constant		--	--	--	0.2092107
		--	--	--	(0.00133)
R^2 *within*		0.21774	0.13255	0.25058	0.20162
RSS		11.80091	11.45298	32.15228	30.99212
F_1		43.09719	24.11763	54.66790	36.04163
		(0.00000)	(0.00000)	(0.00000)	(0.00000)
F_2		21.58262	31.06944	-0.68073	--
		(0.00000)	(0.00000)	(1.00000)	--
F_3		30.80990	--	--	--
		(0.00000)	--	--	--
F_4		-1.52168	--	--	--
		(1.00000)	--	--	--
$LM\,\lambda$		0.48010	0.44814	13.95895	5.62633
		(0.48838)	(0.50322)	(0.00019)	(0.01769)

Numbers in parentheses are p-values obtained using Arellano's (1987) robust serial correlation and heteroskedasticity standard errors.

The above tests help us to chose the most appropriate estimation method under weight matrix W_4. Note that the F_2 *test* from column 3 implies that the no fixed effects estimation method is preferred to the time period fixed effects method. Furthermore, F_2 from column 2 implies that the fixed individual and time period effects estimation method is preferred to the no fixed effects approach. Finally, it remains to evaluate two methods, fixed individual and time period effects jointly approach and the fixed individual effects. Similarly to the three previous sections, the decisive argument will be the lowest RSS in order to choose between these estimation methods. Hence, the most appropriate estimation method under weight matrix W_4 is again the fixed individual effects only, column 2 from Table 6.

According to the results below, an increase of 10 percentage points (0.10 points) on last year's weighted corporate AETR of competing countries provokes a positive effect on any given FDI host country corporate AETR (of the sample) at nearly 6.2164 percentage points (0.06216420).[127] Hence, the competing countries weighted serially lagged corporate AETR, $W\tau_{i,t-1}$, has a positive, expected, robust and significant effect over any given FDI host country corporate AETR, $\tau_{i,t}$. This result indicates that countries react to each others serially lagged and weighted corporate AETR decisions when they are located in a geographically neighboring condition.

Hence, does the significance of global corporate tax competition depend on the geographical distance among the host countries? Similarly to the previous results under each weight matrix, the answer appears to be yes. The estimations show that countries

[127] In the sample, from 1985 to 1986 Egypt shows an increase of nearly 10 percentage points on last year's weighted corporate AETR of competing countries.

change their corporate AETR decisions depending on last year's neighbors' tax decisions. This finding supports other studies from the tax competition literature.[128]

The difference at wage coefficient result, which measures the deviation of the own country wages from the weighted wages of competing countries, shows a non-expected positive effect over the FDI host country corporate AETR, $\tau_{i,t}$. The parameter resulted not significant at a 95 percent level but significant at a 90 percent level. The sample average increase of last year's difference at wage variable is 2,630.8 US dollars; this would encourage a rise at the current corporate AETR setting at about 0.004357245 points, or 0.4357245 percentage points.

Again, it is important to answer question 8 from Chapter 5. Do countries compensate by offering lower AETRs if their wages are higher than those of its competitors? Similarly to the previous three estimations, the answer is no. The obtained effect was not the expected from the theory. Countries appear to significantly increase the corporate AETR at an evidence of a higher own wage in comparison to its competitors.

The serially lagged openness to trade differences, $op_{i,t-1}$, result which serves to answer question 5 of Chapter 5, shows a non-significant and non-expected effect over the corporate AETR. Consequently, the serially lagged similarity of trade policies between countries does not affect the setting of a corporate AETR.

The coefficient from the technology skill differences, $\gamma_{i,t-1}$, implies that the expected theoretical effect is met, however it is not significant at a 95 percent level. Thus, countries do not compensate by offering lower AETRs if their technological skills are

[128] See Chapter 2 for further detail.

lower than those of their competitors at a 95 percent confidence level; this answers question seven of Chapter 5.

The serially lagged foreign direct investment inflow differences variable, $fd_{i,t-1}$, result indicates a significant, negative (non expected) effect over the corporate AETRs. Intuitively, this outcome implies that an increase at the difference between any given country FDI inflow against the weighted average of their competitors will encourage a decrease in its corporate AETR in order to attract FDI. The theory indicates that if $fd_{i,t-1} < 0$ country *i* FDI inflows will be smaller than the weighted FDI inflows of its competing countries *j*, and regarding its effects over the AETR it might oblige a decrease in the corporate AETR of country *i* at time *t* since the policymakers and politicians will react with a one period lag. Therefore, despite of being considerable in magnitude at an increase of 1 billion dollars at the FDI inflows, the theoretical effect was not met and countries do not appear to offer an incentive in terms of a lower corporate AETR (when taking into account their FDI inflows difference against its competitors) in order to attract an additional amount of FDI inflow.

Regarding the serially lagged government expenditure variable, the coefficient result was not significant at a 95 percent level, however it matches the expected sign and the size of the effect is considerable. Similarly, the serially lagged percent change at the exchange rate coefficient was not significant at a 95 percent level and the size of the effect was relatively small. However, opposite to the two previous estimations under weight matrixes W_1 and W_2, and similarly to the estimation under W_3, the effect matched the theoretically expected sign.

The *LM test* for spatial correlation in the error terms (LM_{λ}) from column 2 shows that the null hypothesis ($H_0 : \lambda = 0$) can not be rejected. Hence, the spatial correlation in the error coefficient is significantly not different from zero and there is no spatial error dependence. [129]

In addition, since the fixed individual effects turned out to be significantly different from zero, there are several deterministic factors inherent to every country of the sample that could explain (in part) the corporate AETR setting. Concluding, it results important to note that according to the literature on corporate tax competition, countries react to each others tax rates depending upon their geographical position. The finding from this estimation corroborates those results.

Comparison of the Estimation Results

This section shows a comparison among the fixed individual effects estimation methods previously presented under each of the four weight matrixes. Recall from previous sections that this method was selected given its good performance under each of the four weight matrixes. Table 7 presents the comparison.

As it can be noted below, the results from the serially lagged difference wage variable indicate that the expected effect was not met for none of the four approaches. Furthermore, neither the estimation under W_1, nor the estimation under W_2 presented significant results at least at a 90 percent level. Quite the opposite occurs with the

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[129] See Chapter 5 and Appendix C for further description.

estimation under W_3 and W_4, where both coefficients resulted significant at a 95 and 90 percent levels, respectively.

Table 7
Comparison among the Estimation Results

Explanatory Variables (Expected Signs)		Fixed Individual Effects			
		W_1 (1)	W_2 (2)	W_3 (3)	W_4 (4)
$w\tau_{i,t-1}$	(+)	0.7508322	0.7341452	0.4582160	0.6216420
		(0.00000)	(0.00000)	(0.00000)	(0.00000)
$L_{i,t-1}$	(-)	1.1967E-06	1.4611E-06	2.5383E-06	1.6562E-06
		(0.17126)	(0.10722)	(0.00355)	(0.08325)
$op_{i,t-1}$	(+)	-0.0497860	-0.0531708	-0.0617646	-0.0374149
		(0.31282)	(0.27481)	(0.20692)	(0.39408)
$\gamma_{i,t-1}$	(+)	0.0002197	0.0002728	0.0002420	0.0002750
		(0.21563)	(0.18186)	(0.18475)	(0.12404)
$fd_{i,t-1}$	(+)	-1.0904E-06	-1.1064E-06	-8.7453E-07	-9.7184E-07
		(0.01943)	(0.01673)	(0.04151)	(0.03858)
$ER_{i,t-1}$	(-)	7.6403E-06	4.8765E-06	-1.1462E-05	-7.4192E-06
		(0.70977)	(0.81649)	(0.61681)	(0.73030)
$GE_{i,t-1}$	(+)	0.2647555	0.2366965	0.2565451	0.2390679
		(0.34265)	(0.39693)	(0.43388)	(0.41233)
R^2 *within*		0.14065	0.14190	0.11345	0.13255
RSS		11.34608	11.32952	11.70512	11.45298

Numbers in parentheses are p-values obtained using Arellano's (1987) robust serial correlation and heteroskedasticity standard errors.

Concerning the magnitude of the effect, at first sight it could be assumed as not robust given that at a change of 1 US dollar in last year's difference at wages will induce to a change at the current corporate AETR of 0.0000025383089 points from the parameter of the estimation under W_3. However, a change in the difference at wages variable could be of nearly 1,000 US dollars or 10,000 US dollars, causing a change at the corporate AETR of 0.0025383089 points (0.25383089 percentage points) or

0.025383089 points (2.5383089 percentage points), respectively.[130] So, in this sense, the magnitude of the effect could be not that insignificant at the setting of a corporate AETR. In fact, observe that the highest parameter effect comes from the estimation corresponding to countries that have similar transportation costs, W_3.

These findings indicate that countries do not significantly internalize, in the decision making of their corporate AETR, the serially lagged difference of their wage against the weighted average of the competing countries when these are assumed to compete against each other without regarding any position (W_1), and when countries are assumed to compete against those which have similar economic conditions (W_2). Nonetheless, countries show some level of internalization of the serially lagged difference at wages variable when they assume a tax competition regarding the geographical neighboring condition (W_4) and similarity in transportation costs (W_3); but again, the size of such internalization depends on the amount of the change in the serially lagged difference wage variable.

An explanation for these findings could be that countries, regionally competing in corporate average effective taxes and those competing at a similar transportation costs scheme, when facing a decrease at the serially lagged difference at wages variable, they could try to obtain an additional advantage to attract foreign direct investment inflows by reducing their current corporate AETRs. This argument, despite of being contrary to the theoretical expected effect, has a considerable degree of economic logic. Nonetheless, when an increase at the lagged difference at wages variable is present governments'

[130] In the sample under W_3, Belgium showed an increase in $L_{i,t-1}$ of 1,058 US dollars from 1992 to 1993, while Austria presented an increase of nearly 10,000 US dollars from 1993 to 1994.

policy makers encourage a rise at the current corporate AETR, and the reasoning behind that behavior is not comprehensible.

Consequently, the magnitude, and signs of the effects from the weighting schemes W_3 and W_4 estimations, and why only these schemes are significant and not also W_1 and W_2, remain a puzzle.

About the serially lagged openness to trade differences variable, the results show that none of the parameters from the four approaches were significant at least at an 80 percent level, and moreover, they did not meet the expected sign. Thus, significantly, countries do not take into account their difference in openness to trade to the weighted average of other countries in the decision making of their tax package regarding the corporate AETR for none of the four tax competition weights' assumptions.

Regarding the serially lagged technological skills variable, once more the obtained coefficients under each weight matrix were not statistically different from zero. However, the expected sign was met in the four cases.[131] As a result from the four examined cases, contrary to the theory, the serially lagged technological skill differences variables are not taken into account in a significant way in the setting of the corporate AETRs.

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[131] It is important to note that at least at an 87 percent level the highest effect over the corporate AETRs comes from the estimation under W_4, that is, the weight matrix regarding the geographically neighboring condition weighting approach, while the lowest effect comes from the equally weighted scheme. On the other hand, the next effect in size refers to W_2, the weight matrix regarding to the similar economical position or world-wide tax competition weighting approach. The obtained magnitudes tend to be not that unimportant if we assume that the technology skills difference variable is measured as telephone mainlines per 1,000 people, so a maximum change at the $\gamma_{i,t-1}$ could be of nearly 70 mainlines, encouraging a change at the current corporate AETR at an 87 percent level of confidence of almost 0.0192482 points, or 1.92482 percentage points, under the W_4 estimation approach. The maximum change at the technology skills difference is assumed at 70 mainlines per 1,000 people since that amount corresponds to the greater change at the variable sample.

With regard to the foreign direct investment inflows differences variables, despite of being significant at a 95 percent level in the four estimations, the results did not meet the expected sign. Nevertheless, the magnitude of the effects was moderate if we assume a high change at $fd_{i,t-1}$. For example, at a decrease of last year's FDI inflows differences variable of nearly 1 billion US dollars (which is common in the sample) will encourage an increase at the current corporate AETR of 0.001090445, 0.001106372, 0.000874525, and 0.000971841 points for the estimations under W_1, W_2, W_3, and W_4, respectively.[132] It is obvious that the greater effect comes from the estimation under the similar economic conditions weighting approach, W_2, while the smallest regards the similar transportation costs weighting scheme, W_3.

Despite of the significance and size of the effects, these findings contradict the theory that if a country recognizes a last period's smaller FDI inflow in comparison to its competitors, it will push for a decrease in the corporate AETR as an incentive for the export oriented firms to locate in that country. Hence, in a strict position, countries do not tend to reduce their corporate AETR in order to attract a higher amount of FDI inflows depending on their position of foreign direct investment attraction relative to other countries.

A logical economic explanation for these findings could be that countries (under the four weighting schemes) when facing an increase in $fd_{i,t-1}$ could try to obtain an additional advantage to attract more FDI inflows in comparison to their competing

[132] For example, a change of last year's FDI inflows differences variable of nearly 1 billion US dollars appears in the sample in: (1) under W_1 Argentina (1991-1992), Brazil (1988-1989), and Hong Kong (1998-1999); (2) under W_2 Chile (1990-1991) and Greece (1995-1996); (3) under W_3 India (1995-1996), and Israel (2000-2001); and (4) under W_4 Ireland (1997-1998), and Ecuador (1997-1998), among others.

countries by reducing their current corporate AETRs. But again, opposing the theory and any logical economic explanation, when a decrease at the lagged difference at FDI inflows variable is present, governments' policy makers encourage a rise at the current corporate AETR, and the reasoning behind that behavior is not comprehended.

As a result, the significance, signs, and magnitudes of the effects from the estimations for the four weighting schemes W_1, W_2, W_3, and W_4 is a puzzle.

Now, when comparing the serially lagged percent change at the exchange rate variables from the four weighting scheme cases, all the parameters resulted not statistically significant even at a 50 percent confidence level. Two parameters results matched the theoretically expected sign: (1) the estimation under W_3, the similar transportation costs weighting scheme; and (2) the estimation under W_4, the geographically neighboring condition approach. Bear in mind from Chapter 5 that an increase in $ER_{i,t-1}$ is defined as an appreciation of the national currency against the US dollar, which in turn could induce to a decrease at the current corporate AETR setting as an incentive, that is, the theory establishes a negative expected effect. Thus, the estimated coefficients signs for these two weighting schemes were negative in accordance with the theory.

Contrary to the above, the parameters regarding the equally weighted approach (W_1) and the similar economic condition weighting scheme (W_2) did not meet the theoretical expected signs. Furthermore, the size of the effects for the four cases was relatively small in order to influence considerably the setting of the corporate AETRs. So, the lagged percent change at the exchange rate does not significantly affect the setting of the current AETRs for neither of the estimations regarding the four weighting methods.

Evaluating the serially lagged government expenditure variables, although the expected signs were met and the size of these were considerable in magnitude, none of the four estimations presented statistically significant results. There are several possible explanations behind the lack of response of the corporate AETR to a raise in last year's government expenditure. First, an increase in $GE_{i,t-1}$ could respond to higher government revenues in period $t-1$, or before. Second, governments could increase other taxes such as personal, consumption, property, etc. in period $t-1$, t, both, or further ahead, in order to compensate for the raise in government expenditure. Third, governments could have paid for the raise in $GE_{i,t-1}$ by increasing the level of indebtedness; this of course, would be translated later into rising government revenue for debt payments, but the change in the government revenues does not necessarily has come from increasing the corporate AETR. Hence, serially lagged government expenditure does not significantly affect the setting of the current corporate AETRs.

Turning now to the center point of the study, the four coefficients of the serially lagged weighted corporate AETRs, $W\tau_{i,t-1}$, resulted significant at a very high confidence level (99 percent). They matched the expected positive sign which implies that a decrease at last year's weighted corporate AETR from the competitors would encourage a decrease at the own country corporate AETR. Additionally, the effects were considerable in size in order to be taken into account at the setting of the current corporate AETR. The highest effect corresponds to the same weights scheme W_1 with a value of 0.75083217; the second in size refers to the similar economic condition or global tax competition scheme W_2 with 0.73414524; the third regards the geographically neighboring condition approach W_4 with 0.62164201; and the lowest in size effect corresponds to the similar transportation costs weighting method W_3 with 0.45821595. It is important to observe that the difference between the highest effect and the second in size is just 0.0166869 points, while the difference between the second and third in size is much larger, with nearly 0.1125032 points. Obviously, the difference between the $W\tau_{i,t-1}$ parameters from W_4 and W_3 is larger than the two before, at about 0.1634261 points.

As a result of the numbers above, countries facing similar costs of transportation tend to show some level of corporate tax rate competition since they react significantly to each others last period's weighted corporate AETRs by changing their decision of the current corporate AETR.[133] The parameter obtained from the estimation under W_3 shows that countries could be competing against each other since the export oriented firms from the FDI home countries could find themselves indifferent of where to locate given that they face similar transportation costs. Hence, FDI host countries internalize that fact and try to modify that indifference by changing their corporate AETRs. As a consequence, a corporate tax competition scheme appears to be present among those countries.

On the other hand, the empirical literature on tax competition consulted for this study suggests that countries tend to engage in regional corporate tax competition in order to attract FDI inflows.[134] In this sense, the significant, positive and robust obtained coefficient from the estimation under W_4 (which implies high weights to geographically neighboring located countries) confirms those empirical findings. Thus, countries located as geographical neighbors face some level of corporate tax competition between them. The intuition regards that export oriented firms are indifferent on where to locate if their

[133] Recall that transportation costs weighting scheme are proxied by the geographical distance of the FDI host countries to the FDI home countries. See Chapter 5 for further detail.
[134] See Chapter 3.

target location is a given region. As a consequence, countries are sensitive to this indifference and are inclined to provide an incentive in terms of a lower corporate AETR.

The central point of this study regards examining the possibility that a global or world-wide corporate tax competition among countries can be present. As explained previously at the study, no literature was found that empirically tested corporate tax competition between countries with an economic condition alike. The empirical estimations under weight matrix W_2 imply providing high weights to countries that have a similar economic position. Hence, as it can be observed in Table 7, the significance, positive effect, and magnitude of the estimated $W\tau_{i,t-1}$ coefficient under W_2 represents an indication that countries appear to face some degree of corporate tax competition among those that have similar economic conditions.

The explanation behind this finding regards that export oriented firms search for the most profitable after tax location for their investments taking into account the whole package of costs, such as labor costs, capital costs, and transportation costs, but also the optimal level of labor and capital, as well as taxes, among other deterministic factors. The most profitable location does not *require* to be in the neighboring country of where the firm is already located, and in fact it could be in a completely different continent if the costs determine so. Countries, on the other hand, seek to attract FDI inflows by increasing their relative competitiveness; this is determined by infrastructure, wages, transportation costs, openness to trade, taxes, skills, technology, and availability of labor, among other factors. For example, a country in Asia could be offering higher after tax profits to an export oriented firm already located in America and induce that firm to relocate. Certainly, the country in Asia would be more attractive than that in America for the relocation to occur. Recall that there are factors such as wages that depend on labor market conditions rather than on governments' policymakers' decisions, and others such as infrastructure, skills and technology that can not be changed in a short period of time (they are fixed at the short run). The latter leaves as viable options to decrease the countries' corporate tax rate or to increase the rate of allowance. Hence, the higher attractiveness could come from lower corporate average effective tax rates. Therefore, according to the estimation results, countries in different geographical areas (not geographical neighbors) appear to compete to attract FDI by changing their corporate AETRs taking as a reference their similar economic conditions competitors corporate AETRs. Countries internalize in their decision making that export oriented firms search for a given level of conditions that could maximize their after tax profits, which in the short run can be translated into similar economic conditions. In this sense, is in this form that a global or world-wide tax competition structure could take place.

In addition, note that the level of influence (the higher effect) is greater for the global tax competition framework than that regarding the regional tax competition, and that concerning similar transportation costs. When countries take into account their economic position and that of their competitors, corporate tax competition becomes stronger than when countries take into account the regional position or the similarity in transportation costs of their competitors.

Turning now to the estimation obtained from the same weights scheme W_1, the serially lagged weighted corporate AETR coefficient confirms the presence of corporate tax competition among all countries from the sample. Additionally, observe that the parameter $W\tau_{i,t-1}$ has a greater influence on the setting of the current corporate AETR than the other three parameters from the different weightings schemes. This finding could imply that countries tend to react to each others decisions about the corporate tax rates assuming several factors, such as: the similar transportation costs, the geographically neighboring condition, and the similar economical condition, among others. In other words, the same weights approach (estimation under W_1) could group and synthesize several distinctive factors from each of the 3 weighting schemes that could explain the highest value of this effect.

Summary

This chapter starts with a brief description of the sample a several determinant assumptions used at this study; subsequently the estimation results were presented. The empirical evaluation regarded four estimation methods for each of the four weight matrixes: (1) fixed individual and time effects jointly, Equation 109; (2) fixed individual effects only, Equation 110; (3) fixed time effects only, Equation 111; and (4) no fixed effects: panel data, Equation 112.

After testing the properties and fit of each of the 16 estimated equations (four methods under four weight matrixes), the most appropriate estimation method given its results was the fixed individual effects only approach. In this context, the results can be summarized as follows:

First, countries do not compensate by offering lower AETRs if their wages are higher than those of their competitors. Governments' policymakers do not significantly internalize, in the decision making of their corporate AETR, the serially lagged difference of the own country wage against the weighted average of its competing countries when these are assumed to compete against each other without regarding any position (W_1), and when countries are assumed to compete against those which have similar economic conditions (W_2). Countries show some degree of internalization of the serially lagged difference at wages variable when they assume a tax competition regarding the geographical neighboring condition (W_4) and similarity in transportation costs (W_3); but again, the size of such internalization depends on the change in the difference between wages.

Second, countries do not take into account their difference in openness to trade to the weighted average of other countries in the decision making of their tax package regarding the corporate AETR for none of the four tax competition weights' assumptions.

Third, resulting from the four examined cases, contrary to the theory, the serially lagged technological skill differences variables are not taken into account in a statistically significant way in the setting of the corporate AETRs.

Fourth, countries do not tend to reduce their corporate AETR rate in order to attract a higher amount of FDI inflows depending on their position of foreign direct investment attraction relative to other countries.

Fifth, the current corporate AETR does not depend significantly on the serially lagged percent change at the exchange rate.

Sixth, serially lagged government expenditure does not significantly affect the setting of the current corporate AETRs.

Seventh, the four coefficients of the serially lagged weighted corporate AETRs, $W\tau_{i,t-1}$, resulted significant at a very high confidence level; they matched the expected positive sign and the effects were considerable in size in order to be taken into account at the setting of the current corporate AETR.

Eighth, countries facing similar costs of transportation tend to show some level of corporate tax rate competition since they react significantly to each others last period's weighted corporate AETRs by changing their decision of the current corporate AETR.

Ninth, countries located at the same region or area (geographical neighbors) appear to face some level of corporate tax competition between them confirming the findings from the empirical literature on tax competition consulted for this study.

Tenth, the significance, positive effect, and magnitude of the estimated $W\tau_{i,t-1}$ coefficient under W_2 represents an indication that countries appear to face some degree of corporate tax competition among those that have similar economic conditions. Thus, global or world-wide tax competition in corporate AETRs for export oriented firms could be present.

Eleventh, the serially lagged weighted corporate AETR coefficient obtained from the estimation under W_1 confirms the presence of corporate tax competition among all countries from the sample.

Twelfth, the greatest influence on the setting of the current corporate AETR comes from the same weights approach. The latter could imply that countries tend to react to each others corporate tax rate settings assuming different factors: similarity in transportation costs, a geographical neighboring condition, and a similar economic condition. The same weights approach could be synthesizing several distinctive factors from each of the 3 weighting schemes that could be explaining the highest value of the estimated effect.

Finally, it results important to note that the level of competition is greater for the global tax competition framework than the one regarding the regional tax competition, and that concerning similar transportation costs. Corporate tax competition becomes stronger when governments consider their economic position and that of their competitors, than when they take into account the similarity in transportation costs and regional position of their competitors.

Additionally, since the fixed individual effects were significant, there are several factors from each country, not examined in this section, which could help explain the corporate AETR behavior.

CHAPTER 7

CONCLUDING REMARKS AND FUTURE RESEARCH

The principal objective of this dissertation is to evaluate the presence of a global or world-wide corporate tax competition scheme among countries. Global or world-wide corporate tax competition was defined as uncooperative tax policy reactions between governments of different countries of the world not necessarily near each other geographically, but in similar economic conditions and with the purpose to influence the allocation of a mobile tax base; in this case export oriented foreign direct investment. In a simple form, global tax competition is thought as a tax competition among different countries of the world without providing a significant importance to the geographical location of them, but considering substantially their economic position.

Recall that export oriented firms' purpose is to find and use particular and specific resources at a lower real cost in foreign countries, and then export the output produced to the home country or third countries. On the other hand, market oriented investments aim to set up enterprises in a particular country to supply goods and services to the local market. Work by Reuber (1973), Guisinger (1985), and Coyne (1994), indicate that export oriented firms operate in highly competitive markets with very slim margins, and that these firms are often highly mobile, and more likely to compare taxes across alternative locations. Hence, taxes are an important part of export oriented firms' cost structure, and these companies can easily move to take advantage of more favorable tax regimes. In this case, tax incentives can compensate for resource obstacles making the country more attractive to investors, and consequently more competitive.

The theoretical model was developed following Devereux, Lockwood, and Redoano (2002) framework, but their framework was expanded to allow for a third country, workers, two types of entrepreneurs and capital, geographical distance between countries, transportation costs, labor skills, and technology skills. The theoretical model intents to make understandable the forces that generate competition between countries' corporate tax policies. The aim of the model regards finding optimal corporate tax rates that will serve as governments' reaction functions. Commonly, geographically separated countries are thought as non-reactionary since distance puts a barrier between their responses. Nonetheless, the theoretical model provides an insight into the fact that governments, when competing for export oriented FDI, take into account the geographical distance of their competing countries to the investors' home country, as well as the income distance or economic condition between each other, at the time of deciding their optimal statutory corporate tax rate.

However, the statutory corporate tax rates were discarded since their computation do not take into account the existence of tax holidays, depreciation schedules, inflation adjustments, inventory allowance systems, availability of credits for investment, and deductibility of categories of business expenses. So, we searched within the literature for the most appropriate measure for an effective corporate tax rate. Two methods were analyzed: the marginal effective tax rate and the average effective tax rate. The computation of the first presented several important difficulties since it required detailed sectoral information on tax provisions, deductions, exemptions, special depreciation structures, and other variables of economic influence, which could have diverse definitions in each country. So, the corporate average effective tax rate measure was selected given its properties and suitability to our work.

The empirical model was developed following Revelli (2000), Brueckner and Saavedra (2001), Hayashi and Boadway (2001), Altshuler and Goodspeed (2002), Cavlovic and Jackson (2003), and Brueckner (2003) methodologies. It represents a derivation from the spatial econometric model which was denoted as a pure space-recursive model in Anselin (1999) and as a lagged spatial dependence model in Lopez and Chasco (2004).

Four weight matrixes were constructed in order to evaluate the influence the competing countries' corporate AETRs on the own country AETR. Weight matrix W_1 assumed equal weights to every country. Matrix W_2 internalized the definition of global corporate tax competition and assigned high weights to countries with similar economic conditions. Weight matrix W_3 assumed that countries could face some degree of tax competition among those that have similar transportation costs to the FDI home countries. Finally, matrix W_4 assigns high weights to those countries residing at geographically neighboring conditions, attempting to recreate the current literature on regional corporate tax competition.

The sample covered 53 countries from different areas of the world for a time period of 19 years, from 1984 to 2002.

The empirical evaluation regarded four estimation methods for each of the four weight matrixes: fixed individual and time effects jointly, fixed individual effects only, fixed time effects only, and no fixed effects (simple panel data). After evaluating each of the 16 equation results, the fixed individual effects only approach was the most appropriate estimation method for the four weight matrixes.

The results in Chapter 6 show that when governments are assumed to compete against each other without regarding any position (W_1), and against those which have similar economic conditions (W_2), countries of the sample do not consider, in the decision making of their corporate AETR, the serially lagged difference of their wage against the weighted average of the competing countries. In contrast, countries show a significant degree of internalization of the $L_{i,t-1}$ variable in the optimal corporate AETR, when a tax competition scheme regarding the geographical neighboring condition (W_4) and similarity in transportation costs (W_3) are assumed. However, the size of such internalization depends on the amount of the change in $L_{i,t-1}$. Despite that the coefficients from the estimations from the geographical neighboring condition and similarity in transportation costs were statistically significant; the expected sign were not met for none of the four cases.

A possible explanation for the results above could be that at the presence of a decrease at the serially lagged difference at wage variable, when we assume a tax competition under a similar transportation costs scheme and that regarding the geographical neighboring condition, governments could try to take an additional advantage to attract FDI inflows by decreasing their current corporate AETRs. Despite of opposing the expected theoretical effect, this argument has a considerable degree of economic logic. Nonetheless, when an increase at the lagged difference at wages variable is present, governments' policy makers encourage an increase at the current corporate

AETR, and the reasoning behind that behavior can not be explained in a economic comprehensible form.

Consequently, it remains a puzzle why the estimation from the weighting schemes W_3 and W_4 were statistically significant and not also W_1 and W_2.

As a conclusion, countries do not compensate by offering lower AETRs if their wages are higher than those of their competitors when the weighting assumptions regard similar economic conditions, similar transportation costs, geographically neighboring conditions and the same weights to every country.

Second, countries do not take into account in the decision making of the corporate AETR the serially lagged difference in openness to trade. The obtained coefficients from the equally weighted, the similar economic condition weighted, the similar transportation costs weighted, and the geographically neighboring condition weighted were not statistically significant, did not meet the theoretical expected effect and their magnitude was not robust.

Third, resulting from the four examined cases, despite of matching the theoretical expected sign, the serially lagged technological skill differences variables are not taken into account in a statistically significant way in the setting of the current corporate AETRs. This fact contradicts the theory which indicates that countries tend to offer some compensation in order to attract FDI inflows when their technological skills are smaller than those of their competitors.

Fourth, despite of the significance and size of the serially lagged difference at FDI inflows effects, the theory regarding this variable's effect is contradicted. If a country recognizes that in the last period received a smaller inflow of FDI in comparison to its competitors, it will push for a reduction in its corporate AETR in order to provide an incentive for the export oriented firms to come and locate in that country or not move from it. Consequently, countries appear to not decrease their corporate AETR rate as an incentive in order to attract a higher amount of FDI inflows depending on their position of foreign direct investment attraction relative to other countries.

A explanation for these findings could be that, at an increase in $fd_{i,t-1}$, countries could try to attract more FDI inflows in comparison to their competing countries by reducing their current corporate AETRs. But again, when a decrease at the lagged difference at FDI inflows variable is present, governments' policy makers encourage a rise at the current corporate AETR opposing the theory and any logical economic explanation. As a result, the significance, signs, and magnitudes of the effects from the estimations for the four weighting schemes W_1, W_2, W_3, and W_4 are also a puzzle.

Fifth, by making a comparison at the $ER_{i,t-1}$ estimated parameters from the four weighting scheme cases, the following conclusions arise: (1) all the coefficients resulted not statistically different from zero; (2) the parameters obtained from the estimations under the similar transportation costs weighting scheme (W_3) and the geographically neighboring condition approach (W_4) matched the theoretically expected sign; and (3) the parameters regarding the equally weighted approach (W_1) and the similar economic condition weighting scheme (W_2) did not meet the expectations from the theory. Hence, the lagged percent change at the exchange rate does not affect significantly the setting of the current AETRs for neither of the estimations regarding the four weighting methods.

Sixth, although the expected signs were met for the serially lagged government expenditure coefficient under each weight matrix, the estimated parameters turned out statistically not different from zero. Hence, serially lagged government expenditure does not significantly affect the setting of the current corporate AETRs.

Seventh, the four coefficients of the serially lagged weighted corporate AETRs, $W\tau_{i,t-1}$, resulted significant at a very high confidence level; they matched the expected positive sign, and the effects were considerable in size in order to be taken into account at the setting of the current corporate AETR.

Eighth, countries facing similar costs of transportation appear to show corporate tax rate competition since they react in a significant form to each others last period's weighted corporate AETRs by changing their current corporate AETR setting.

Ninth, countries located at the same region or area face some level of corporate tax competition between them confirming the findings from the empirical literature on tax competition consulted for this study.

Tenth, since the $W\tau_{i,t-1}$ estimated coefficient under W_2 was statistically significant, matched the expected sign and its magnitude was robust, countries tend to face a significant degree of corporate tax competition among those that have similar economic conditions. As a consequence, countries of the sample show a global or world-wide tax competition in corporate AETRs behavior for export oriented firms.

Eleventh, the serially lagged weighted corporate AETR coefficient obtained from the estimation under W_1 confirms a corporate tax competition behavior among all countries from the sample.

Different conclusions arise when taking into account the above findings. One of them considers that the level of competition is greater for the global tax competition framework than that regarding the regional tax competition, and that concerning similar transportation costs. When countries take into account their economic position and that of their competitors, corporate tax competition becomes stronger than when countries take into account the regional position or the similarity in transportation costs of their competitors.

Another conclusion regards that countries from the sample behave in a tax competitive way *not only* in geographical neighboring terms as the current corporate tax competition literature suggest, *but also* in a global or world-wide approach assuming similar economic conditions, and when internalizing the fact that their competitors have similar transportation costs. For example, the greatest influence on the setting of the current corporate AETR comes from the same weights approach; this suggests that countries tend to react to each others decisions about the corporate tax rates assuming several factors, such as: similarity in transportation costs, geographically neighboring condition, and similar economic condition, among others. The same weights approach could synthesize several distinctive factors from each of the other 3 weighting schemes that could explain the highest value of this effect.

Additionally, it needs to be established that there are several facts that have to be taken into account when analyzing the corporate tax competition for export oriented FDI inflows. For example, regarding wages and labor, there are countries with particularly difficult labor agreements which may influence the allocation of firms. Furthermore, there are several institutional factors including corruption of the government and stability of policies which could influence corporate tax competition.

Further work regards evaluating if there exists a form or a distinctive point to discriminate among which type of countries compete in terms of corporate AETRs depending on the geographical neighboring condition, which type on the economic condition, and which taking into account the similarity in transportation costs. For example, it could be interesting to evaluate if countries behave in a leader-follower way, and how to identify the characteristics of each type of country.

Moreover, it would be interesting to evaluate if countries show some degree of tax compensation (cross subsidy in taxes), i.e., if average effective corporate tax rates are driven down in order to attract FDI inflows or maintain the firms' already residing in the country, governments policymakers could compensate a possible fall in total tax revenues by increasing other taxes, such as personal income taxes or consumption taxes, among others. That is, countries could charge a higher corporate tax rate to the immobile tax base, and a lower corporate tax rate to the mobile tax base in order to compensate for a possible fall at the total tax revenues.

A different research could embark on finding the optimal time lag that countries take to react to other countries corporate tax rates policies. Perhaps, the reaction period would depend on the economic or geographical position of them. Additional studies could be based on dividing the dataset in two time periods. For example, as in García-Herrero and Santabárbara (2004) the sample of data could be divided from 1984 to 1994 and from 1995 to 2002 and after that analyze if factors which were considered not significant for the whole sample period could change their status.

Regarding policy implications, this work could help to recognize that some governments have internalized that their competitors do not need to be only their geographical neighbor countries, but also all of those that have similar economic conditions which are being seek by export oriented firms. Thus, it is imperative that countries policymakers, especially in developing countries, identify that a proactive fiscal policy, with observance on fiscal, financial and trade policies of regionally neighboring and similar economic conditions countries, could be transformed into an increase in competitiveness that could raise FDI attraction and thus increase employment. Also, it must be mentioned that governments should not depend only on their fiscal policy in order to attract export oriented FDI. Countries' governments, especially developing countries, should put attention on policies regarding technology developing and infrastructure investment projects, but most importantly, they have to provide confidence to foreign firms by building a reliable state of law.

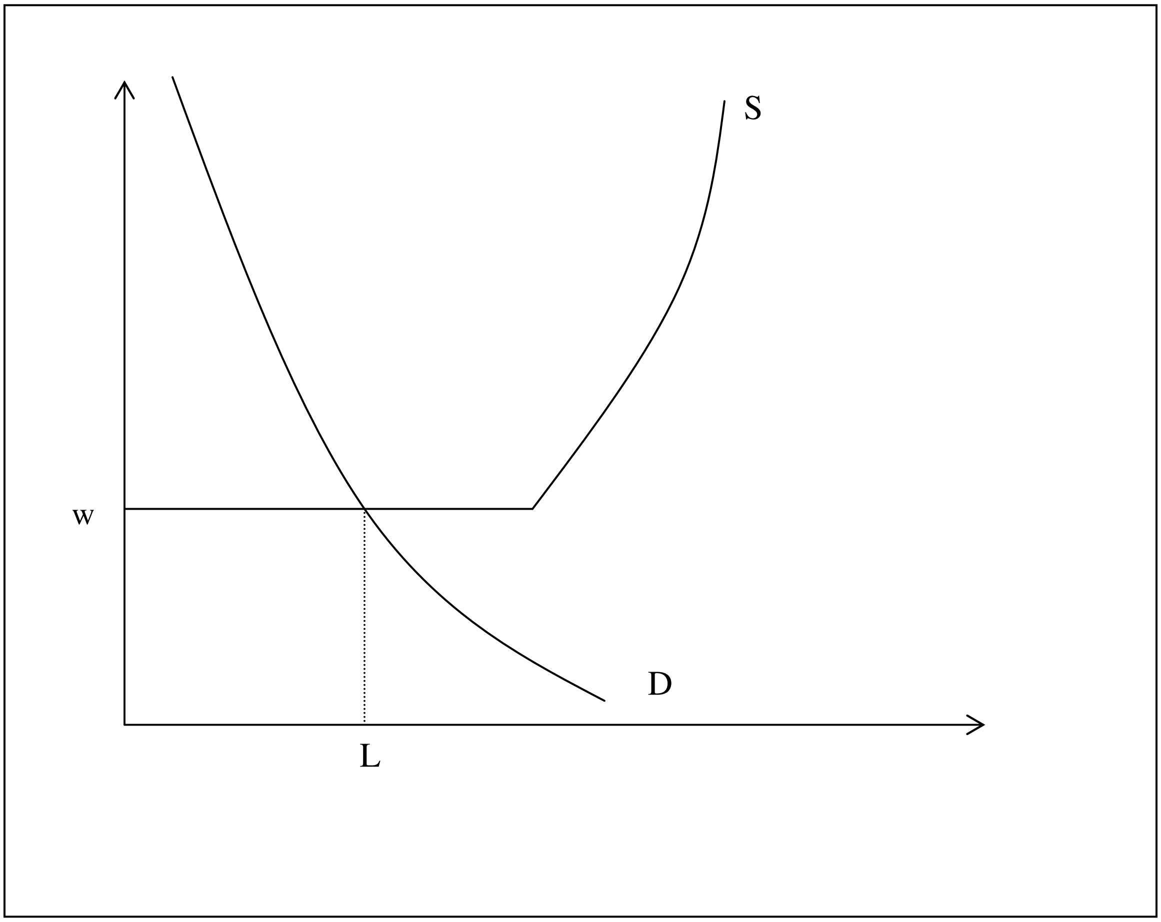
APPENDIX A

GENERAL ISSUES

Table A1
Hypothesis and Questions

Hypothesis:	Matrix
There is a presence of a significant level of global corporate tax competition among countries.	W_1 and W_2
Questions:	
1. Does the optimal corporate tax rate of a country depend significantly on the corporate tax rates of other countries?	W_1
2. Does the significance of global corporate tax competition depend on the fact that the "economic" distance of a country with its competitors is similar?	W_2
3. Does the level of corporate global or world-wide tax competition depends significantly on the transportation costs (proxied by the geographical distance) between the host country and the investors' home countries?	W_3
4. Does the significance of global corporate tax competition depend on the geographical distance among the host countries?	W_4
5. Can the similarity or disparity of trade policies between countries affect significantly the setting of a country's optimal corporate tax rate?	$op_{i,t-1} = \left(o_{i,t-1} - \overline{op}_{j,t-1} \right)$
6. Do countries tend to reduce their corporate tax rate in order to increase the amount of foreign direct investment inflows depending on their position of foreign direct investment attraction relative to other countries?	$fd_{i,t-1} = \left(f_{i,t-1} - \overline{f}_{j,t-1} \right)$
7. Do countries compensate by offering lower AETRs if their technological skills are lower than those of their competitors?	$\gamma_{i,t-1} = \left(\Omega_{i,t-1} - \overline{\Omega}_{i,t-1} \right)$
8. Finally, do countries compensate by offering lower AETRs if their wages are higher than those of their competitors?	$L_{i,t-1} = \left(SL_{i,t-1} - \overline{L}_{i,t-1} \right)$

Figure A1
Labor Market Conditions



APPENDIX B

THEORETICAL MODEL: MATHEMATICAL APPROACH

Workers and Wages

According to Brueckner and Saavedra (2001) wages for the home producing firm are determined by:

$$w_i^c = F(k_i^c, \gamma_i, \varphi_i) - k_i^c F'(k_i^c) \qquad \text{(B1)}$$

Proof:

Define a production function of the form:

$$F(K, L, \gamma, \varphi) = \gamma_i \varphi_i K_i^c - \frac{\delta_i K_i^{c\,2}}{2L_i^c} \quad \text{where } \gamma_i, \varphi_i, \delta_i > 0 \qquad \text{(B2)}$$

where:

$$F'_L = \frac{\delta_i K_i^{c\,2}}{2L_i^c} \qquad \text{(B3)}$$

In per-capita terms:

$$F(k, \gamma, \varphi) = \gamma_i \varphi_i k - \frac{\delta_i}{2} k_i^{c\,2} \qquad \text{(B4)}$$

where $F'_k = \gamma_i \varphi_i - \delta_i k_i^c$ and $F''_k = -\delta_i$.

For the home producing firms $F'_L = w_i^c$, thus:

$$w_i^c = \frac{\delta_i K_i^{c\,2}}{2L_i^{c\,2}} = \frac{\delta_i}{2} k_i^{c\,2} \qquad \text{(B5)}$$

While using Equation B1, then:

$$w_i^c = \left(\gamma_i \varphi_i k_i^c - \frac{\delta_i}{2} k_i^{c\,2} - k_i^c \left(\gamma_i \varphi_i - \delta_i k_i^c \right) \right) \qquad \text{(B6)}$$

Thus, wages for the home producing entrepreneurs are given by:

$$w_i^c = \frac{\delta_i}{2} k_i^{c\,2} \qquad \text{(B7)}$$

Alternatively, wages for the export oriented firm are determined by:

$$w_i^b = (1-\theta_i)\left(F(k_i^b, \gamma_i, \varphi_i) - k_i^b F'(k_i^b)\right) \tag{B8}$$

Proof:

For the exporting firms:

$$F'_L = w_i^b + \frac{dh}{dF} F'_L \;\Rightarrow\; (1-\theta)F'_L = w_i^b \tag{B9}$$

$$w_i^b = (1-\theta)\frac{\delta_i}{2} k_i^{b2} \tag{B10}$$

While by the formula $w_i = (1-\theta_i)\left(F(k_i, \gamma_i, \varphi_i) - k_i F'(k_i)\right)$ for exporting firms:

$$w_i^b = (1-\theta_i)\left(\gamma_i \varphi_i k_i^b - \frac{\delta_i}{2} k_i^{b2} - k_i^b\left(\gamma_i \varphi_i - \delta_i k_i^b\right)\right) \tag{B11}$$

Hence, wages for the export oriented firms' workers are given by:

$$w_i^b = (1-\theta_i)\frac{\delta_i}{2} k_i^{b2} \tag{B12}$$

Now, from the home producing firm wage, Equation B1, let's define:

$$\frac{dw_i}{dt_i} = \left(F'(k_i)\frac{dk_i}{dt_i} - F'(k_i)\frac{dk_i}{dt_i} - k_i F''(k_i)\frac{dk_i}{dt_i}\right) \tag{B13}$$

$$\frac{dw_i}{dt_i} = \left(-k_i F''(k_i)\frac{dk_i}{dt_i}\right) < 0 \tag{B14}$$

since both $\frac{dk_i}{dt_i}$ and $F''(k_i)$ are negative. $\frac{dk_i}{dt_i} < 0$ and $F''(k_i) < 0$.

While for the export oriented entrepreneurs:

$$\frac{dw_i^b}{dt_i} = (1-\theta_i)\left(-k_i^c F''(k_i^c)\frac{dk_i^c}{dt_i}\right) < 0 \tag{B15}$$

Now, using Equation B7 and substituting $k_i^c = K_i^c / L_i^c$ the number of workers for the home producing entrepreneurs is determined by:

$$L_i^c = \left(\frac{\delta_i}{2w_i^c}\right)^{1/2} K_i^c \tag{B16}$$

While using Equation B12, the number of workers for the export oriented entrepreneurs can be expressed as:

$$L_i^b = \left[(1-\theta_i)\frac{\delta_i}{2w_i^b}\right]^{1/2} K_i^b \tag{B17}$$

Now, it is also possible to assume a different production function. Suppose that:

$$F(K, L, \gamma, \varphi) = \left(\gamma_i K_i^c\right)^{\alpha} \left(\varphi_i L_i^c\right)^{\beta} \tag{B18}$$

where $\alpha + \beta = 1$ which implies constant returns to scale.

Now, in per-capita terms:

$$F(k, \gamma, \varphi) = \gamma_i^{\alpha} \varphi_i^{\beta} \left(k_i^c\right)^{\alpha} \tag{B19}$$

where $F'_k = \alpha\gamma_i^{\alpha}\varphi_i^{\beta}\left(k_i^c\right)^{\alpha-1} > 0$ and $F''_k = (\alpha-1)\alpha\gamma_i^{\alpha}\varphi_i^{\beta}\left(k_i^c\right)^{\alpha-2} < 0$.

Hence, from Equation B1, wages for the home producing firms' workers are:

$$w_i^c = \gamma_i^{\alpha}\varphi_i^{\beta}\left(k_i^c\right)^{\alpha} - k_i^c\alpha\gamma_i^{\alpha}\varphi_i^{\beta}\left(k_i^c\right)^{\alpha-1} \tag{B20}$$

$$w_i^c = (1-\alpha)\gamma_i^{\alpha}\varphi_i^{\beta}\left(k_i^c\right)^{\alpha} = \beta\gamma_i^{\alpha}\varphi_i^{\beta}\left(k_i^c\right)^{\alpha} \tag{B21}$$

On the other hand, using Equation B8, wages for export oriented firms' workers are expressed as:

$$w_i^b = (1-\theta)\beta\gamma_i^{\alpha}\varphi_i^{\beta}\left(k_i^b\right)^{\alpha} \tag{B22}$$

Thus, the number of workers for both types of entrepreneurs is determined by:

$$L_i^c = \left[\frac{\gamma_i^\alpha \varphi_i^\beta \beta}{w_i^c}\right]^{\frac{1}{\alpha}} K_i^c \tag{B23}$$

$$L_i^b = \left[\frac{(1-\theta)\gamma_i^\alpha \varphi_i^\beta \beta}{w_i^b}\right]^{\frac{1}{\alpha}} K_i^b \tag{B24}$$

Home Producing Entrepreneurs

The after tax profits of home producing firms located in country *i* can be expressed as:

$$\Pi_i^c = F(k_i^c, \gamma_i, \varphi_i) - rk_i^c - w_i - t_i\left(F(k_i^c, \gamma_i, \varphi_i) - a_i rk_i^c - w_i\right) \tag{B25}$$

or

$$\Pi_i^c = (1-t_i)\left(F(k_i^c, \gamma_i, \varphi_i) - w_i\right) - (1-t_i a_i) rk_i^c \tag{B26}$$

$$\Pi_i^c = (1-t_i)\left[\left(F(k_i^c, \gamma_i, \varphi_i) - w_i\right) - \frac{(1-t_i a_i)}{(1-t_i)} rk_i^c\right] \tag{B27}$$

Define:

$$z_i = \frac{(1-t_i a_i)}{(1-t_i)} = 1 + m_i \tag{B28}$$

where

$$\frac{dz_1}{dt_1} = \frac{1-a_1}{(1-t_1)^2} \tag{B29}$$

where $\frac{dz_1}{dt_1} > 0$ if $a < 1$ and $\frac{dz_1}{dt_1} < 0$ if $a > 1$. While:

$$\frac{dz_1}{da_1} = \frac{-t_1}{(1-t_i)} < 0 \tag{B30}$$

And

$$\frac{dz_1}{dm_1} = 1 \tag{B31}$$

Continuing,

$$\Pi_i^c = (1-t_i)\left[\left(F(k_i^c, \gamma_i, \varphi_i) - w_i\right) - z_i r k_i^c\right] \tag{B32}$$

Define:

$$\Gamma_i = \left[\left(F(k_i^c, \gamma_i, \varphi_i) - w_i\right) - z_i r k_i^c\right] \tag{B33}$$

Thus:

$$\Pi_i^c = (1-t_i)\Gamma_i \tag{B34}$$

Home producing entrepreneurs search to maximize after tax profit, Equation B32.

$$\frac{d\Pi_i^c}{dk_i} = (1-t_i)F'(k_i^c, \gamma_i, \varphi_i) - (1-t_i a_i)r = 0 \tag{B35}$$

$$F'(k_i^c, \gamma_i, \varphi_i) = \frac{(1-t_i a_i)}{(1-t_i)} r = z_i r \tag{B36}$$

Assuming a production function as in Equation B4, hence:

$$\gamma_i \varphi_i - \delta_i k_i^c = z_i r \tag{B37}$$

Thus, the optimal home producing firm’s capital per-capita is determined by:

$$k_i^c = \frac{\gamma_i \varphi_i - z_i r}{\delta_i} \tag{B38}$$

where:

$$\frac{dk_i^c}{d\gamma_i} = \frac{\varphi_i}{\delta_i} > 0 \tag{B39}$$

$$\frac{dk_i^c}{d\varphi_i} = \frac{\gamma_i}{\delta_i} > 0 \tag{B40}$$

$$\frac{dk_i^c}{dr} = -\frac{z_i}{\delta_i} < 0 \tag{B41}$$

$$\frac{dk_i^c}{dz_i} = \frac{dk_i^c}{dm_i} = \frac{-r}{\delta_i} < 0 \tag{B42}$$

Export Oriented Entrepreneurs

In addition, the after tax profits of the export oriented firms located in country *i* can be expressed as:

$$\Pi_i^b = F(k_i^b, \gamma_i, \varphi_i) - rk_i^b - w_i - h_i - t_i\left(F(k_i^b, \gamma_i, \varphi_i) - a_i r k_i^b - w_i - h_i\right) \tag{B43}$$

$$\Pi_i^b = (1 - t_i)\left(F(k_i^b, \gamma_i, \varphi_i) - w_i - h_i\right) - (1 - t_i a_i) r k_i^b \tag{B44}$$

$$\Pi_i^b = (1 - t_i)\left[\left(F(k_i^b, \gamma_i, \varphi_i) - w_i - h_i\right) - \frac{(1 - t_i a_i)}{(1 - t_i)} r k_i^b\right] \tag{B45}$$

$$\Pi_i^b = (1 - t_i)\left[\left(F(k_i^b, \gamma_i, \varphi_i) - w_i - h_i\right) - z_i r k_i^b\right] \tag{B46}$$

Let's define:

$$\Psi_i = \left(F(k_i^b, \gamma_i, \varphi_i) - w_i - h_i - z_i r k_i^b\right) \tag{B47}$$

Thus, export oriented entrepreneurs after tax profit is given by:

$$\Pi_i^b = (1 - t_i)\Psi_i \tag{B48}$$

Export oriented entrepreneurs search to maximize after tax profit. Consequently:

$$\frac{d\Pi_i}{dk_i} = (1-t_i)\left(F'(k_i,\gamma_i,\varphi_i) - \frac{dh_i}{dF} F'(k_i,\gamma_i,\varphi_i) \right) - (1-t_i a_i) r = 0 \tag{B49}$$

$$(1-t_i)(1-\theta_i) F'(k_i,\gamma_i,\varphi_i) - (1-t_i a_i) r = 0 \tag{B50}$$

$$(1-\theta_i) F'(k_i,\gamma_i,\varphi_i) = \frac{(1-t_i a_i)}{(1-t_i)} r \tag{B51}$$

Now, assume a production function as in Equation B4 and with the same properties, hence:

$$F(k_i^b,\gamma,\varphi) = \gamma_i \varphi_i k_i^b - \frac{\delta_i (k_i^b)^2}{2} \quad \text{where } \gamma_i,\varphi_i,\delta_i > 0 \tag{B52}$$

$$F'(k_i^b,\gamma,\varphi) = \gamma_i \varphi_i - \delta_i k_i^b \tag{B53}$$

And:

$$(1-\theta_i)(\gamma_i \varphi_i - \delta_i k_i^b) = z_i r \tag{B54}$$

Thus, the optimal export oriented capital per-capita in terms of the international cost of capital ends:

$$k_i^b = \frac{\gamma_i \varphi_i}{\delta_i} - \frac{z_i r}{\delta_i (1-\theta_i)} \tag{B55}$$

Now, in order to obtain the export oriented capital of country 1 in function country's 2 variables, let's establish:

$$\frac{1}{z_1}(1-\theta_1) F'(k_1^b,\gamma_1,\varphi_1) = \frac{1}{z_2}(1-\theta_2) F'(k_2^b,\gamma_2,\varphi_2) \tag{B56}$$

and using Equation B53 above, then:

$$\delta_2 k_2^b - \delta_1 k_1^b \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)} = \gamma_2\varphi_2 - \gamma_1\varphi_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)} \tag{B57}$$

Hence, using equation $\overline{K}_3 = k_1^b + k_2^b$, the optimal export oriented entrepreneurs' capital per-capita in terms of country's 2 variables can be expressed as:

$$k_1^b = \frac{\delta_2 \overline{K}_3 - \gamma_2\varphi_2 + \gamma_1\varphi_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}}{\left[\delta_2 + \delta_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}\right]} \tag{B58}$$

or

$$k_1^b = \frac{\delta_2 \overline{K}_3 z_1(1-\theta_2) - \gamma_2\varphi_2 z_1(1-\theta_2) + \gamma_1\varphi_1 z_2(1-\theta_1)}{\left[\delta_2 z_1(1-\theta_2) + \delta_1 z_2(1-\theta_1)\right]} \tag{B59}$$

where

$$\frac{dk_1^b}{d\overline{K}_3} = \frac{\delta_2}{\left[\delta_2 + \delta_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}\right]} > 0 \tag{B60}$$

$$\frac{dk_1^b}{d\gamma_2} = \frac{-\varphi_2}{\left[\delta_2 + \delta_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}\right]} < 0 \tag{B61}$$

$$\frac{dk_1^b}{d\varphi_2} = \frac{-\gamma_2}{\left[\delta_2 + \delta_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}\right]} < 0 \tag{B62}$$

$$\frac{dk_1^b}{d\gamma_1} = \frac{\varphi_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}}{\left[\delta_2 + \delta_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}\right]} > 0 \tag{B63}$$

$$\frac{dk_1^b}{d\varphi_1} = \frac{\gamma_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}}{\left[\delta_2 + \delta_1 \frac{z_2(1-\theta_1)}{z_1(1-\theta_2)}\right]} > 0 \qquad \text{(B64)}$$

By assuming that:

$$\gamma_2\varphi_2\delta_1 + \gamma_1\varphi_1\delta_2 - \delta_1\delta_2\overline{K}_3 > 0 \qquad \text{(B65)}$$

Then:

$$\frac{dk_1^b}{dz_2} = \frac{z_1(1-\theta_1)(1-\theta_2)\left[\delta_2\gamma_1\varphi_1 + \delta_1\gamma_2\varphi_2 - \delta_1\delta_2\overline{K}_3\right]}{\left[\delta_2 z_1(1-\theta_2) + \delta_1 z_2(1-\theta_1)\right]^2} > 0 \qquad \text{(B66)}$$

$$\frac{dk_1^b}{dz_1} = \left(z_2(1-\theta_1)(1-\theta_2)\right)\frac{\left(\delta_2\delta_1\overline{K}_3 - \gamma_2\varphi_2\delta_1 - \gamma_1\varphi_1\delta_2\right)}{\left[\delta_2 z_1(1-\theta_2) + \delta_1 z_2(1-\theta_1)\right]^2} < 0 \qquad \text{(B67)}$$

$$\frac{dk_1^b}{d\theta_1} = \frac{z_1 z_2(1-\theta_2)(1-\theta_2)\left[\delta_1\delta_2\overline{K}_3 - \gamma_2\varphi_2\delta_1 - \delta_2\gamma_1\varphi_1\right]}{\left[\delta_2 z_1(1-\theta_2) + \delta_1 z_2(1-\theta_1)\right]^2} < 0 \qquad \text{(B68)}$$

$$\frac{dk_1^b}{d\theta_2} = \frac{z_1 z_2(1-\theta_1)\left[\delta_1\gamma_2\varphi_2 + \delta_2\gamma_1\varphi_1 - \delta_1\delta_2\overline{K}_3\right]}{\left[\delta_2 z_1(1-\theta_2) + \delta_1 z_2(1-\theta_1)\right]^2} > 0 \qquad \text{(B69)}$$

Condition of Investment

Let's define the condition regarding the number of entrepreneurs investing in country 1.

$$(1+\Omega) = \frac{(1-t_1)(\Psi_1)}{(1-t_2)(\Psi_2)} \qquad \text{(B70)}$$

where:

$$\frac{d(1+\Omega)}{dt_1} = \frac{d\Omega}{dt_1} = \frac{-\Psi_1}{(1-t_2)\Psi_2} + \frac{(1-t_1)}{\underset{+}{(1-t_2)\Psi_2}}\underset{+}{\frac{d\Psi_1}{dk_1^b}}\underset{-}{\frac{dk_1^b}{dz_1}}\underset{?}{\frac{dz_1}{dt_1}} < 0 \qquad \text{(B71)}$$

assuming $\left|\frac{\Psi_1}{(1-t_1)\Psi_2}\right| > \left|\frac{(1-t_1)}{(1-t_1)\Psi_2}\frac{d\Psi_1}{dk_1^b}\frac{dk_1^b}{dz_1}\frac{dz_1}{dt_1}\right|$ in the case that $\frac{dz_1}{dt_1} < 0$. Hence:

$$\frac{d(1+\Omega)}{da_1} = \frac{d\Omega}{da_1} = \underset{+}{\frac{(1-t_1)}{(1-t_1)\Psi_2}}\underset{+}{\frac{d\Psi_1}{dk_1^b}}\underset{-}{\frac{dk_1^b}{dz_1}}\underset{-}{\frac{dz_1}{da_1}} > 0 \tag{B72}$$

$$\frac{d(1+\Omega)}{dz_1} = \frac{d\Omega}{dz_1} = \frac{(1-t_1)\left(\frac{d\Psi_1}{dz_1}\right)}{(1-t_2)\Psi_2} = \frac{-rk_1^b(1-t_1)}{(1-t_2)\Psi_2} < 0 \tag{B73}$$

where

$$\frac{d\Psi_i}{dz_i} = \left[F'(k_i^b,\gamma_i,\varphi_i)(1-\theta_i) - z_i r\right]\frac{dk_i^b}{dz_i} - rk_i^b = -rk_i^b < 0 \tag{B74}$$

$$\frac{d\Psi_1}{dt_1} = \frac{d\Psi_1}{dz_1}\frac{dz_1}{dt_1} = -rk_1\frac{dz_1}{dt_1} < 0 \tag{B75}$$

Government Budget Constraint

Country's 1 government finance the provision of the public good g_1 through the corporate statutory tax rate t_1 and the allowance rate a_1. Hence, if the governments' revenues are used completely to finance g_i then:

$$g_1 = t_1(1+\Omega)\left(F(k_1^b,\gamma_1,\varphi_1) - w_1 - h_1 - a_1 rk_1^b\right) + t_1\left(F(k_1^c,\gamma_1,\varphi_1) - w_1 - a_1 rk_1^c\right) \tag{B76}$$

$$\begin{aligned} g_1 = {} & t_1(1+\Omega)\left(F(k_1^b,\gamma_1,\varphi_1) - w_1 - h_1 - z_1 rk_1^b + z_1 rk_1^b - a_1 rk_1^b\right) \\ & + t_1\left(F(k_1^c,\gamma_1,\varphi_1) - w_1 - z_1 rk_1^c + z_1 rk_1^c - a_1 rk_1^c\right) \end{aligned} \tag{B77}$$

$$g_1 = (1+\Omega)\left(t_1\Psi_1 + (z_1 - a_1)t_1 rk_1^b\right) + \left(t_1\Gamma_1 + (z_1 - a_1)t_1 rk_1^c\right) \tag{B78}$$

and since $(z_1 - a_1)t_1 = (z_1 - 1)$

Then:

$$g_1 = (1+\Omega)\left[t_1\Psi_1 + (z_1 - 1)rk_1^b\right] + \left[t_1\Gamma_1 + (z_1 - 1)rk_1^c\right] \tag{B79}$$

Observe that:

$$\frac{dg_1}{dt_1} = \frac{d\Omega}{dt_1}\left[t_1(\Psi_1) + (z-1)rk_1{}^b\right] + (1+\Omega)\Psi_1 + \Gamma_1 + \frac{dg_1}{dz_1}\frac{dz_1}{dt_1} \tag{B80}$$

Government Maximization Problem

Country's 1 government searches to:

$$\underset{t_1, z_1}{Max}\ SWF_1 = w_1 + rk_1^c + v(g_1)(4+\Omega) + (1-t_1)\Gamma_1 + (1+\Omega)(1-t_1)\Psi_1 \tag{B81}$$

$$\textit{Subject to:} \quad (1+\Omega) = \frac{(1-t_1)(\Psi_1)}{(1-t_2)(\Psi_2)} \tag{B82}$$

Consequently, the first order conditions can be expressed as:

$$\frac{dSWF_1}{dt_1} = \frac{d(w_1 + rk_1^c)}{dt_1} + \frac{dy_1^c}{dt_1} + \frac{dy_1^b}{dt_1} + \frac{dv(g_1)}{dt_1}[4+\Omega] + \frac{dSWF_1}{d\Omega}\frac{d\Omega}{dt_1} = 0 \tag{B83}$$

$$\frac{dSWF_1}{dz_1} = \frac{d(w_1 + rk_1^c)}{dz_1} + \frac{dy_1^c}{dz_1} + \frac{dy_1^b}{dz_1} + \frac{dv(g_1)}{dz_1}[4+\Omega] + \frac{dSWF_1}{d\Omega}\frac{d\Omega}{dz_1} = 0 \tag{B84}$$

Hence, by assuming $0 < t_1^* < 1$ and $z_1 = 1$, then:

$$\frac{dy_1^c}{dt_1} = -\Gamma_1 \tag{B85}$$

$$\frac{dy_1^b}{dt_1} = -(1+\Omega)\Psi_1 + (1-t_1)\frac{d\Omega}{dt_1}\Psi_1 \tag{B86}$$

$$\frac{dg_1}{dt_1} = \frac{d\Omega}{dt_1}\left[t_1(\Psi_1)\right] + (1+\Omega)\Psi_1 + \Gamma_1 \tag{B87}$$

$$\frac{d\Omega}{dt} = \frac{-(\Psi_1)}{(1-t_2)(\Psi_2)} \tag{B88}$$

$$(1+\Omega) = -(1-t_1)\frac{d\Omega}{dt_1} \tag{B89}$$

and substituting into Equation B83:

$$\begin{aligned}\frac{dSWF_1}{dt_1} &= \frac{d\left(w_1 + rk_1^c\right)}{dt_1} + \frac{dy_1^c}{dt_1} - (1+\Omega)\Psi_1 + (1-t_1)\frac{d\Omega}{dt_1}\Psi_1 \\ &+ \left(\frac{d\Omega}{dt_1}t_1(\Psi_1) + (1+\Omega)\Psi_1 + \Gamma_1\right)[4+\Omega] + \frac{dSWF_1}{d\Omega}\frac{d\Omega}{dt_1} = 0\end{aligned} \tag{B90}$$

$$\begin{aligned}\frac{dSWF_1}{dt_1} &= \left[\frac{\frac{d\left(w_1 + rk_1^c\right)}{dt_1}}{\frac{d\Omega}{dt_1}} + \frac{\frac{dy_1^c}{dt_1}}{\frac{d\Omega}{dt_1}} - \frac{(1+\Omega)\Psi_1}{\frac{d\Omega}{dt_1}} + (1-t_1)\Psi_1\right. \\ &\left. + \left(t_1(\Psi_1) + \frac{(1+\Omega)\Psi_1}{\frac{d\Omega}{dt_1}} + \frac{\Gamma_1}{\frac{d\Omega}{dt_1}}\right)[4+\Omega] + \frac{dSWF_1}{d\Omega}\right]\frac{d\Omega}{dt_1} = 0\end{aligned} \tag{B91}$$

$$\begin{aligned}\frac{dSWF_1}{dt_1} &= \left[\frac{d\left(w_1 + rk_1^c\right)}{d\Omega} + \frac{dy_1^c}{d\Omega} - \frac{\left(-(1-t_1)\frac{d\Omega}{dt_1}\right)\Psi_1}{\frac{d\Omega}{dt_1}} + (1-t_1)\Psi_1 + \right. \\ &\left. + \left(t_1(\Psi_1) + \frac{\left(-(1-t_1)\frac{d\Omega}{dt_1}\right)\Psi_1}{\frac{d\Omega}{dt_1}} - \frac{\frac{dy_1^c}{dt_1}}{\frac{d\Omega}{dt_1}}\right)[4+\Omega] + \frac{dSWF_1}{d\Omega}\right]\frac{d\Omega}{dt_1} = 0\end{aligned} \tag{B92}$$

Thus:

$$\left.\frac{dSWF_1}{dt_1}\right|_{z_1=1} = \begin{bmatrix} \frac{d\left(w_1 + rk_1^c\right)}{d\Omega} + \frac{dy_1^c}{d\Omega} + 2(1-t_1)\Psi_1 \\ +\phi\left(t_1\Psi_1 - (1-t_1)\Psi_1 - \frac{dy_1^c}{d\Omega}\right)[4+\Omega] + \frac{dSWF_1}{d\Omega} \end{bmatrix} \frac{d\Omega}{dt_1} = 0 \quad \text{(B93)}$$

Now, repeating the same procedure to Equation B84, using:

$$\frac{dy_1^c}{dz_1} = (1-t_1)\frac{d\Gamma_1}{dz_1} = -rk_1^c(1-t_1) \quad \text{(B94)}$$

$$\frac{dy_1^b}{dz_1} = (1-t_1)\frac{d\Omega}{dz_1}\Psi_1 + (1-t_1)(1+\Omega)\frac{d\Psi_1}{dz_1} \quad \text{(B95)}$$

$$\frac{d\Psi_1}{dz_1} = \left[(1-\theta)F'(k_1^b) - z_1 r\right]\frac{dk_1^b}{dz_1} - rk_1^b = -rk_1^b \quad \text{(B96)}$$

$$\frac{d\Omega}{dz_1} = \frac{(1-t_1)}{(1-t_2)(\Psi_2)}\frac{d\Psi_1}{dz_1} = \frac{-rk_1^b(1-t_1)}{(1-t_2)(\Psi_2)} < 0 \quad \text{(B97)}$$

$$\begin{aligned} \frac{dg_1}{dz_1} = \frac{d\Omega}{dz_1}\left[t_1\Psi_1 + (z_1-1)rk_1^{\,b}\right] + (1+\Omega)\left[(z_1-1)r\frac{dk_1^{\,b}}{dz_1} + rk_1^{\,b}(1-t_1)\right] \\ + \left[(z_1-1)r\frac{dk_1^{\,c}}{dz_1} + rk_1^{\,c}(1-t_1)\right] \end{aligned} \quad \text{(B98)}$$

and

$$z_1 = 1 \quad \text{(B99)}$$

Hence;

$$\begin{aligned} \frac{dSWF_1}{dz_1} = \frac{d\left(w_1 + rk_1^c\right)}{dz_1} + \frac{dy_1^c}{dz_1} + (1-t_1)\frac{d\Omega}{dz_1}\Psi_1 + (1-t_1)(1+\Omega)\frac{d\Psi_1}{dz_1} \\ +\phi\left(\frac{d\Omega}{dz}[t_1\Psi_1] + (1+\Omega)rk_1^{\,b}(1-t_1) + rk_1^{\,c}(1-t_1)\right)[4+\Omega] + \frac{dSWF_1}{d\Omega}\frac{d\Omega}{dz_1} = 0 \end{aligned} \quad \text{(B100)}$$

$$\frac{dSWF_1}{dz_1}=\left[\frac{\frac{d\left(w_1+rk_1^c\right)}{dz_1}}{\frac{d\Omega}{dz_1}}+\frac{\frac{dy_1^c}{dz_1}}{\frac{d\Omega}{dz_1}}+\left(1-t_1\right)\Psi_1+\frac{\left(1-t_1\right)\left(1+\Omega\right)\frac{d\Psi_1}{dz_1}}{\frac{d\Omega}{dz_1}}\right.$$
$$\left.+\phi\left(\left[t_1\Psi_1\right]+\frac{(1+\Omega)rk_1{}^b\left(1-t_1\right)}{\frac{d\Omega}{dz_1}}+\frac{rk_1{}^c\left(1-t_1\right)}{\frac{d\Omega}{dz_1}}\right)\left[4+\Omega\right]+\frac{dSWF_1}{d\Omega}\right]\frac{d\Omega}{dz_1}=0 \tag{B101}$$

$$\frac{dSWF_1}{dz_1}=\left[\frac{\frac{d\left(w_1+rk_1^c\right)}{dz_1}}{\frac{d\Omega}{dz_1}}+\frac{\frac{dy_1^c}{dz_1}}{\frac{d\Omega}{dz_1}}+\left(1-t_1\right)\Psi_1+\frac{\left(1-t_1\right)\left(1+\Omega\right)\frac{d\Psi_1}{dz_1}}{\frac{\left(1-t_1\right)}{\left(1-t_2\right)\left(\Psi_2\right)}\frac{d\Psi_1}{dz}}\right.$$
$$\left.+\phi\left(\left[t_1\Psi_1\right]-\frac{(1+\Omega)\frac{d\Psi_1}{dz}\left(1-t_1\right)}{\frac{\left(1-t_1\right)}{\left(1-t_2\right)\left(\Psi_2\right)}\frac{d\Psi_1}{dz}}-\frac{\frac{dy_1^c}{dz_1}}{\frac{d\Omega}{dz_1}}\right)\left[4+\Omega\right]+\frac{dSWF_1}{d\Omega}\right]\frac{d\Omega}{dz_1}=0 \tag{B102}$$

$$\frac{dSWF_1}{dz_1}=\left[\frac{d\left(w_1+rk_1^c\right)}{d\Omega}+\frac{dy_1^c}{d\Omega}+\left(1-t_1\right)\Psi_1+(1+\Omega)\left(1-t_2\right)\left(\Psi_2\right)\right.$$
$$\left.+\phi\left(\left[t_1\Psi_1\right]-(1+\Omega)\left(1-t_2\right)\left(\Psi_2\right)-\frac{dy_1^c}{d\Omega}\right)\left[4+\Omega\right]+\frac{dSWF_1}{d\Omega}\right]\frac{d\Omega}{dz_1}=0 \tag{B103}$$

$$\left.\frac{dSWF_1}{dz_1}\right|_{z_1=1}=\left[\begin{array}{l}\frac{d\left(w_1+rk_1^c\right)}{d\Omega}+\frac{dy_1^c}{d\Omega}+2\left(1-t_1\right)\Psi_1\\+\phi\left[t_1\Psi_1-(1-t)\Psi_1-\frac{dy_1^c}{d\Omega}\right]\left[4+\Omega\right]+\frac{dSWF_1}{d\Omega}\end{array}\right]\frac{d\Omega}{dz_1}=0 \tag{B104}$$

Consequently, from Equation B94, since $\frac{d\Omega}{dt_1}\neq 0$ then:

$\left[\frac{d\left(w_1+rk_1^c\right)}{d\Omega}+\frac{dy_1^c}{d\Omega}+2\left(1-t_1\right)\Psi_1+\phi\left(t_1\Psi_1-\left(1-t_1\right)\Psi_1-\frac{dy_1^c}{d\Omega}\right)\left[4+\Omega\right]+\frac{dSWF_1}{d\Omega}\right]$ must equal zero,

and thus $z_1=1$.

$$\left[\frac{d\left(w_1 + rk_1^c\right)}{d\Omega} + \frac{dy_1^c}{d\Omega} + 2(1-t_1)\Psi_1 + \phi\left(t_1\Psi_1 - (1-t_1)\Psi_1 - \frac{dy_1^c}{d\Omega}\right)[4+\Omega] + \frac{dSWF_1}{d\Omega}\right] = 0 \qquad \text{(B105)}$$

In addition, from Equation B104 and since $\frac{d\Omega}{dz_1} \neq 0$ at $z_1 = 1$, then:

$$\left.\frac{dSWF_1}{dz_1}\right|_{z_1=1} = 0 \qquad \text{(B106)}$$

Hence, the value of z_1 that maximizes the social welfare function is $z_1^* = 1$. Thus, $z_1^* = 1$; $a_1^* = 1$; $m_1^* = 0$; $0 < t_1^* < 1$; and $\lambda_1^* = t_1^*$.

Optimal Statutory Corporate Tax Rate

Hence from:

$$\frac{dSWF_1}{dt_1} = \frac{d\left(w_1 + rk_1^c\right)}{dt_1} + \frac{dy_1^c}{dt_1} + \frac{dy_1^b}{dt_1} + \frac{dv(g_1)}{dt_1}[4+\Omega] + \frac{dSWF_1}{d\Omega}\frac{d\Omega}{dt_1} = 0 \qquad \text{(B107)}$$

and using Equations B85 through B89, plus:

$$\frac{d\left(w_1 + rk_1^c\right)}{dt} = 0 \text{ since } z_1^* = 1 \qquad \text{(B108)}$$

Then:

$$\begin{aligned} &-\Gamma_1 - (1+\Omega)\Psi_1 + (1-t_1)\frac{d\Omega}{dt_1}\Psi_1 + \phi\left[\frac{d\Omega}{dt}t_1\Psi_1 + (1+\Omega)\Psi_1 + \Gamma_1\right][4+\Omega] \\ &+ \phi\left[(1+\Omega)t_1\Psi_1 + t_1\Gamma_1\right]\frac{d\Omega}{dt_1} = 0 \end{aligned} \qquad \text{(B109)}$$

Hence with Equation B88:

$$-\Gamma_1+(1-t_1)\frac{d\Omega}{dt_1}\Psi_1+(1-t_1)\frac{d\Omega}{dt_1}\Psi_1$$
$$+\phi\left[\frac{d\Omega}{dt}t_1\Psi_1-(1-t_1)\frac{d\Omega}{dt_1}\Psi_1+\Gamma_1\right]\left[3-(1-t_1)\frac{d\Omega}{dt_1}\right] \tag{B110}$$
$$+\phi\left[-(1-t_1)\frac{d\Omega}{dt_1}t_1\Psi_1+t_1\Gamma_1\right]\frac{d\Omega}{dt_1}=0$$

$$\left(-\Gamma_1+2\frac{d\Omega}{dt_1}\Psi_1\right)-t_1 2\frac{d\Omega}{dt_1}\Psi_1$$
$$+\left[2\frac{d\Omega}{dt}t_1\Psi_1+\left(\Gamma_1-\frac{d\Omega}{dt_1}\Psi_1\right)\right]\left[\left(3\phi-\frac{d\Omega}{dt_1}\phi\right)+t_1\phi\frac{d\Omega}{dt_1}\right] \tag{B111}$$
$$+\left[t_1{}^2\left(\frac{d\Omega}{dt_1}\right)^2\Psi_1\phi-t_1\Psi_1\phi\left(\frac{d\Omega}{dt_1}\right)^2+t_1\Gamma_1\phi\frac{d\Omega}{dt_1}\right]=0$$

$$\left(\left(\Gamma_1-\frac{d\Omega}{dt_1}\Psi_1\right)\left(3\phi-\frac{d\Omega}{dt_1}\phi\right)+2\frac{d\Omega}{dt_1}\Psi_1-\Gamma_1\right)$$
$$+t_1\left[2\frac{d\Omega}{dt}\Psi_1(3\phi-1)-4\left(\frac{d\Omega}{dt_1}\right)^2\phi\Psi_1+2\frac{d\Omega}{dt_1}\phi\Gamma_1\right] \tag{B112}$$
$$+t_1{}^2\left[3\left(\frac{d\Omega}{dt}\right)^2\Psi_1\phi\right]=0$$

Using the general formula for a quadratic equation:

$$x=\frac{-b}{2a}\pm\frac{\sqrt{b^2-4ac}}{2a} \tag{B113}$$

where

$$c=\left(\left(\Gamma_1-\frac{d\Omega}{dt_1}\Psi_1\right)\left(3\phi-\frac{d\Omega}{dt_1}\phi\right)+2\frac{d\Omega}{dt_1}\Psi_1-\Gamma_1\right) \tag{B114}$$

$$b = \left[2\frac{d\Omega}{dt}\Psi_1(3\phi - 1) - 4\left(\frac{d\Omega}{dt_1}\right)^2 \phi\Psi_1 + 2\frac{d\Omega}{dt_1}\phi\Gamma_1 \right] \tag{B115}$$

$$a = \left[3\left(\frac{d\Omega}{dt}\right)^2 \Psi_1\phi \right] \tag{B116}$$

Therefore, the optimal statutory corporate tax rate is:

$$t_1^* = \frac{-\left[2\frac{d\Omega}{dt}\Psi_1(3\phi - 1) - 4\left(\frac{d\Omega}{dt_1}\right)^2 \phi\Psi_1 + 2\frac{d\Omega}{dt_1}\phi\Gamma_1 \right]}{2\left[3\left(\frac{d\Omega}{dt}\right)^2 \Psi_1\phi \right]} \pm \frac{\sqrt{\begin{aligned}&\left[2\frac{d\Omega}{dt}\Psi_1(3\phi - 1) - 4\left(\frac{d\Omega}{dt_1}\right)^2 \phi\Psi_1 + 2\frac{d\Omega}{dt_1}\phi\Gamma_1 \right]^2 + \\ &-4\left[3\left(\frac{d\Omega}{dt}\right)^2 \Psi_1\phi \right]\left[\left(\Gamma_1 - \frac{d\Omega}{dt_1}\Psi_1\right)\left(3\phi - \frac{d\Omega}{dt_1}\phi\right) + 2\frac{d\Omega}{dt_1}\Psi_1 - \Gamma_1 \right]\end{aligned}}}{2\left[3\left(\frac{d\Omega}{dt}\right)^2 \Psi_1\phi \right]} \tag{B117}$$

Where by numerical evaluation, and $0 < t_1^* < 1$ the t_1^* is given by:

$$t_1^* = \frac{-\left[\Psi_1(3\phi - 1) - 2\frac{d\Omega}{dt_1}\phi\Psi_1 + \phi\Gamma_1 \right]}{\left[3\frac{d\Omega}{dt}\Psi_1\phi \right]} - \frac{\sqrt{\begin{aligned}&\left[2\frac{d\Omega}{dt}\Psi_1(3\phi - 1) - 4\left(\frac{d\Omega}{dt_1}\right)^2 \phi\Psi_1 + 2\frac{d\Omega}{dt_1}\phi\Gamma_1 \right]^2 + \\ &-4\left[3\left(\frac{d\Omega}{dt}\right)^2 \Psi_1\phi \right]\left[\left(\Gamma_1 - \frac{d\Omega}{dt_1}\Psi_1\right)\left(3\phi - \frac{d\Omega}{dt_1}\phi\right) + 2\frac{d\Omega}{dt_1}\Psi_1 - \Gamma_1 \right]\end{aligned}}}{2\left[3\left(\frac{d\Omega}{dt}\right)^2 \Psi_1\phi \right]} \tag{B118}$$

where the slope of the reaction function is determined by:

$$\frac{dt_1^*}{dt_2} = \frac{dt_1^*}{d\left(\frac{d\Omega}{dt_1}\right)} \frac{d\left(\frac{d\Omega}{dt_1}\right)}{dt_2} > 0 \tag{B119}$$

First part:

$$\frac{dt_1^*}{d\left(\frac{d\Omega}{dt}\right)} = \frac{\left[2\frac{d\Omega}{dt}\Psi_1\phi\right] + \left[\Psi_1(3\phi - 1) - 2\frac{d\Omega}{dt_1}\phi\Psi_1 + \phi\Gamma_1\right]}{\left[3\left(\frac{d\Omega}{dt}\right)^2 \Psi_1\phi\right]} \tag{B120}$$

Reaction Function of the AETR

Redefine $1+\Omega$ in terms of λ_1^b:

$$1+\Omega = \frac{(F_1 - w_1 - rk_1 - h_1) - t_1 \frac{(F_1 - w_1 - a_1 rk_1 - h_1)}{(F_1 - w_1 - rk_1 - h_1)}(F_1 - w_1 - rk_1 - h_1)}{(F_2 - w_2 - rk_2 - h_2) - t_2(F_2 - w_2 - a_2 rk_2 - h_2)} \tag{B121}$$

$$1+\Omega = \frac{(1-\lambda_1^b)(F_1 - w_1 - rk_1 - h_1)}{(1-\lambda_2^b)(F_2 - w_2 - rk_2 - h_2)} \tag{B122}$$

where:

$$\lambda_1^b = \frac{t_1\left(F(k_1^b, \gamma_1, \varphi_1) - w_1 - h_1 - a_1 rk_1^b\right)}{F(k_1^b, \gamma_1, \varphi_1) - w_1 - h_1 - rk_1^b} \tag{B123}$$

If:

$$\Lambda_i = \left(F(k_i^b, \gamma_i^b, \varphi_i^b) - w_i^b - rk_i^b - h_i^b\right) \tag{B124}$$

Then,

$$1+\Omega=\frac{\left(1-\lambda_1^b\right)(\Lambda_1)}{\left(1-\lambda_2^b\right)(\Lambda_2)} \tag{B125}$$

where

$$\frac{d1+\Omega}{d\lambda_1^b}=\frac{-(\Lambda_1)}{\left(1-\lambda_2^b\right)(\Lambda_2)} \tag{B126}$$

Similarly, redefine government revenue to:

$$\begin{aligned} g_1 &= (1+\Omega)\frac{t_1\left[F_1^b-w_1^b-a_1rk_1^b-h_1\right]}{\left[F_1^b-w_1^b-rk_1^b-h_1\right]}\left[F_1^b-w_1^b-rk_1^b-h_1\right] \\ &+\frac{t_1\left[F_1^c-w_1^c-a_1rk_1^c\right]}{\left[F_1^c-w_1^c-rk_1^c\right]}\left[F_1^c-w_1^c-rk_1^c\right] \end{aligned} \tag{B127}$$

where

$$\lambda_1^c=\frac{t_1\left(F(k_1^c,\gamma_1,\varphi_1)-w_1-a_1rk_1^c\right)}{F(k_1^c,\gamma_1,\varphi_1)-w_1-rk_1^c} \tag{B128}$$

$$g_1=(1+\Omega)\lambda_1^b\left[F_1-w_1-rk_1-h_1\right]+\lambda_1^c\left[F_1-w_1-rk_1\right] \tag{B129}$$

$$g_i=(1+\Omega)\lambda_i^b\Lambda_i+\lambda_i^c\Sigma_i \tag{B130}$$

where

$$\Sigma_i=\left(F(k_i^c,\gamma_i^c,\varphi_i^c)-w_i^c-rk_i^c\right) \tag{B131}$$

and

$$\frac{dg_1}{d\lambda_1^b}=(1+\Omega)\Lambda+\left(\frac{d\Omega}{d\lambda_1^b}\right)\lambda_1^b\Lambda=\frac{\left(1-2\lambda_1^b\right)\Lambda_1{}^2}{(1-\lambda_2)(\Lambda_2)} \tag{B132}$$

Also, export oriented entrepreneurs after tax income ends:

$$y_1^b=(1+\Omega)\left(1-\lambda_1^b\right)\Lambda_1 \tag{B133}$$

$$\frac{dy_i^b}{d\lambda_1^b}=\left(\frac{d\Omega}{d\lambda_1^b}\right)\left(1-\lambda_1^b\right)\Lambda-(1+\Omega)\Lambda=-2\frac{\left(1-\lambda_1^b\right)(\Lambda_1)}{(1-\lambda_2)(\Lambda_2)}\Lambda_1 \tag{B134}$$

where

$$k_1^b = \frac{\gamma_1\varphi_1}{\delta_1} - \frac{r}{\delta_1(1-\theta_1)} \tag{B135}$$

Alternatively, home producing entrepreneur's after tax income ends:

$$y_1^c = (1-\lambda_1^c)(\Sigma_1) \tag{B136}$$

$$\frac{dy_1^c}{d\lambda_1^b} = \frac{dy_1^c}{d\lambda_1^c}\frac{d\lambda_1^c}{d\lambda_1^b} \tag{B137}$$

where

$$k_1^c = \frac{\gamma_1\varphi_1 - r}{\delta_1} \tag{B138}$$

The government searches for:

$$\underset{\lambda_1^b}{Max}\ SWF_1 = w_1 + rk_1^c + v(g_1)(4+\Omega) + y_i^c + y_i^b \tag{B139}$$

$$Subject\ to: \quad (1+\Omega) = \frac{(1-\lambda_1^b)\Lambda_1}{(1-\lambda_2^b)\Lambda_2} \tag{B140}$$

The first order condition ends:

$$\frac{dSWF_1}{d\lambda_1^b} = \frac{d(w_1 + rk_1^c)}{d\lambda_1^b} + \frac{dy_1^c}{d\lambda_1^b} + \frac{dy_1^b}{d\lambda_1^b} + \frac{dv(g_1)}{d\lambda_1^b}[4+\Omega] + v(g_1)\frac{d\Omega}{d\lambda_1^b} = 0 \tag{B141}$$

So, by solving for λ_1^b and since:

$$\frac{d(w_1 + rk_1^c)}{d\lambda_1^b} = 0 \tag{B142}$$

Hence,

$$\lambda_1^{b\,2}\left[\frac{3\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)(\Lambda_2)}\right]+\lambda_1^b\left[+2\Lambda_1-6\phi\Lambda_1-\frac{4\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)\Lambda_2}\right]$$
$$+\left[-2\Lambda_1+3\phi\Lambda_1+\frac{\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)\Lambda_2}-\phi\lambda_1^c\Sigma_1+\frac{dx_1^c}{d\lambda_1^c}\frac{d\lambda_1^c}{d\lambda_1^b}\left(\frac{(1-\lambda_2^b)(\Lambda_2)}{(\Lambda_1)}\right)\right]=0 \qquad \text{(B143)}$$

The optimal AETR for export oriented entrepreneurs can be expressed as:

$$\lambda_1^b=-\frac{\left[2\Lambda_1-6\phi\Lambda_1-\frac{4\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)\Lambda_2}\right]}{2\left[\frac{3\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)(\Lambda_2)}\right]}$$
$$\pm\frac{\left[\left[2\Lambda_1-6\phi\Lambda_1-\frac{4\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)\Lambda_2}\right]^2-4\left[\frac{3\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)(\Lambda_2)}\right]\left[-2\Lambda_1+3\phi\Lambda_1+\frac{\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)\Lambda_2}-\phi\lambda_1^c\Sigma_1+\frac{dx_1^c}{d\lambda_1^c}\frac{d\lambda_1^c}{d\lambda_1^b}\left(\frac{(1-\lambda_2^b)(\Lambda_2)}{(\Lambda_1)}\right)\right]\right]^{1/2}}{2\left[\frac{3\phi\Lambda_1^{\ 2}}{(1-\lambda_2^b)(\Lambda_2)}\right]} \qquad \text{(B144)}$$

where

$$\lambda_1^b=\lambda\left(\underset{+}{\lambda_2^b},\underset{-}{\lambda_1^c},\underset{-}{h_1},\underset{+}{h_2},\underset{-}{r},\underset{+}{\gamma_1},\underset{+}{\varphi_1},\underset{-}{\gamma_2},\underset{-}{\varphi_2},\underset{-}{w_1},\underset{+}{w_2},\underset{+}{\overline{K}_3}\right) \qquad \text{(B145)}$$

Effects on the Reaction Functions

From the optimal statutory corporate tax rate the following conclusions can be extracted:

$$\frac{dt_1^*}{dt_2}>0 \quad \frac{dt_1^*}{dD_2}>0 \quad \frac{dt_1^*}{d\theta_2}>0 \quad \frac{dt_1^*}{d\gamma_2}<0 \quad \frac{dt_1^*}{d\varphi_2}<0$$

$$\frac{dt_1^*}{dD_1}<0 \quad \frac{dt_1^*}{d\theta_1}<0 \quad \frac{dt_1^*}{d\gamma_1}>0 \quad \frac{dt_1^*}{d\varphi_1}>0 \quad \frac{dt_1^*}{d\Gamma_1}>0 \quad \frac{dt_1^*}{dr}<0 \qquad \text{(B146)}$$

Also, by assuming $\phi = 0.25$ and that Γ_1 is high, then:

$$\left.\frac{dt_1^*}{dt_2}\right|_{D_1 < D_2} < \left.\frac{dt_1^*}{dt_2}\right|_{D_1 > D_2} \tag{B147}$$

$$\left.\frac{dt_1^*}{dt_2}\right|_{\theta_1 < \theta_2} < \left.\frac{dt_1^*}{dt_2}\right|_{\theta_1 > \theta_2} \tag{B148}$$

Thus:

$$\begin{aligned}
\frac{dt_1^*}{dt_2} = \frac{1}{6\phi\Psi_1} \Big(& -2\Gamma_1\phi\Psi_1\Psi_2 + 2\Psi_1{}^2\Psi_2 - 6\phi\Psi_1{}^2\Psi_2 - \Big(2\big(2\Gamma_1\phi\Psi_1\Psi_2 - 2\Psi_1{}^2\Psi_2 + 6\phi\Psi_1{}^2\Psi_2\big)\big(-4\phi\Psi_1{}^3 \\
& -2\Gamma_1\phi(1-t_2)\Psi_1\Psi_2 + 2(1-t_2)\Psi_1{}^2\Psi_2 - 6\phi\Psi_1{}^2\Psi_2\big) - 12\phi\Psi_1{}^3\big(-\Gamma_1\phi\Psi_1\Psi_2 + 2\Psi_1{}^2\Psi_2 - 3\phi\Psi_1{}^2\Psi_2 \\
& + 2\Gamma_1(1-t_2)\Psi_2{}^2 \\
& - 6\Gamma_1\phi(1-t_2)\Psi_2{}^2\big)\Big)\Big/ \left(2\sqrt{\begin{pmatrix} \big(-4\phi\Psi_1{}^3 - 2\Gamma_1\phi(1-t_2)\Psi_1\Psi_2 + 2(1-t_2)\Psi_1{}^2\Psi_2 - 6\phi(1-t_2)\Psi_1{}^2\Psi_2\big)^2 - \\ 12\phi\Psi_1{}^3\big(\phi\Psi_1{}^3 + \Gamma_1\phi(1-t_2)\Psi_1\Psi_2 - 2(1-t_2)\Psi_1{}^2\Psi_2 + 3\phi(1-t_2)\Psi_1{}^2\Psi_2 \\ -\Gamma_1(1-t_2)^2\Psi_2^2 + 3\Gamma_1\phi(1-t_2)^2\Psi_2^2\big) \end{pmatrix}} \right)\Big)
\end{aligned} \tag{B149}$$

Average Effective Tax Rates

Since $\lambda_i^b = \lambda_i^c = \tau_i$. Then:

$$y_1^c = (1-\tau_1)\Sigma_1 \tag{B150}$$

$$\frac{dy_1^c}{d\lambda_1^b} = \frac{dy_1^c}{d\tau_1} = -\Sigma_1 \tag{B151}$$

$$\tau_1{}^2\left[\frac{3\phi\Lambda_1{}^2}{(1-\tau_2)(\Lambda_2)}\right]+\tau_1\left[+2\Lambda_1-6\phi\Lambda_1-\frac{4\phi\Lambda_1{}^2}{(1-\lambda_2^b)\Lambda_2}\right]$$
$$+\left[-2\Lambda_1+3\phi\Lambda_1+\frac{\phi\Lambda_1{}^2}{(1-\tau_2)\Lambda_2}-\phi\tau_1\Sigma_1-\Sigma_1\left(\frac{(1-\lambda_2^b)(\Lambda_2)}{(\Lambda_1)}\right)\right]=0 \tag{B152}$$

$$\tau_1{}^2\left[\frac{3\phi\Lambda_1{}^2}{(1-\tau_2)(\Lambda_2)}\right]+\tau_1\left[+2\Lambda_1-6\phi\Lambda_1-\frac{4\phi\Lambda_1{}^2}{(1-\lambda_2^b)\Lambda_2}-\phi\Sigma_1\right]$$
$$+\left[-2\Lambda_1+3\phi\Lambda_1+\frac{\phi\Lambda_1{}^2}{(1-\tau_2)\Lambda_2}-\Sigma_1\left(\frac{(1-\lambda_2^b)(\Lambda_2)}{(\Lambda_1)}\right)\right]=0 \tag{B153}$$

Hence:

$$\tau_1=-\frac{\left[2\Lambda_1-6\phi\Lambda_1-\frac{4\phi\Lambda_1{}^2}{(1-\tau_2)\Lambda_2}-\phi\Sigma_1\right]}{2\left[\frac{3\phi\Lambda_1{}^2}{(1-\tau_2)\Lambda_2}\right]}$$
$$\pm\frac{\left[\left[2\Lambda_1-6\phi\Lambda_1-\frac{4\phi\Lambda_1{}^2}{(1-\tau_2)\Lambda_2}-\phi\Sigma_1\right]^2-4\left[\frac{3\phi\Lambda_1{}^2}{(1-\tau_2)(\Lambda_2)}\right]\left[-2\Lambda_1+3\phi\Lambda_1+\frac{\phi\Lambda_1{}^2}{(1-\tau_2)\Lambda_2}-\Sigma_1\left(\frac{(1-\lambda_2^b)(\Lambda_2)}{(\Lambda_1)}\right)\right]\right]^{1/2}}{2\left[\frac{3\phi\Lambda_1{}^2}{(1-\tau_2)(\Lambda_2)}\right]} \tag{B154}$$

APPENDIX C

EMPIRICAL MODEL: SPECIFICATIONS AND TESTS

Lagrange Multiplier Tests

Following Baltagi (2003), assuming fixed individual and time effects and that $\tau_{it} = y_{it}$, the econometric model can be represented as:

$$y_{it} = \phi + \alpha W y_{it-1} + X_{it-1}\beta + u_{it} \qquad i = 1,2,........N \qquad \text{(C1)}$$

$$t = 1,2,.......T$$

$$u_{it} = \mu_i + \eta_t + \varepsilon_{it} \qquad \text{(C2)}$$

Additionally, similarly to Baltagi, Song, Jung, and Koh (2003) the disturbances can be defined as:

where

$$\varepsilon_{it} = \lambda W_{NT}\varepsilon_{it} + v_{it} \qquad \text{(C3)}$$

$$v_{it} = \rho v_{it-1} + e_{it} \qquad \text{(C4)}$$

Note that W_{NT} is a NT x NT weight matrix, where $W_{NT} = W \otimes I_T$, where W is a N x N weight matrix. Also, e_{it} ~IIN $(0, \sigma_e^2)$, v_{it} ~N $(0, \sigma_e^2/(1-\rho^2))$.

In order to obtain the within estimator it is necessary to define:

$$\tilde{y}_{it} = y_{it} - \bar{y}_{i.} - \bar{y}_{.t} + \bar{y}_{..} \qquad \text{(C5)}$$

$$\tilde{y}_{it-1} = y_{it-1} - \bar{y}_{i.'} - \bar{y}_{.t-1} + \bar{y}_{..'} \qquad \text{(C6)}$$

$$\tilde{X}_{it-1} = X_{it-1} - \bar{X}_{i.'} - \bar{X}_{.t-1} + \bar{X}_{..'} \quad \text{(C7)}$$

$$\tilde{\varepsilon}_{it} = \varepsilon_{it} - \bar{\varepsilon}_{i.} - \bar{\varepsilon}_{.t} + \bar{\varepsilon}_{..} \quad \text{(C8)}$$

$$\tilde{v}_{it} = v_{it} - \bar{v}_{i.} - \bar{v}_{.t} + \bar{v}_{..} \quad \text{(C9)}$$

$$\tilde{v}_{it-1} = v_{it-1} - \bar{v}_{i.'} - \bar{v}_{.t-1} + \bar{v}_{..'} \quad \text{(C10)}$$

$$\tilde{e}_{it} = e_{it} - \bar{e}_{i.} - \bar{e}_{.t} + \bar{e}_{..} \quad \text{(C11)}$$

$$\sum_{i=1}^{N} \mu_i = 0 \text{ and } \sum_{i=1}^{T} \eta_t = 0 \quad \text{(C12)}$$

Where $\bar{y}_{i.} = \frac{1}{T}\sum_{t=1}^{T} y_{it}$, $\bar{y}_{t.} = \frac{1}{N}\sum_{i=1}^{N} y_{it}$, $\bar{y}_{..} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=}^{T} y_{it}$ and $\bar{y}_{i.'} = \frac{1}{T}\sum_{t=1}^{T-1} y_{it-1}$.

Therefore:

$$y_{it} = \phi + \alpha W y_{it-1} + X_{it-1}\beta + \mu_i + \eta_t + \varepsilon_{it} \quad \text{(C13)}$$

$$\bar{y}_{i.} = \phi + \alpha W \bar{y}_{i.'} + \bar{X}_{i.'}\beta + \mu_i + \bar{\varepsilon}_{i.} \quad \text{(C14)}$$

$$\bar{y}_{.t} = \phi + \alpha W \bar{y}_{.t-1} + \bar{X}_{.t-1}\beta + \eta_t + \bar{\varepsilon}_{.t} \quad \text{(C15)}$$

$$\bar{y}_{..} = \phi + \alpha W \bar{y}_{..'} + \bar{X}_{..'}\beta + \bar{\varepsilon}_{..} \quad \text{(C16)}$$

Using the above equations to obtain the within estimator:

$$\begin{aligned} y_{it} - \bar{y}_{i.} - \bar{y}_{.t} + \bar{y}_{..} &= (\phi - \phi - \phi + \phi) + \alpha W(y_{it-1} - \bar{y}_{i.'} - \bar{y}_{.t-1} + \bar{y}_{..}') \\ &+ (X_{it-1} - \bar{X}_{i.'} - \bar{X}_{.t-1} + \bar{X}_{..'})\beta + (\varepsilon_{it} - \bar{\varepsilon}_{i.} - \bar{\varepsilon}_{.t} + \bar{\varepsilon}_{..}) \end{aligned} \quad \text{(C17)}$$

Hence,

$$\tilde{y}_{it} = \alpha W \tilde{y}_{it-1} + \tilde{X}_{it-1}\beta + \tilde{\varepsilon}_{it} \quad \text{(C18)}$$

Also, note from Equations C3 and C8 that:

$$\tilde{\varepsilon}_{it} = (I_{NT} - \lambda W_{NT})^{-1}(v_{it} - \bar{v}_{i.} - \bar{v}_{.t} + \bar{v}_{..}) \quad \text{(C19)}$$

Hence:

$$\tilde{\varepsilon}_{it} = \left(I_{NT} - \lambda W_{NT}\right)^{-1} \tilde{v}_{it} \quad \text{(C20)}$$

and from Equations C4, C10 and C11:

$$\tilde{v}_{it} = v_{it} - \bar{v}_{i.} - \bar{v}_{.t} + \bar{v}_{..} = \rho\left(v_{it-1} - \bar{v}_{i.'} - \bar{v}_{.t-1} + \bar{v}_{..'}\right) + \left(e_{it} - \bar{e}_{i.} - \bar{e}_{.t} + \bar{e}_{..}\right) \quad \text{(C21)}$$

$$\tilde{v} = \rho\tilde{v}_{it-1} + \tilde{e}_{it} \quad \text{(C22)}$$

Also, $\tilde{e}_{it} \sim \text{IIN}(0, \sigma_e^2)$, $\tilde{v}_{it} \sim \text{N}(0, \tilde{\sigma}_e^2/(1-\rho^2))$ and $\tilde{\sigma}_e^2 = \dfrac{\tilde{v}'\tilde{v}}{(N-1)(T-1)-K}$ where K represents the number of independent variables at the estimation.

Hence, from Equation C20 and since $W_{NT} = W \otimes I_T$ and $I_{NT} = I_N \otimes I_T$ (where I_N and I_T are identity matrices of order N and T, respectively):

$$\tilde{\varepsilon}_{it} = \left(I_N - \lambda W\right)^{-1} \tilde{v}_{it} \otimes I_T \quad \text{(C23)}$$

Denote $B = \left(I_N - \lambda W\right)$, hence:

$$\tilde{\varepsilon} = B^{-1}\tilde{v} \otimes I_T \quad \text{(C24)}$$

And the variance covariance matrix is:

$$\Omega = (B'B)^{-1} \otimes V = \tilde{\sigma}_e^2 (B'B)^{-1} \otimes V_\rho \quad \text{(C25)}$$

Define:

$$V = E(\tilde{v}\tilde{v}') = \tilde{\sigma}_e^2\left(\frac{1}{1-\rho^2}\right)V_1 \quad \text{(C26)}$$

$$V = \tilde{\sigma}_e^2 V_\rho \quad \text{(C27)}$$

Where

$$V_\rho = \left(\frac{1}{1-\rho^2}\right)V_1 \text{ and } V_1 = \begin{bmatrix} 1 & \rho & \rho^2 & .. & \rho^{T-1} \\ \rho & 1 & \rho & .. & \rho^{T-2} \\ \rho^2 & \rho & 1 & .. & : \\ : & : & : & : & : \\ \rho^{T-1} & \rho^{T-2} & \rho^{T-3} & .. & 1 \end{bmatrix} \tag{C28}$$

Testing for $H_0^e : \lambda = \rho = 0$, Equation C6 at H_0^e reduces to:

$$\Omega_0 = \sigma_e^2 I_N \otimes I_T \tag{C29}$$

$$\frac{\partial \Omega}{\partial \sigma_e^2} = (B'B)^{-1} \otimes V_\rho \Rightarrow \left.\frac{\partial \Omega}{\partial \sigma_e^2}\right|_{H_0^e} = I_N \otimes I_T \tag{C30}$$

$$\frac{\partial \Omega}{\partial \rho} = \sigma_e^2 (B'B)^{-1} \otimes \frac{\partial V_\rho}{\partial \rho} \Rightarrow \left.\frac{\partial \Omega}{\partial \rho}\right|_{H_0^e} = \sigma_e^2 I_N \otimes G \tag{C31}$$

Where $\frac{\partial V_\rho}{\partial \rho} = \frac{1}{1-\rho^2}\frac{\partial V_1}{\partial \rho} + \frac{2\rho}{\left(1-\rho^2\right)^2} V_1$ and $\left.\frac{\partial V_1}{\partial \rho}\right|_{H_0^e} = G$ and G is a bidiagonal matrix

obtained from derivation of V_1 with respect to ρ.

$$\frac{\partial V_1}{\partial \rho} = \begin{bmatrix} 0 & 1 & 2\rho & .. & (T-1)\rho^{T-2} \\ 1 & 0 & 1 & .. & (T-2)\rho^{T-3} \\ 2\rho & 1 & 0 & .. & : \\ : & : & : & : & : \\ (T-1)\rho^{T-2} & (T-2)\rho^{T-3} & (T-3)\rho^{T-4} & .. & 0 \end{bmatrix} \tag{C32}$$

$$\left.\frac{\partial V_1}{\partial \rho}\right|_{H_0^e} = \begin{bmatrix} 0 & 1 & 0 & .. & 0 \\ 1 & 0 & 1 & .. & 0 \\ 0 & 1 & 0 & .. & : \\ : & : & : & : & : \\ 0 & 0 & 0 & .. & 0 \end{bmatrix} \tag{C33}$$

$$\frac{\partial \Omega}{\partial \lambda} = \sigma_e^2 (B'B)^{-1}\left(W'B + B'W\right)(B'B)^{-1} \otimes V_\rho \Rightarrow \left.\frac{\partial \Omega}{\partial \lambda}\right|_{H_0^e} = \sigma_e^2 \left(W' + W\right) \otimes I_T \tag{C34}$$

The above using the fact that $\frac{\partial (B'B)^{-1}}{\partial \lambda} = (B'B)^{-1}(W'B + B'W)(B'B)^{-1}$ according to Anselin (1988, p. 164).

The LM statistic is given by:

$$LM = \tilde{D}'_{\theta} \, \tilde{J}'^{-1}_{\theta} \, \tilde{D}_{\theta} \tag{C35}$$

where

$$\tilde{D}_{\theta} = (\partial L / \partial \theta)(\tilde{\theta}) \tag{C36}$$

and θ represents the variable in question. The general formula that is commonly used to obtain $\tilde{D}_{\theta}$:

$$\frac{\partial L}{\partial \theta_r} = -\frac{1}{2} tr\left[\Omega^{-1} \frac{\partial \Omega}{\partial \theta_r}\right] + \frac{1}{2}\hat{u}'\left(\Omega^{-1} \frac{\partial \Omega}{\partial \theta_r} \Omega^{-1}\right)\hat{u} \qquad r = 1,2,3. \tag{C37}$$

Where $\hat{u}$ represents the OLS residuals from the within estimation and

$\tilde{\sigma}_e^2 = \frac{\hat{u}'\hat{u}}{(N-1)(T-1)-K}$.

Thus, from Equation C30:

$$\Omega^{-1} \frac{\partial \Omega}{\partial \sigma_e^2}\bigg|_{H_0^e} = \frac{1}{\sigma_e^2} I_N \otimes I_T \tag{C38}$$

$$tr\left[\Omega^{-1} \frac{\partial \Omega}{\partial \sigma_e^2}\bigg|_{H_0^e}\right] = \frac{NT}{\sigma_e^2} \tag{C39}$$

$$\Omega^{-1} \frac{\partial \Omega}{\partial \sigma_e^2} \Omega^{-1}\bigg|_{H_0^e} = \frac{1}{\sigma_e^4} I_N \otimes I_T \tag{C40}$$

Using Equation C37:

$$\frac{\partial L}{\partial \sigma_e^2} = -\frac{1}{2}\frac{NT}{\sigma_e^2} + \frac{1}{2}\hat{u}'\left(\frac{1}{\sigma_e^4} I_N \otimes I_T\right)\hat{u} = 0 \tag{C41}$$

Similarly, from Equation C31:

$$\Omega^{-1}\frac{\partial\Omega}{\partial\rho}\bigg|_{H_0^e} = I_N \otimes G \tag{C42}$$

$$tr\left[\Omega^{-1}\frac{\partial\Omega}{\partial\rho}\bigg|_{H_0^e}\right] = 0 \tag{C43}$$

$$\Omega^{-1}\frac{\partial\Omega}{\partial\rho}\Omega^{-1}\bigg|_{H_0^e} = \frac{1}{\sigma_e^2} I_N \otimes G \tag{C44}$$

Using Equation C37:

$$\frac{\partial L}{\partial\rho} = \frac{1}{2}\hat{u}'\left(\frac{1}{\sigma_e^2} I_N \otimes G\right)\hat{u} \tag{C45}$$

From Equation C34:

$$\Omega^{-1}\frac{\partial\Omega}{\partial\lambda}\bigg|_{H_0^e} = (W'+W)\otimes I_T \tag{C46}$$

$$tr\left[\Omega^{-1}\frac{\partial\Omega}{\partial\lambda}\bigg|_{H_0^e}\right] = 0 \tag{C47}$$

$$\Omega^{-1}\frac{\partial\Omega}{\partial\lambda}\Omega^{-1}\bigg|_{H_0^e} = \frac{1}{\tilde{\sigma}_e^2}(W'+W)\otimes I_T \tag{C48}$$

Using Equation C37:

$$\frac{\partial L}{\partial\lambda} = \frac{1}{2}\hat{u}'\left(\frac{1}{\tilde{\sigma}_e^2}(W'+W)\otimes I_T\right)\hat{u} \tag{C49}$$

$$\tilde{D}_1 = \begin{bmatrix} \dfrac{\partial L}{\partial\tilde{\sigma}_e^2} \\ \dfrac{\partial L}{\partial\rho} \\ \dfrac{\partial L}{\partial\lambda} \end{bmatrix} = \begin{bmatrix} 0 \\ \dfrac{\hat{u}'(I_N \otimes G)\hat{u}}{2\tilde{\sigma}_e^2} \\ \dfrac{\hat{u}'((W'+W)\otimes I_T)\hat{u}}{2\tilde{\sigma}_e^2} \end{bmatrix} \tag{C50}$$

Using the following matrix differentiation formula given in Harville (1977):

$$J_{rs} = E\left[-\frac{\partial^2 L}{\partial\theta_r \partial\theta_s}\right] = \frac{1}{2} tr\left[\Omega^{-1}\frac{\partial\Omega}{\partial\theta_r}\Omega^{-1}\frac{\partial\Omega}{\partial\theta_s}\right] \text{ for } r,s = 1,2,3. \tag{C51}$$

Thus,

$$J_{11} = E\left[-\frac{\partial^2 L}{\partial(\sigma_e^2)^2}\right] = \frac{1}{2} tr\left[\frac{1}{\sigma_e^4} I_N \otimes I_T\right] = \frac{NT}{2\sigma_e^4} \tag{C52}$$

$$J_{12} = E\left[-\frac{\partial^2 L}{\partial\sigma_e^2 \partial\rho}\right] = \frac{1}{2} tr\left[\frac{1}{\sigma_e^2} I_N \otimes G\right] = 0 \tag{C53}$$

$$J_{13} = E\left[-\frac{\partial^2 L}{\partial\sigma_e^2 \partial\lambda}\right] = \frac{1}{2} tr\left[\frac{1}{\sigma_e^2}(W + W')\otimes I_T\right] = 0 \tag{C54}$$

$$J_{22} = E\left[-\frac{\partial^2 L}{\partial\rho^2}\right] = \frac{1}{2} tr\left[I_N \otimes G^2\right] = N(T-1) \tag{C55}$$

$$J_{23} = E\left[-\frac{\partial^2 L}{\partial\rho\partial\lambda}\right] = \frac{1}{2} tr\left[(W + W')\otimes G\right] = 0 \tag{C56}$$

$$J_{33} = E\left[-\frac{\partial^2 L}{\partial\lambda^2}\right] = \frac{1}{2} tr\left[(W + W')^2 \otimes I_T\right] = T\left[tr\left(W^2 + W'W\right)\right] \tag{C57}$$

$$\tilde{J}_1 = \begin{bmatrix} \frac{NT}{2\sigma_e^4} & 0 & 0 \\ 0 & N(T-1) & 0 \\ 0 & 0 & T\left[tr\left(W^2 + W'W\right)\right] \end{bmatrix} \tag{C58}$$

$$\tilde{J}_1^{-1} = \begin{bmatrix} \frac{2\sigma_e^4}{NT} & 0 & 0 \\ 0 & \frac{1}{N(T-1)} & 0 \\ 0 & 0 & \frac{1}{T\left[tr\left(W^2 + W'W\right)\right]} \end{bmatrix} \tag{C59}$$

$$\tilde{D}_1^{'}\tilde{J}_1 = \begin{bmatrix} 0 & \frac{\hat{u}'(I_N \otimes G)\hat{u}}{2\hat{\sigma}_e^2} & \frac{\hat{u}'((W'+W)\otimes I_T)\hat{u}}{2\hat{\sigma}_e^2} \end{bmatrix} \begin{bmatrix} \frac{2\hat{\sigma}_e^4}{NT} & 0 & 0 \\ 0 & \frac{1}{N(T-1)} & 0 \\ 0 & 0 & \frac{1}{T\left[tr\left(W^2+W'W\right)\right]} \end{bmatrix} \tag{C60}$$

$$\tilde{D}_1^{'}\tilde{J}_1 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & \frac{\hat{u}'(I_N \otimes G)\hat{u}}{N(T-1)2\hat{\sigma}_e^2} & 0 \\ 0 & 0 & \frac{\hat{u}'((W'+W)\otimes I_T)\hat{u}}{T\left[tr\left(W^2+W'W\right)\right]2\hat{\sigma}_e^2} \end{bmatrix} \tag{C61}$$

$$\tilde{D}_1^{'}\tilde{J}_1\tilde{D}_1 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & \frac{\hat{u}'(I_N \otimes G)\hat{u}}{N(T-1)2\hat{\sigma}_e^2} & 0 \\ 0 & 0 & \frac{\hat{u}'((W'+W)\otimes I_T)\hat{u}}{T\left[tr\left(W^2+W'W\right)\right]2\hat{\sigma}_e^2} \end{bmatrix} \begin{bmatrix} 0 \\ \frac{\hat{u}'(I_N \otimes G)\hat{u}}{2\hat{\sigma}_e^2} \\ \frac{\hat{u}'((W'+W)\otimes I_T)\hat{u}}{2\hat{\sigma}_e^2} \end{bmatrix} \tag{C62}$$

$$LM = \tilde{D}_1^{'}\tilde{J}_1\tilde{D}_1 = \begin{bmatrix} LM_\sigma \\ LM_\rho \\ LM_\lambda \end{bmatrix} = \begin{bmatrix} 0 \\ \frac{1}{N(T-1)}\left(\frac{\hat{u}'(I_N \otimes G)\hat{u}}{2\hat{\sigma}_e^2}\right)^2 \\ \frac{1}{T\left[tr\left(W^2+W'W\right)\right]}\left(\frac{\hat{u}'((W'+W)\otimes I_T)\hat{u}}{2\hat{\sigma}_e^2}\right)^2 \end{bmatrix} \tag{C63}$$

Thus, the LM tests for $H_0^e : \rho = 0$ and $H_0^e : \lambda = 0$ are given by:

$$LM_\rho = \frac{1}{N(T-1)}\left(\frac{\hat{u}'(I_N \otimes G)\hat{u}}{2\hat{\sigma}_e^2}\right)^2 \tag{C64}$$

$$LM_\lambda = \frac{1}{T\left[tr\left(W^2+W'W\right)\right]}\left(\frac{\hat{u}'((W'+W)\otimes I_T)\hat{u}}{2\hat{\sigma}_e^2}\right)^2 \tag{C65}$$

Which are asymptotically distributed as χ_1^2.

Thus, the joint test for $H_0^e : \lambda = \rho = 0$ can be expressed as:

$$LM_{\lambda\rho} = LM_{\rho} + LM_{\lambda} \qquad \text{(C66)}$$

which is asymptotically distributed as χ_2^2.

Note that $\hat{\sigma}_e^2 = \dfrac{\hat{u}'\hat{u}}{(N-1)(T-1)-K}$ comes from the within estimator assuming fixed individual and time effects. The LM tests derived above can also be used with no fixed affects, with individual fixed effects and with time fixed effects, depending on the notation of σ_e^2 and the residuals. For example:

Table C1

Different σ_e^2 for each Estimation Method

Estimation Method	Variance
A) No fixed affects	$\sigma_e^2 = \dfrac{e'e}{NT}$ where e are the OLS residuals.
B) Individual fixed effects only	$\hat{\sigma}_e^2 = \dfrac{\tilde{u}'\tilde{u}}{N(T-1)-K}$ where $\tilde{u}$ are the residuals from within estimator model with fixed individual effects.
C) Time fixed effects only	$\breve{\sigma}_e^2 = \dfrac{\breve{u}'\breve{u}}{T(N-1)-K}$ where $\breve{u}$ are the residuals from within estimator model with fixed time effects.
D) Individual and time fixed effects	$\hat{\sigma}_e^2 = \dfrac{\hat{u}'\hat{u}}{(N-1)(T-1)-K}$ where $\hat{u}$ represent the OLS residuals from the within estimator.

Tests for Time and Individual Effects: The F tests

According to Baltagi (2003), fixed time and individual effects can be tested as follows:

a) An F test for jointly testing individual and time effects. Denoting the μ 's as the individual fixed effects, and the η 's as the time fixed effects, the null hypothesis is given by:

$H_0 : \mu_1 = ... = \mu_{N-1} = 0$ and $\eta_1 = ... = \eta_{t-1} = 0$

which will be tested by:

$$F = \frac{(RRSS - URSS)/(N + T - 2)}{URSS/((N-1)(T-1) - K)} \qquad \text{(C67)}$$

where *RRSS* refers to the restricted residual sum of squares of the pooled regression, $URSS = \varepsilon'\varepsilon$. On the other hand, the *URSS* is defined as the unrestricted residual sum of squares that of using Equation C18, $URSS = \tilde{\varepsilon}'\tilde{\varepsilon}$.

This test is distributed as: $F_{(N+T-2),(N-1)(T-1)-K}$.

b) A second test is carried out as to check for the existence of individual effects given the time effects. So, the null hypothesis is represented as:

$H_0 : \mu_1 = ... = \mu_{N-1} = 0$ and $\eta_t \neq 0$ for *t=1,……, T-1.*

The same F test from Equation C67 applies, and *URSS* is still the within residual sum of squares from Equation C18, however *RRSS* is the residuals sum of squares of the time series only, that is, of the regression based upon

$y_{it} - \bar{y}_{.t} = (x_{it} - \bar{x}_{.t})\beta + (\varepsilon_{it} - \bar{\varepsilon}_{.t})$. This test is distributed as: $F_{(N-1),(N-1)(T-1)-K}$.

c) Finally, a third F test validates the existence of time effects given the individual effects, hence the null hypothesis is given by:

$H_0 : \eta_1 = ... = \eta_{t-1} = 0$ and $\mu_i \neq 0$ for *i=1,……, N-1.*

Again, the F test of Equation C67 applies, however the *RRSS* is given by $y_{it} - \bar{y}_{i.} = (x_{it} - \bar{x}_{i.})\beta + (\varepsilon_{it} - \bar{\varepsilon}_{i.})$, while the *URSS* is obtained from Equation C18. This test is distributed as: $F_{(T-1),(N-1)(T-1)-K}$.

Arellano's Robust Standard Error Estimators

Following Arellano (1987), it is possible to compute robust standard errors for within-groups estimators when having heteroskedasticity and serial correlation of arbitrary form. Assuming that the within-groups estimators are given by:

$$\beta_{WG} = (\tilde{X}'\tilde{X})'\tilde{X}'\tilde{y} \tag{C68}$$

and since $\tilde{X}' = (\tilde{X}_1, \tilde{X}_2, ..., \tilde{X}_N)$, then the robust variance covariance matrix of $\hat{\beta}$ can be represented by:

$$AVM(\beta) = (\tilde{X}_i'\tilde{X}_i)^{-1}\left(\sum_{i=1}^{N}\tilde{X}_i'\varepsilon_i\varepsilon_i'\tilde{X}_i\right)(\tilde{X}_i'\tilde{X}_i)^{-1} \tag{C69}$$

where in both cases, Equations C68 and C69, the $\tilde{X}$ include all the independent variables, that is, it includes the $\tilde{y}_{it-1}$ and $\tilde{X}_{it-1}$ (right hand side of Equation C18).

APPENDIX D

EMPIRICAL RESULTS

Results for Estimations under Weight Matrix W_1

Table D1
Individual and Time Fixed Effects using W_1

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\,\tau_{i,t-1}$	0.7638344	0.05084	15.02376	0.00000	0.06551	11.65902	0.00000
$L_{i,t-1}$	1.3071E-06	6.8446E-07	1.90960	0.05649	8.7596E-07	1.49214	0.13600
$op_{i,t-1}$	-0.0531589	0.03209	-1.65631	0.09800	0.04975	-1.06848	0.28558
$\gamma_{i,t-1}$	0.0001900	0.00012	1.64607	0.10009	1.8279E-04	1.03949	0.29885
$fd_{i,t-1}$	-1.1380E-06	3.8485E-07	-2.95692	0.00319	4.7625E-07	-2.38945	0.01707
$ER_{i,t-1}$	2.6619E-05	6.0229E-05	0.44197	0.65861	1.5729E-05	1.69243	0.09090
$GE_{i,t-1}$	0.2611465	0.17377	1.50282	0.13323	0.25507	1.02381	0.30619
ρ	0.47037144	0.03254824	14.45152	0.00000			
R^2 *within*	0.22782		Variance	0.01254			
R^2 *adjusted*	0.16381		RSS	11.64889			
R^2 *ordinary*	0.69992						
Durbin-Watson	0.87427		Breusch-Pagan	480.37852			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual and time effects				
F_1	45.68036		F_2	22.34489			
P-value	0.00000		P-value	0.00000			
3) F-test for individual given time effects			4) F-test for time given individual effects				
F_3	31.39913		F_4	-1.34160			
P-value	0.00000		P-value	1.00000			
$LM\ \rho$	176.22143		P-value	0.00000			
$LM\ \lambda$	0.36158		P-value	0.54763			
$LM\ \rho+\lambda$	176.58302		P-value	0.00000			

Table D2
Individual Fixed Effects using W_1

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\,\tau_{i,t-1}$	0.7508322	0.06889	10.89970	0.00000	0.12387	6.06141	0.00000
$L_{i,t-1}$	1.1967E-06	6.6949E-07	1.78745	0.07418	8.7400E-07	1.36921	0.17126
$op_{i,t-1}$	-0.0497860	0.03137	-1.58694	0.11286	0.04930	-1.00987	0.31282
$\gamma_{i,t-1}$	0.0002197	0.00011	1.94691	0.05184	1.7729E-04	1.23907	0.21563
$fd_{i,t-1}$	-1.0904E-06	3.7622E-07	-2.89839	0.00384	4.6575E-07	-2.34125	0.01943
$ER_{i,t-1}$	7.6403E-06	5.9524E-05	0.12836	0.89789	2.0523E-05	0.37228	0.70977
$GE_{i,t-1}$	0.2647555	0.17182	1.54085	0.12369	0.27886	0.94942	0.34265
ρ	0.4591521	0.02776	16.54221	0.00000			
R^2 *within*	0.14065		Variance	0.01198			
R^2 *adjusted*	0.08711		RSS	11.34608			
R^2 *ordinary*	0.70772						
Durbin-Watson	0.88520		Breusch-Pagan	501.73848			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	25.83195		F_2	31.96683			
P-value	0.00000		P-value	0.00000			
$LM\,\rho$	175.25500		P-value	0.00000			
$LM\,\lambda$	0.51570		P-value	0.47268			
$LM\,\rho+\lambda$	175.77070		P-value	0.00000			

Table D3
Time Fixed Effects using W_1

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-1}$	1.0128148	0.08171	12.39530	0.00000	0.17577	5.76213	0.00000
$L_{i,t-1}$	2.3648E-06	5.9503E-07	3.97428	0.00008	2.3091E-06	1.02414	0.30602
$op_{i,t-1}$	-0.1063855	0.01045	-10.17749	0.00000	0.02689	-3.95703	0.00008
$\gamma_{i,t-1}$	-0.0002074	0.00005	-4.33705	0.00002	1.6131E-04	-1.28555	0.19890
$fd_{i,t-1}$	-1.3511E-06	5.1214E-07	-2.63808	0.00847	7.6995E-07	-1.75477	0.07961
$ER_{i,t-1}$	1.1248E-04	9.4697E-05	1.18775	0.23522	9.6418E-05	1.16656	0.24367
$GE_{i,t-1}$	-0.2617789	0.11976	-2.18586	0.02906	0.39469	-0.66325	0.50733
ρ	0.7983248	0.03223	24.76927	0.00000			
R^2 *within*	0.25128		Variance	0.03274			
R^2 *adjusted*	0.23220		RSS	32.12227			
R^2 *ordinary*	0.17251						
Durbin-Watson	0.18139		Breusch-Pagan	625.07589			
1) F-test for the all coefficients equal zero			2) F-test for fixed time effects				
F_1	54.87173		F_2	-0.50528			
P-value	0.00000		P-value	1.00000			
LM ρ	588.69121		P-value	0.00000			
LM λ	1.82737		P-value	0.17644			
LM $\rho+\lambda$	590.51858		P-value	0.00000			

Table D4

No Fixed Effects using W_1 (Simple Panel Data Estimation)

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
Constant	0.1540253	0.04194	3.67291	0.00025	0.06399	2.40687	0.01627
$w\ \tau_{i,t-1}$	0.6363172	0.11009	5.77974	0.00000	0.14514	4.38411	0.00001
$L_{i,t-1}$	2.4548E-06	5.8044E-07	4.22930	0.00003	2.2352E-06	1.09828	0.27235
$op_{i,t-1}$	-0.1064499	0.01012	-10.51515	0.00000	0.02524	-4.21775	0.00003
$\gamma_{i,t-1}$	-0.0002065	0.00005	-4.42861	0.00001	1.6291E-04	-1.26738	0.20532
$fd_{i,t-1}$	-1.4528E-06	5.0066E-07	-2.90171	0.00379	7.6434E-07	-1.90067	0.05763
$ER_{i,t-1}$	1.3328E-05	9.3791E-05	0.14210	0.88703	2.4544E-05	0.54301	0.58724
$GE_{i,t-1}$	-0.2254035	0.11776	-1.91401	0.05590	0.36995	-0.60929	0.54247
ρ	0.7974026	0.01851	43.07635	0.00000			
R^2 *within*	0.19467		Variance	0.03129			
R^2 *adjusted*	0.18903		RSS	31.26192			
R^2 *ordinary*	0.19467						
Durbin-Watson	0.18969		Breusch-Pagan	612.24840			
1) F-test for the all coefficients equal zero							
F_1	34.49888						
P-value	0.00000						
LM ρ	609.33492		P-value	0.00000			
LM λ	1.61636		P-value	0.20360			
LM $\rho+\lambda$	610.95128		P-value	0.00000			

Results for Estimations under Weight Matrix W_2

Table D5
Individual and Time Fixed Effects using W_2

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\,\tau_{i,t-1}$	0.7499148	0.05064	14.80953	0.00000	0.06639	11.29518	0.00000
$L_{i,t-1}$	1.5762E-06	7.0165E-07	2.24635	0.02492	9.0976E-07	1.73249	0.08352
$op_{i,t-1}$	-0.0575175	0.03198	-1.79841	0.07244	0.04905	-1.17263	0.24125
$\gamma_{i,t-1}$	0.0002525	0.00013	2.00975	0.04475	2.0980E-04	1.20342	0.22912
$fd_{i,t-1}$	-1.1511E-06	3.9001E-07	-2.95147	0.00324	4.7017E-07	-2.44828	0.01454
$ER_{i,t-1}$	2.2649E-05	6.0179E-05	0.37636	0.70673	1.5440E-05	1.46688	0.14275
$GE_{i,t-1}$	0.2258508	0.17467	1.29303	0.19632	0.25438	0.88783	0.37486
ρ	0.46938905	0.03255049	14.42034	0.00000			

R^2 *within*	0.22901	Variance	0.01252
R^2 *adjusted*	0.16510	RSS	11.63093
R^2 *ordinary*	0.70038		
Durbin-Watson	0.87784	Breusch-Pagan	483.73877
1) F-test for the all coefficients equal zero		2) F-test for fixed individual and time effects	
F_1	45.98989	F_2	22.34383
P-value	0.00000	P-value	0.00000
3) F-test for individual given time effects		4) F-test for time given individual effects	
F_3	31.22494	F_4	-1.33750
P-value	0.00000	P-value	1.00000
$LM\ \rho$	175.43775	P-value	0.00000
$LM\ \lambda$	0.19861	P-value	0.65585
$LM\ \rho+\lambda$	175.63636	P-value	0.00000

Table D6

Individual Fixed Effects using W_2

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\,\tau_{i,t-1}$	0.7341452	0.06854	10.71132	0.00000	0.12400	5.92049	0.00000
$L_{i,t-1}$	1.4611E-06	6.8646E-07	2.12844	0.03356	9.0620E-07	1.61234	0.10722
$op_{i,t-1}$	-0.0531708	0.03127	-1.70050	0.08936	0.04866	-1.09268	0.27481
$\gamma_{i,t-1}$	0.0002728	0.00012	2.22107	0.02658	2.0416E-04	1.33604	0.18186
$fd_{i,t-1}$	-1.1064E-06	3.8129E-07	-2.90166	0.00380	4.6161E-07	-2.39677	0.01673
$ER_{i,t-1}$	4.8765E-06	5.9477E-05	0.08199	0.93467	2.1008E-05	0.23212	0.81649
$GE_{i,t-1}$	0.2366965	0.17263	1.37116	0.17065	0.27929	0.84751	0.39693
ρ	0.4582452	0.02778	16.49714	0.00000			
R^2 *within*	0.14190		Variance	0.01196			
R^2 *adjusted*	0.08844		RSS	11.32952			
R^2 *ordinary*	0.70814						
Durbin-Watson	0.88896		Breusch-Pagan	505.73898			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	26.10047		F_2	31.96125			
P-value	0.00000		P-value	0.00000			
$LM\ \rho$	174.45313		P-value	0.00000			
$LM\ \lambda$	0.30047		P-value	0.58359			
$LM\ \rho+\lambda$	174.75360		P-value	0.00000			

Table D7
Time Fixed Effects using W_2

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-1}$	1.0439724	0.07968	13.10186	0.00000	0.17893	5.83457	0.00000
$L_{i,t-1}$	2.4955E-06	5.9677E-07	4.18166	0.00003	2.3797E-06	1.04865	0.29460
$op_{i,t-1}$	-0.1052313	0.01035	-10.16456	0.00000	0.02627	-4.00509	0.00007
$\gamma_{i,t-1}$	-0.0001545	0.00005	-2.88603	0.00399	1.9246E-04	-0.80271	0.42234
$fd_{i,t-1}$	-1.4169E-06	5.1803E-07	-2.73510	0.00635	7.6013E-07	-1.86397	0.06262
$ER_{i,t-1}$	1.1284E-04	9.4519E-05	1.19379	0.23285	1.0113E-04	1.11580	0.26478
$GE_{i,t-1}$	-0.3123613	0.11778	-2.65213	0.00813	0.40306	-0.77497	0.43855
ρ	0.7963903	0.03225	24.69701	0.00000			
R^2 *within*	0.25507		Variance	0.03258			
R^2 *adjusted*	0.23609		RSS	31.95935			
R^2 *ordinary*	0.17671						
Durbin-Watson	0.17433		Breusch-Pagan	647.83225			
1) F-test for the all coefficients equal zero			2) F-test for fixed time effects				
F_1	55.98490		F_2	-0.44068			
P-value	0.00000		P-value	1.00000			
$LM\ \rho$	584.68097		P-value	0.00000			
$LM\ \lambda$	1.40118		P-value	0.23653			
$LM\ \rho+\lambda$	586.08215		P-value	0.00000			

Table D8

No Fixed Effects using W_2 (Simple Panel Data Estimation)

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
Constant	0.1342073	0.04122	3.25592	0.00117	0.06742	1.99061	0.04680
$w\,\tau_{i,t-1}$	0.7341181	0.10737	6.83730	0.00000	0.17274	4.24986	0.00002
$L_{i,t-1}$	2.6091E-06	5.8295E-07	4.47560	0.00001	2.2855E-06	1.14157	0.25391
$op_{i,t-1}$	-0.1055033	0.01007	-10.47733	0.00000	0.02410	-4.37834	0.00001
$\gamma_{i,t-1}$	-0.0001702	0.00005	-3.26469	0.00113	1.9273E-04	-0.88315	0.37737
$fd_{i,t-1}$	-1.5447E-06	5.0735E-07	-3.04471	0.00239	7.6335E-07	-2.02362	0.04328
$ER_{i,t-1}$	1.1174E-05	9.3726E-05	0.11922	0.90512	2.4815E-05	0.45032	0.65258
$GE_{i,t-1}$	-0.2944339	0.11595	-2.53928	0.01126	0.38211	-0.77056	0.44115
ρ	0.7960888	0.01859	42.82195	0.00000			
R^2 *within*	0.19594		Variance	0.03124			
R^2 *adjusted*	0.19031		RSS	31.21281			
R^2 *ordinary*	0.19594						
Durbin-Watson	0.18670		Breusch-Pagan	618.45292			
1) F-test for the all coefficients equal zero							
F_1	34.777699						
P-value	0.00000						
LM ρ	606.17156		P-value	0.00000			
LM λ	2.03485		P-value	0.15373			
LM $\rho+\lambda$	608.20642		P-value	0.00000			

Results for Estimations under Weight Matrix W_3

Table D9
Individual and Time Fixed Effects using W_3

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\,\tau_{i,t-1}$	0.5663070	0.04346	13.03097	0.00000	0.05168	10.95765	0.00000
$L_{i,t-1}$	2.8020E-06	7.1924E-07	3.89582	0.00010	8.6570E-07	3.23674	0.00125
$op_{i,t-1}$	-0.0617623	0.03165	-1.95156	0.05129	0.04866	-1.26928	0.20466
$\gamma_{i,t-1}$	0.0002186	0.00012	1.76429	0.07801	1.7837E-04	1.22554	0.22068
$fd_{i,t-1}$	-8.9758E-07	3.9214E-07	-2.28893	0.02231	4.1675E-07	-2.15376	0.03152
$ER_{i,t-1}$	1.6076E-06	6.1396E-05	0.02618	0.97912	1.5841E-05	0.10148	0.91919
$GE_{i,t-1}$	0.2678937	0.17690	1.51442	0.13026	0.29009	0.92347	0.35600
ρ	0.46936100	0.03246113	14.45917	0.00000			
R^2 *within*	0.19652		Variance	0.01305			
R^2 *adjusted*	0.12992		RSS	12.12108			
R^2 *ordinary*	0.68775						
Durbin-Watson	0.90062		Breusch-Pagan	467.73000			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual and time effects				
F_1	37.86909		F_2	20.88407			
P-value	0.00000		P-value	0.00000			
3) F-test for individual given time effects			4) F-test for time given individual effects				
F_3	29.93036		F_4	-1.77114			
P-value	0.00000		P-value	1.00000			
$LM\ \rho$	177.35634		P-value	0.00000			
$LM\ \lambda$	1.18176		P-value	0.27700			
$LM\ \rho+\lambda$	178.53810		P-value	0.00000			

Table D10
Individual Fixed Effects using W_3

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-1}$	0.4582160	0.05215	8.78595	0.00000	0.06939	6.60396	0.00000
$L_{i,t-1}$	2.5383E-06	7.0222E-07	3.61468	0.00032	8.6838E-07	2.92305	0.00355
$op_{i,t-1}$	-0.0617646	0.03083	-2.00344	0.04541	0.04891	-1.26294	0.20692
$\gamma_{i,t-1}$	0.0002420	0.00012	2.00473	0.04528	1.8230E-04	1.32723	0.18475
$fd_{i,t-1}$	-8.7453E-07	3.8229E-07	-2.28758	0.02238	4.2844E-07	-2.04120	0.04151
$ER_{i,t-1}$	-1.1462E-05	6.0427E-05	-0.18968	0.84960	2.2899E-05	-0.50054	0.61681
$GE_{i,t-1}$	0.2565451	0.17437	1.47129	0.14154	0.32768	0.78290	0.43388
ρ	0.4634507	0.02766	16.75486	0.00000			

R^2 *within*	0.11345	Variance	0.01236
R^2 *adjusted*	0.05822	RSS	11.70512
R^2 *ordinary*	0.69847		
Durbin-Watson	0.88632	Breusch-Pagan	484.38169
1) F-test for the all coefficients equal zero		2) F-test for fixed individual effects	
F_1	20.19826	F_2	30.32346
P-value	0.00000	P-value	0.00000
$LM\ \rho$	180.04927	P-value	0.00000
$LM\ \lambda$	0.00019	P-value	0.98892
$LM\ \rho+\lambda$	180.04946	P-value	0.00000

Table D11
Time Fixed Effects using W_3

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-1}$	0.7185726	0.05346	13.44199	0.00000	0.11365	6.32247	0.00000
$L_{i,t-1}$	2.8493E-06	6.4690E-07	4.40451	0.00001	2.4337E-06	1.17074	0.24199
$op_{i,t-1}$	-0.0975845	0.00985	-9.90322	0.00000	0.02157	-4.52513	0.00001
$\gamma_{i,t-1}$	-0.0001730	0.00005	-3.60982	0.00032	1.3900E-04	-1.24459	0.21358
$fd_{i,t-1}$	-9.5760E-07	5.2579E-07	-1.82126	0.06887	7.8178E-07	-1.22489	0.22091
$ER_{i,t-1}$	7.2841E-05	9.5031E-05	0.76650	0.44357	8.3643E-05	0.87085	0.38405
$GE_{i,t-1}$	-0.2617015	0.10391	-2.51851	0.01194	0.28673	-0.91271	0.36162
ρ	0.7908752	0.03226	24.51403	0.00000			

R^2 *within*	0.24415		Variance	0.03306
R^2 *adjusted*	0.22489		RSS	32.42785
R^2 *ordinary*	0.16464			
Durbin-Watson	0.20058		Breusch-Pagan	616.31107
1) F-test for the all coefficients equal zero			2) F-test for fixed time effects	
F_1	52.81396		F_2	-0.71726
P-value	0.00000		P-value	1.00000
LM ρ	575.48855		P-value	0.00000
LM λ	15.38701		P-value	0.00009
LM $\rho+\lambda$	590.87556		P-value	0.00000

Table D12

No Fixed Effects using W_3 (Simple Panel Data Estimation)

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
Constant	0.2046791	0.02806	7.29467	0.00000	0.06221	3.29033	0.00104
$w\ \tau_{i,t-1}$	0.5165254	0.06054	8.53201	0.00000	0.11716	4.40868	0.00001
$L_{i,t-1}$	2.7078E-06	6.2848E-07	4.30850	0.00002	2.4141E-06	1.12165	0.26228
$op_{i,t-1}$	-0.0998978	0.00951	-10.50407	0.00000	0.02120	-4.71204	0.00000
$\gamma_{i,t-1}$	-0.0001626	0.00005	-3.48074	0.00052	1.3798E-04	-1.17857	0.23885
$fd_{i,t-1}$	-1.2225E-06	5.1316E-07	-2.38232	0.01739	7.4958E-07	-1.63093	0.10322
$ER_{i,t-1}$	1.7585E-06	9.3536E-05	0.01880	0.98500	2.8363E-05	0.06200	0.95057
$GE_{i,t-1}$	-0.2708811	0.10193	-2.65759	0.00800	0.26835	-1.00944	0.31301
ρ	0.7918509	0.01885	42.00687	0.00000			
R^2 *within*	0.19640		Variance	0.03123			
R^2 *adjusted*	0.19077		RSS	31.19494			
R^2 *ordinary*	0.19640						
Durbin-Watson	0.19593		Breusch-Pagan	620.96751			
1) F-test for the all coefficients equal zero							
F_1	34.87938						
P-value	0.00000						
$LM\ \rho$	598.68931		P-value	0.00000			
$LM\ \lambda$	3.96442		P-value	0.04647			
$LM\ \rho{+}\lambda$	602.65373		P-value	0.00000			

Results for Estimations under Weight Matrix W_4

Table D13
Individual and Time Fixed Effects using W_4

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\,\tau_{i,t-1}$	0.6835585	0.04712	14.50680	0.00000	0.06629	10.31223	0.00000
$L_{i,t-1}$	1.8529E-06	7.3171E-07	2.53235	0.01149	9.7019E-07	1.90988	0.05646
$op_{i,t-1}$	-0.0377291	0.03163	-1.19273	0.23328	0.04303	-0.87691	0.38076
$\gamma_{i,t-1}$	0.0002730	0.00012	2.32545	0.02026	1.7828E-04	1.53116	0.12607
$fd_{i,t-1}$	-9.6939E-07	3.9843E-07	-2.43306	0.01516	4.6904E-07	-2.06676	0.03903
$ER_{i,t-1}$	8.9367E-06	6.0735E-05	0.14714	0.88305	1.4839E-05	0.60224	0.54716
$GE_{i,t-1}$	0.2306899	0.17359	1.32894	0.18419	0.26170	0.88152	0.37827
ρ	0.47095908	0.03250772	14.48761	0.00000			
R^2	0.21774		Variance	0.01270			
R^2 *adjusted*	0.15290		RSS	11.80091			
R^2 *ordinary*	0.69600						
Durbin-Watson	0.88647		Breusch-Pagan	470.84793			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual and time effects				
F_1	43.09719		F_2	21.58262			
P-value	0.00000		P-value	0.00000			
3) F-test for individual given time effects			4) F-test for time given individual effects				
F_3	30.80990		F_4	-1.52168			
P-value	0.00000		P-value	1.00000			
$LM\,\rho$	177.54465		P-value	0.00000			
$LM\,\lambda$	0.48010		P-value	0.48838			
$LM\,\rho+\lambda$	178.02475		P-value	0.00000			

Table D14
Individual Fixed Effects using W_4

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-1}$	0.6216420	0.05938	10.46886	0.00000	0.10548	5.89319	0.00000
$L_{i,t-1}$	1.6562E-06	7.1445E-07	2.31819	0.02065	9.5517E-07	1.73395	0.08325
$op_{i,t-1}$	-0.0374149	0.03086	-1.21223	0.22573	0.04388	-0.85263	0.39408
$\gamma_{i,t-1}$	0.0002750	0.00011	2.40104	0.01654	1.7862E-04	1.53941	0.12404
$fd_{i,t-1}$	-9.7184E-07	3.8886E-07	-2.49923	0.01261	4.6914E-07	-2.07154	0.03858
$ER_{i,t-1}$	-7.4192E-06	5.9937E-05	-0.12378	0.90151	2.1516E-05	-0.34483	0.73030
$GE_{i,t-1}$	0.2390679	0.17133	1.39538	0.16323	0.29149	0.82017	0.41233
ρ	0.4609265	0.02767	16.66052	0.00000			
R^2	0.13255		Variance	0.01209			
R^2 *adjusted*	0.07851		RSS	11.45298			
R^2 *ordinary*	0.70496						
Durbin-Watson	0.89273		Breusch-Pagan	501.94259			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	24.11763		F_2	31.06944			
P-value	0.00000		P-value	0.00000			
$LM\ \rho$	177.32602		P-value	0.00000			
$LM\ \lambda$	0.44814		P-value	0.50322			
$LM\ \rho+\lambda$	177.77417		P-value	0.00000			

Table D15
Time Fixed Effects using W_4

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-1}$	0.7742964	0.06073	12.75020	0.00000	0.15269	5.07102	0.00000
$L_{i,t-1}$	1.6019E-06	5.9897E-07	2.67446	0.00761	2.0927E-06	0.76549	0.44416
$op_{i,t-1}$	-0.1183671	0.01012	-11.69319	0.00000	0.02161	-5.47768	0.00000
$\gamma_{i,t-1}$	-0.0000954	0.00005	-1.83660	0.06657	1.3317E-04	-0.71607	0.47412
$fd_{i,t-1}$	-1.1581E-06	5.2441E-07	-2.20839	0.02745	8.6099E-07	-1.34509	0.17891
$ER_{i,t-1}$	8.4045E-05	9.5001E-05	0.88467	0.37655	8.6843E-05	0.96778	0.33339
$GE_{i,t-1}$	-0.4914919	0.10747	-4.57315	0.00001	0.28483	-1.72559	0.08474
ρ	0.8002518	0.03229	24.78505	0.00000			
R^2	0.25058		Variance	0.03278			
R^2 *adjusted*	0.23148		RSS	32.15228			
R^2 *ordinary*	0.17174						
Durbin-Watson	0.18993		Breusch-Pagan	615.42699			
1) F-test for the all coefficients equal zero			2) F-test for fixed time effects				
F_1	54.66790		F_2	-0.68073			
P-value	0.00000		P-value	1.00000			
$LM\ \rho$	587.35385		P-value	0.00000			
$LM\ \lambda$	13.95895		P-value	0.000187			
$LM\ \rho+\lambda$	601.31280		P-value	0.00000			

Table D16

No Fixed Effects using W_4 (Simple Panel Data Estimation)

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
Constant	0.2092107	0.02733	7.65496	0.00000	0.06498	3.21939	0.00133
$w\,\tau_{i,t-1}$	0.5477322	0.07147	7.66372	0.00000	0.15990	3.42543	0.00064
$L_{i,t-1}$	0.0000015	5.8317E-07	2.50532	0.01239	1.9954E-06	0.73220	0.46422
$op_{i,t-1}$	-0.1185545	9.7742E-03	-12.12928	0.00000	0.02075	-5.71397	0.00000
$\gamma_{i,t-1}$	-1.0379E-04	5.0248E-05	-2.06567	0.03912	1.2725E-04	-0.81566	0.41489
$fd_{i,t-1}$	-1.3538E-06	5.1042E-07	-2.65241	0.00812	8.3383E-07	-1.62363	0.10477
$ER_{i,t-1}$	-6.7628E-06	9.3592E-05	-0.07226	0.94241	2.8726E-05	-0.23543	0.81392
$GE_{i,t-1}$	-0.3774506	0.10480	-3.60153	0.00033	0.25873	-1.45888	0.14491
ρ	0.7973530	0.01860	42.85797	0.00000			
R^2 *within*	0.20162		Variance	0.03102			
R^2 *adjusted*	0.19603		RSS	30.99212			
R^2 *ordinary*	0.20162						
Durbin-Watson	0.18718		Breusch-Pagan	593.47834			
1) F-test for the all coefficients equal zero							
F_1	36.04163						
P-value	0.00000						
LM ρ	603.90894		P-value	0.00000			
LM λ	5.62633		P-value	0.01769			
LM $\rho+\lambda$	609.53527		P-value	0.00000			

APPENDIX E

HAUSMAN TEST

The “Hausman specification test” regards the estimation of 2 models: (1) the fixed effects model, consistent under the null and alternative hypotheses (where $H_0 = E(u_{it} / X_{it}) = 0$); and (2) the random effects model, consistent under the null hypothesis but inconsistent under the alternative (where $H_a = E(u_{it} / X_{it}) \neq 0$). Once these models have been estimated, we compare the parameters obtained under each approach and if they are statistically different, we can conclude that the model inconsistent under H_a should not be used.

To statistically compare the coefficients estimated, Baltagi (2003) defines the Hausman specification test as follows:

$$m = \hat{q}' Var(\hat{q})^{-1} \hat{q} \tag{E1}$$

where $\hat{q} = \hat{\beta}_{FE} - \hat{\beta}_{RE(GLS)}$; $Var(\hat{q}) = Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE(GLS)})$ and m is distributed as χ_k^2.

If m shows that the coefficients estimated by the random effects ($\beta_{RE(GLS)}$) are the same as the ones estimated through fixed effects (β_{FE}) (by obtaining a not statistically significant P-value, Prob > χ^2 larger than 0.05), then we should use random effects. To the contrary, if we obtain a statistically significant P-value (Prob > χ^2 smaller than 0.05), then we should use fixed effects.

For the four weight matrixes, we estimate the coefficients through the random effects generalized least squares (GLS) approach and compare them in the Hausman test with the previously obtained individual fixed effects from Appendix D.

Hausman Test Estimations under Weight Matrix W_1

Table E1
Fixed Effects: Individual (Within Regression) under W_1

Variable	Coefficient	Standard Error	T-Test	P-value	[95% Confidence Interval]	
$w\ \tau_{i,t-1}$	0.7508322	0.06889	10.89970	0.00000	0.6156462	0.88602
$L_{i,t-1}$	1.1967E-06	6.6949E-07	1.78745	0.07418	-1.1700E-07	2.51E-06
$op_{i,t-1}$	-0.0497860	0.03137	-1.58694	0.11286	-0.1113533	0.01178
$\gamma_{i,t-1}$	0.0002197	0.00011	1.94691	0.05184	-1.7600E-06	4.41E-04
$fd_{i,t-1}$	-1.0904E-06	3.7622E-07	-2.89839	0.00384	-1.8300E-06	-3.52E-07
$ER_{i,t-1}$	7.6403E-06	5.9524E-05	0.12836	0.89789	-1.0920E-04	1.25E-04
$GE_{i,t-1}$	0.2647555	0.17182	1.54085	0.12369	-0.0724454	0.60196
cons	0.0359748	0.03370	1.07000	0.28600	-0.0301668	0.10212
R^2	0.14065					

Source: Appendix D, own estimations.

Table E2
Random Effects GLS Regression under W_1

Variable	Coefficient	Standard Error	Z	P-value	[95% Confidence Interval]	
$w\ \tau_{i,t-1}$	0.6363172	0.11009	5.78000	0.00000	0.4205361	0.85210
$L_{i,t-1}$	2.4500E-06	5.8000E-07	4.23000	0.00000	1.3200E-06	3.59E-06
$op_{i,t-1}$	-0.1064499	0.01012	-10.52000	0.00000	-0.1262915	-0.08661
$\gamma_{i,t-1}$	-0.0002065	0.00005	-4.43000	0.00000	-2.9780E-04	-1.15E-04
$fd_{i,t-1}$	-1.4500E-06	5.0100E-07	-2.90000	0.00400	-2.4300E-06	-4.71E-07
$ER_{i,t-1}$	1.3300E-05	9.3800E-05	0.14000	0.88700	-1.7050E-04	1.97E-04
$GE_{i,t-1}$	-0.2254035	0.11776	-1.91000	0.05600	-0.4562185	0.00541
cons	0.1540253	0.04194	3.67000	0.00000	0.0718332	0.23622
R^2	0.10890		Wald chi2	241.49		
			Prob > chi2	0.00000		

Table E3

Hausman Test under W_1

Variable	Fixed Effects β_{FE}	Random Effects $\beta_{RE(GLS)}$	Difference $\beta_{FE} - \beta_{RE(GLS)}$	Standard Error $(diag(V(\beta_{FE})-V(\beta_{RE})))^{1/2}$
$w\,\tau_{i,t-1}$	0.7508322	0.6363172	0.11452	-
$L_{i,t-1}$	1.2000E-06	2.4500E-06	-1.26E-06	3.34E-07
$op_{i,t-1}$	-0.0497860	-0.1064499	0.05666	0.02969
$\gamma_{i,t-1}$	0.0002197	-0.0002065	0.00043	1.03E-04
$fd_{i,t-1}$	-1.0900E-06	-1.4500E-06	3.62E-07	-
$ER_{i,t-1}$	7.6400E-06	1.3300E-05	-5.69E-06	-
$GE_{i,t-1}$	0.2647555	-0.22540350	0.49016	0.12512

Hence, using Equation E1 we obtain:

$\hat{m} = 32.34$

Prob > $\chi^2 = 0.0000$

Thus, we reject the null hypothesis that the difference in coefficients is not systematic, and we should use the fixed effects estimator.

Hausman Test Estimations under Weight Matrix W_2

Table E4

Fixed Effects: Individual (Within Regression) under W_2

Variable	Coefficient	Standard Error	T-Test	P-value	[95% Confidence Interval]	
$w\,\tau_{i,t-1}$	0.7341452	0.06854	10.71132	0.00000	0.599639	0.86865
$L_{i,t-1}$	1.4611E-06	6.8646E-07	2.12844	0.03356	1.1400E-07	2.810E-06
$op_{i,t-1}$	-0.0531708	0.03127	-1.70050	0.08936	-0.1145329	0.00819
$\gamma_{i,t-1}$	0.0002728	0.00012	2.22107	0.02658	3.1800E-05	5.14E-04
$fd_{i,t-1}$	-1.1064E-06	3.8129E-07	-2.90166	0.00380	-1.8500E-06	-3.58E-07
$ER_{i,t-1}$	4.8765E-06	5.9477E-05	0.08199	0.93467	-1.1180E-04	1.22E-04
$GE_{i,t-1}$	0.2366965	0.17263	1.37116	0.17065	-0.1020758	0.57547
cons	0.0536104	0.03377	1.59000	0.11300	-0.0126618	0.11988
R^2	0.14190					

Source: Appendix D.

Table E5

Random Effects GLS Regression under W_2

Variable	Coefficient	Standard Error	Z	P-value	[95% Confidence Interval]	
$w\,\tau_{i,t-1}$	0.7512447	0.06841	10.98000	0.00000	0.6171698	0.88532
$L_{i,t-1}$	1.4600E-06	6.6000E-07	2.22000	0.02700	1.6800E-07	2.76E-06
$op_{i,t-1}$	-0.0784134	0.02402	-3.26000	0.00100	-0.1254992	-0.03133
$\gamma_{i,t-1}$	0.0000531	0.00010	0.55000	0.57900	-1.3470E-04	2.41E-04
$fd_{i,t-1}$	-1.0100E-06	3.7700E-07	-2.67000	0.00800	-1.7500E-06	-2.67E-07
$ER_{i,t-1}$	4.5800E-06	5.9600E-05	0.08000	0.93900	-1.1220E-04	1.21E-04
$GE_{i,t-1}$	0.1168666	0.16159	0.72000	0.47000	-0.1998514	0.43358
cons	0.0646072	0.03863	1.67000	0.09400	-0.0110998	0.14031
R^2	0.13730		Wald chi2	158.25		
			Prob > chi2	0.00000		

Table E6

Hausman Test under W_2

Variable	Fixed Effects β_{FE}	Random Effects $\beta_{RE(GLS)}$	Difference $\beta_{FE} - \beta_{RE(GLS)}$	Standard Error $(diag(V(\beta_{FE})-V(\beta_{RE})))^{1/2}$
$w\,\tau_{i,t-1}$	0.7341452	0.7512447	-0.01710	4.26E-03
$L_{i,t-1}$	1.4600E-06	1.4600E-06	-7.64E-10	1.89E-07
$op_{i,t-1}$	-0.0531708	-0.0784134	0.02524	0.02001
$\gamma_{i,t-1}$	0.0002728	0.0000531	2.20E-04	7.68E-05
$fd_{i,t-1}$	-1.1100E-06	-1.0100E-06	-9.92E-08	5.45E-08
$ER_{i,t-1}$	4.8800E-06	4.5800E-06	2.94E-07	-
$GE_{i,t-1}$	0.2366966	0.11686660	0.11983	0.06072

With Equation E1 we obtain:

$\hat{m} = 11.51$

Prob > $\chi^2 = 0.0214$

We should use the fixed effects estimator since we reject the null hypothesis that the difference in coefficients is not systematic.

Hausman Test Estimations under Weight Matrix W_3

Table E7
Fixed Effects: Individual (Within Regression) under W_3

Variable	Coefficient	Standard Error	T-Test	P-value	[95% Confidence Interval]	
$w\,\tau_{i,t-1}$	0.4582160	0.05215	8.78595	0.00000	0.35588	0.56058
$L_{i,t-1}$	2.5383E-06	7.0222E-07	3.61468	0.00032	1.1600E-06	3.92E-06
$op_{i,t-1}$	-0.0617646	0.03083	-2.00344	0.04541	-0.12228	-0.00128
$\gamma_{i,t-1}$	0.0002420	0.00012	2.00473	0.04528	5.1200E-06	4.79E-04
$fd_{i,t-1}$	-8.7453E-07	3.8229E-07	-2.28758	0.02238	-1.6200E-06	-1.24E-07
$ER_{i,t-1}$	-1.1462E-05	6.0427E-05	-0.18968	0.84960	-1.3000E-04	1.07E-04
$GE_{i,t-1}$	0.2565451	0.17437	1.47129	0.14154	-0.08565	0.59873
cons	0.1419756	0.03069	4.63000	0.00000	0.08175	0.20220
R^2	0.11345325					

Source: Appendix D.

Table E8
Random Effects GLS Regression under W_3

Variable	Coefficient	Standard Error	Z	P-value	[95% Confidence Interval]	
$w\,\tau_{i,t-1}$	0.4675695	0.05135	9.11000	0.00000	0.36692	0.56822
$L_{i,t-1}$	2.5700E-06	6.7800E-07	3.79000	0.00000	1.2400E-06	3.90E-06
$op_{i,t-1}$	-0.0820616	0.02308	-3.56000	0.00000	-0.12729	-0.03683
$\gamma_{i,t-1}$	0.0000373	0.00009	0.40000	0.69300	-1.4770E-04	2.22E-04
$fd_{i,t-1}$	-8.1900E-07	3.8000E-07	-2.15000	0.03100	-1.5600E-06	-7.41E-08
$ER_{i,t-1}$	-1.2600E-05	6.0500E-05	-0.21000	0.83600	-1.3120E-04	1.06E-04
$GE_{i,t-1}$	0.1298552	0.15967	0.81000	0.41600	-0.18309	0.44280
cons	0.1583008	0.03548	4.46000	0.00000	0.08876	0.22784
R^2	0.10910		Wald chi2	124.75		
			Prob > chi2	0.00000		

Table E9
Hausman Test under W_3

Variable	Fixed Effects β_{FE}	Random Effects $\beta_{RE(GLS)}$	Difference $\beta_{FE} - \beta_{RE(GLS)}$	Standard Error $(diag(V(\beta_{FE})-V(\beta_{RE})))^{1/2}$
$w\,\tau_{i,t-1}$	0.4582281	0.4675695	-0.00934	9.11E-03
$L_{i,t-1}$	2.5400E-06	2.5700E-06	-3.18E-08	1.82E-07
$op_{i,t-1}$	-0.0617818	-0.0820616	0.02028	0.02044
$\gamma_{i,t-1}$	0.0002420	0.0000373	2.05E-04	7.52E-05
$fd_{i,t-1}$	-8.7500E-07	-8.1900E-07	-5.56E-08	4.15E-08
$ER_{i,t-1}$	-1.1500E-05	-1.2600E-05	1.10E-06	-
$GE_{i,t-1}$	0.2565363	0.12985520	0.12668	0.07007

Thus, with Equation E1 we obtain:

$\hat{m} = 11.14$

Prob > $\chi^2 = 0.0250$

We reject the null hypothesis that the difference in coefficients is not systematic. As a consequence, we should use the fixed effects estimator.

Hausman Test Estimations under Weight Matrix W_4

Table E10
Fixed Effects: Individual (Within Regression) under W_4

Variable	Coefficient	Standard Error	T-Test	P-value	[95% Confidence Interval]	
$w\,\tau_{i,t-1}$	0.6216420	0.05938	10.46886	0.00000	0.50513	0.73819
$L_{i,t-1}$	1.6562E-06	7.1445E-07	2.31819	0.02065	2.5400E-07	3.06E-06
$op_{i,t-1}$	-0.0374149	0.03086	-1.21223	0.22573	-0.09806	0.02308
$\gamma_{i,t-1}$	0.0002750	0.00011	2.40104	0.01654	5.0200E-05	5.00E-04
$fd_{i,t-1}$	-9.7184E-07	3.8886E-07	-2.49923	0.01261	-1.7300E-06	-2.09E-07
$ER_{i,t-1}$	-7.4192E-06	5.9937E-05	-0.12378	0.90151	-1.2500E-04	1.10E-04
$GE_{i,t-1}$	0.2390679	0.17133	1.39538	0.16323	-0.09718	0.57527
cons	0.0851734	0.03098	2.75000	0.00600	0.02438	0.14596
R^2	0.13255					

Source: Appendix D.

Table E11

Random Effects GLS Regression under W_4

Variable	Coefficient	Standard Error	Z	P-value	[95% Confidence Interval]	
$w\,\tau_{i,t-1}$	0.6207920	0.05894	10.53000	0.00000	0.50528	0.73630
$L_{i,t-1}$	1.4600E-06	6.8400E-07	2.13000	0.03300	1.1700E-07	2.80E-06
$op_{i,t-1}$	-0.0809714	0.02335	-3.47000	0.00100	-0.12674	-0.03520
$\gamma_{i,t-1}$	0.0000680	0.00009	0.74000	0.45900	-1.1200E-04	2.48E-04
$fd_{i,t-1}$	-9.1300E-07	3.8700E-07	-2.36000	0.01800	-1.6700E-06	-1.55E-07
$ER_{i,t-1}$	-1.1800E-05	6.0100E-05	-0.20000	0.84500	-1.2960E-04	1.06E-04
$GE_{i,t-1}$	0.0796341	0.15786	0.50000	0.61400	-0.22977	0.38904
cons	0.1108903	0.03566	3.11000	0.00200	0.04101	0.18077
R^2	0.12640		Wald chi2	143.78		
			Prob > chi2	0.00000		

Table E12

Hausman Test under W_4

Variable	Fixed Effects β_{FE}	Random Effects $\beta_{RE(GLS)}$	Difference $\beta_{FE} - \beta_{RE(GLS)}$	Standard Error $(diag(V(\beta_{FE})-V(\beta_{RE})))^{1/2}$
$w\,\tau_{i,t-1}$	0.6216572	0.6207920	0.00087	7.25E-03
$L_{i,t-1}$	1.6600E-06	1.4600E-06	1.98E-07	2.06E-07
$op_{i,t-1}$	-0.0374912	-0.0809714	0.04348	0.02018
$\gamma_{i,t-1}$	0.0002750	0.0000680	2.07E-04	6.84E-05
$fd_{i,t-1}$	-9.7200E-07	-9.1300E-07	-5.92E-08	4.17E-08
$ER_{i,t-1}$	-7.4200E-06	-1.1800E-05	4.36E-06	-
$GE_{i,t-1}$	0.2390448	0.07963410	0.15941	0.06658

Thus, we obtain:

$\hat{m} = 15.61$

Prob > $\chi^2 = 0.0036$

As a result, we reject the null hypothesis that the difference in coefficients is not systematic, and we should use the fixed effects estimator.

APPENDIX F

TIME LAG EXERCISE

Several regressions were performed as an exercise using different time lags for the independent variables. We chose the fixed individual effects model for this analysis since in the dissertation it proved to be the most appropriate estimation method. Equation 110 from Chapter 6 was transformed to include two and three time lags.

The two period time lag equation for the fixed individual effects model can be described as:

$$\tau_{i,t} = \phi + \mu_i + \alpha W \tau_{i,t-2} + X_{i,t-2}\beta + \varepsilon_{it} \qquad \text{(F1)}$$

On the other hand, the three period time lag equation is expressed as:

$$\tau_{i,t} = \phi + \mu_i + \alpha W \tau_{i,t-3} + X_{i,t-3}\beta + \varepsilon_{it} \qquad \text{(F2)}$$

Hence, the following tables present the estimation results for each weight matrix for the fixed individual effects approach using Equations F1 and F2.

Two Period Time Lag (2PTL): Equation F1

Table F1
2PTL Results for Estimations under Weight Matrix W_1

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-2}$	0.6613889	0.06892	9.59684	0.00000	1.2227E-01	5.40907	0.00000
$L_{i,t-2}$	1.2135E-06	6.8141E-07	1.78084	0.07528	8.5208E-07	1.42414	0.15475
$op_{i,t-2}$	-0.0521835	0.03269	-1.59622	0.11079	4.8980E-02	-1.06541	0.28698
$\gamma_{i,t-2}$	0.0002023	0.00012	1.70091	0.08931	1.8876E-04	1.07178	0.28411
$fd_{i,t-2}$	-8.3882E-07	3.8481E-07	-2.17986	0.02953	3.8553E-07	-2.17576	0.02983
$ER_{i,t-2}$	2.2121E-05	5.9798E-05	0.36992	0.71153	7.2188E-06	3.06432	0.00225
$GE_{i,t-2}$	0.0548599	0.18137	0.30248	0.76236	2.6845E-01	0.20436	0.83812
ρ	0.4419130	0.02850	15.50835	0.00000			

R^2	0.11388	Variance	0.01170
R^2 *adjusted*	0.05540	RSS	10.45965
R^2 *ordinary*	0.71116		
Durbin-Watson	0.92895	Breusch-Pagan	456.62718
1) F-test for the all coefficients equal zero		2) F-test for fixed individual effects	
F_1	19.14958	F_2	30.77342
P-value	0.00000	P-value	0.00000
$LM\ \rho$	0.01185	P-value	0.91330
$LM\ \lambda$	1.65176	P-value	0.19872
$LM\ \rho+\lambda$	1.66361	P-value	0.43526

Table F2
2PTL Results for Estimations under Weight Matrix W_2

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t\text{-}2}$	0.6496425	0.06842	9.49550	0.00000	1.2281E-01	5.28963	0.00000
$L_{i,t\text{-}2}$	1.4533E-06	6.9864E-07	2.08015	0.03780	9.3362E-07	1.55660	0.11992
$op_{i,t\text{-}2}$	-0.0553291	0.03255	-1.69964	0.08955	4.8082E-02	-1.15072	0.25015
$\gamma_{i,t\text{-}2}$	0.0002640	0.00013	2.02684	0.04298	2.1669E-04	1.21823	0.22346
$fd_{i,t\text{-}2}$	-8.1251E-07	3.9036E-07	-2.08146	0.03768	3.7734E-07	-2.15328	0.03156
$ER_{i,t\text{-}2}$	2.0423E-05	5.9714E-05	0.34201	0.73242	7.0817E-06	2.88388	0.00402
$GE_{i,t\text{-}2}$	0.0248554	0.18223	0.13640	0.89154	2.6979E-01	0.09213	0.92662
ρ	0.4411082	0.02851	15.46964	0.00000			
R^2	0.11630		Variance	0.01167			
R^2 *adjusted*	0.05798		RSS	10.43116			
R^2 *ordinary*	0.71195						
Durbin-Watson	0.93336		Breusch-Pagan	458.36440			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	19.60873		F_2	30.85143			
P-value	0.00000		P-value	0.00000			
$LM\ \rho$	0.01370		P-value	0.90681			
$LM\ \lambda$	1.17127		P-value	0.27914			
$LM\ \rho+\lambda$	1.18498		P-value	0.55295			

Table F3

2PTL Results for Estimations under Weight Matrix W_3

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-2}$	0.3202299	0.05344	5.99263	0.00000	8.2207E-02	3.89541	0.00011
$L_{i,t-2}$	1.6091E-06	7.2582E-07	2.21695	0.02688	9.4291E-07	1.70654	0.08825
$op_{i,t-2}$	-0.0717976	0.03272	-2.19414	0.02848	4.9557E-02	-1.44877	0.14775
$\gamma_{i,t-2}$	0.0003045	0.00013	2.37209	0.01790	2.2303E-04	1.36547	0.17245
$fd_{i,t-2}$	-5.5751E-07	3.9167E-07	-1.42341	0.15497	4.0243E-07	-1.38536	0.16629
$ER_{i,t-2}$	1.9769E-06	6.1364E-05	0.03222	0.97431	9.6841E-06	0.20413	0.83830
$GE_{i,t-2}$	0.1190120	0.18642	0.63841	0.52337	3.3887E-01	0.35120	0.72552
ρ	0.4414317	0.02820	15.65431	0.00000			
R^2	0.06581		Variance	0.01233			
R^2 *adjusted*	0.00415		RSS	11.02716			
R^2 *ordinary*	0.69549						
Durbin-Watson	0.92404		Breusch-Pagan	443.89325			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	10.49574		F_2	28.76829			
P-value	0.00000		P-value	0.00000			
$LM\ \rho$	0.03275		P-value	0.85639			
$LM\ \lambda$	24.67796		P-value	0.00000			
$LM\ \rho+\lambda$	24.71071		P-value	0.00000			

Table F4

2PTL Results for Estimations under Weight Matrix W_4

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-2}$	0.5464243	0.06029	9.06385	0.00000	1.0603E-01	5.15349	0.00000
$L_{i,t-2}$	1.4787E-06	7.3094E-07	2.02301	0.04337	9.7321E-07	1.51942	0.12901
$op_{i,t-2}$	-0.0428065	0.03199	-1.33798	0.18124	4.6185E-02	-0.92685	0.35425
$\gamma_{i,t-2}$	0.0002872	0.00012	2.38497	0.01729	2.0082E-04	1.43024	0.15300
$fd_{i,t-2}$	-5.2591E-07	3.9994E-07	-1.31495	0.18886	4.1986E-07	-1.25259	0.21068
$ER_{i,t-2}$	1.2112E-05	6.0266E-05	0.20097	0.84076	9.5260E-06	1.27147	0.20389
$GE_{i,t-2}$	0.0568459	0.18083	0.31437	0.75332	2.7982E-01	0.20315	0.83906
ρ	0.4433932	0.02841	15.60781	0.00000			
R^2	0.10386		Variance	0.01183			
R^2 *adjusted*	0.04472		RSS	10.57795			
R^2 *ordinary*	0.70789						
Durbin-Watson	0.93593		Breusch-Pagan	442.41798			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	17.26892		F_2	29.72503			
P-value	0.00000		P-value	0.00000			
$LM\ \rho$	0.00001		P-value	0.99753			
$LM\ \lambda$	3.57737		P-value	0.05857			
$LM\ \rho+\lambda$	3.57738		P-value	0.16718			

Three Period Time Lag (3PTL): Equation F2

Table F5
3PTL Results for Estimations under Weight Matrix W_1

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-3}$	0.5389827	0.06895	7.81755	0.00000	1.1543E-01	4.66915	0.00000
$L_{i,t-3}$	3.2693E-07	6.8513E-07	0.47718	0.63336	7.5725E-07	0.43173	0.66605
$op_{i,t-3}$	-0.0639987	0.03437	-1.86209	0.06294	5.1490E-02	-1.24294	0.21424
$\gamma_{i,t-3}$	0.0002880	0.00012	2.31253	0.02099	1.8358E-04	1.56881	0.11707
$fd_{i,t-3}$	-6.6720E-07	5.9626E-07	-1.11898	0.26347	6.5128E-07	-1.02445	0.30592
$ER_{i,t-3}$	1.2707E-05	5.8599E-05	0.21685	0.82838	2.0181E-05	0.62966	0.52909
$GE_{i,t-3}$	-0.3047072	0.18771	-1.62327	0.10491	2.8321E-01	-1.07591	0.28228
ρ	0.4355913	0.02932	14.85797	0.00000			
R^2	0.07860		Variance	0.01118			
R^2 *adjusted*	0.01396		RSS	9.40458			
R^2 *ordinary*	0.71803						
Durbin-Watson	0.93697		Breusch-Pagan	435.66414			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	11.95650		F_2	30.03931			
P-value	0.00000		P-value	0.00000			
$LM\ \rho$	3.91298		P-value	0.04791			
$LM\ \lambda$	0.11100		P-value	0.73900			
$LM\ \rho+\lambda$	4.02399		P-value	0.13372			

Table F6

3PTL Results for Estimations under weight Matrix W_2

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-3}$	0.5263548	0.06835	7.70035	0.00000	1.1563E-01	4.55188	0.00001
$L_{i,t-3}$	4.9253E-07	7.0365E-07	0.69996	0.48415	7.7903E-07	0.63223	0.52741
$op_{i,t-3}$	-0.0660760	0.03424	-1.92980	0.05397	5.1097E-02	-1.29315	0.19632
$\gamma_{i,t-3}$	0.0003503	0.00014	2.55253	0.01087	2.0886E-04	1.67736	0.09384
$fd_{i,t-3}$	-5.9431E-07	6.0264E-07	-0.98617	0.32433	6.6134E-07	-0.89864	0.36910
$ER_{i,t-3}$	1.1987E-05	5.8573E-05	0.20466	0.83789	2.0715E-05	0.57869	0.56295
$GE_{i,t-3}$	-0.3332360	0.18904	-1.76276	0.07830	2.8599E-01	-1.16521	0.24426
ρ	0.4351570	0.02935	14.82789	0.00000			
R^2	0.08003		Variance	0.01117			
R^2 *adjusted*	0.01549		RSS	9.38994			
R^2 *ordinary*	0.71847						
Durbin-Watson	0.94056		Breusch-Pagan	439.38246			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	12.19367		F_2	30.13706			
P-value	0.00000		P-value	0.00000			
$LM\ \rho$	3.87735		P-value	0.04894			
$LM\ \lambda$	0.23033		P-value	0.63128			
$LM\ \rho{+}\lambda$	4.10768		P-value	0.12824			

Table F7

3PTL Results for Estimations under Weight Matrix W_3

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\ \tau_{i,t-3}$	0.2986694	0.05365	5.56722	0.00000	6.5026E-02	4.59310	0.00001
$L_{i,t-3}$	5.2938E-07	7.2318E-07	0.73202	0.46436	8.0088E-07	0.66099	0.50880
$op_{i,t-3}$	-0.0749841	0.03414	-2.19635	0.02834	5.0725E-02	-1.47825	0.13972
$\gamma_{i,t-3}$	0.0004244	0.00013	3.20018	0.00142	1.9902E-04	2.13251	0.03325
$fd_{i,t-3}$	-3.9556E-07	6.4030E-07	-0.61776	0.53690	7.3863E-07	-0.53552	0.59243
$ER_{i,t-3}$	-7.6771E-07	5.9403E-05	-0.01292	0.98969	2.4055E-05	-0.03191	0.97455
$GE_{i,t-3}$	-0.2661267	0.18995	-1.40102	0.16158	3.1118E-01	-0.85522	0.39267
ρ	0.4430878	0.02909	15.23286	0.00000			
R^2	0.05398		Variance	0.01148			
R^2 *adjusted*	-0.01238		RSS	9.65581			
R^2 *ordinary*	0.71049						
Durbin-Watson	0.92076		Breusch-Pagan	428.01833			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	7.99853		F_2	28.97935			
P-value	0.00000		P-value	0.00000			
$LM\ \rho$	4.56552		P-value	0.03262			
$LM\ \lambda$	3.11946		P-value	0.07736			
$LM\ \rho+\lambda$	7.68499		P-value	0.02144			

Table F8

3PTL Results for Estimations under Weight Matrix W_4

Variable	Coefficient	Standard Error	T-Test	P-value	Robust SE	T-Test	P-value
$w\,\tau_{i,t\text{-}3}$	0.4135585	0.06074	6.80820	0.00000	1.0254E-01	4.03317	0.00006
$L_{i,t\text{-}3}$	5.8086E-07	7.4221E-07	0.78261	0.43408	9.6429E-07	0.60237	0.54709
$op_{i,t\text{-}3}$	-0.0478215	0.03337	-1.43297	0.15224	4.9002E-02	-0.97591	0.32939
$\gamma_{i,t\text{-}3}$	0.0003710	0.00013	2.94314	0.00334	1.9650E-04	1.88822	0.05934
$fd_{i,t\text{-}3}$	-6.8344E-08	6.2764E-07	-0.10889	0.91332	8.2126E-07	-0.08322	0.93370
$ER_{i,t\text{-}3}$	1.1115E-05	5.9505E-05	0.18679	0.85187	2.2650E-05	0.49072	0.62375
$GE_{i,t\text{-}3}$	-0.2740829	0.18724	-1.46379	0.14363	2.9502E-01	-0.92904	0.35314
ρ	0.4332824	0.02938	14.74624	0.00000			
R^2	0.06402		Variance	0.01136			
R^2 *adjusted*	-0.00165		RSS	9.55339			
R^2 *ordinary*	0.71357						
Durbin-Watson	0.95445		Breusch-Pagan	433.17379			
1) F-test for the all coefficients equal zero			2) F-test for fixed individual effects				
F_1	9.58689		F_2	28.87411			
P-value	0.00000		P-value	0.00000			
$LM\,\rho$	3.82623		P-value	0.05046			
$LM\,\lambda$	0.07134		P-value	0.78940			
$LM\,\rho+\lambda$	3.89757		P-value	0.14245			

The following presents a comparison among one, two and three period time lags regressions under each of the four weight matrixes.

First, under weight matrix W_1 when comparing Table D2, Table F1, and Table F5 we found the following:

1. The estimated coefficients for $w\tau$ were statistically different from zero and maintained their positive signs in the three cases, while $w\tau_{i,t-1} > w\tau_{i,t-2} > w\tau_{i,t-3}$.
2. The parameters estimated for L, op, γ, and GE turned out statistically not different from zero in the three cases.
3. Results for the one and two period time lag regressions show that fd coefficients were statistically different from zero, maintained their negative signs, and

$fd_{i,t-2} > fd_{i,t-1}$. The estimated coefficient for the three period time lag equation was statistically not different from zero.

4. The *ER* estimated coefficient resulted statistically different from zero in the two period time lag regression. To the contrary, in the one and three period time lag regressions the coefficients were not statistically significant.

Second, using weight matrix W_2 the comparison of Table D6, Table F2, and Table F6 provided the following conclusions:

1. For the three cases, the $w\tau$ coefficients were statistically different from zero, maintained their positive signs, and $w\tau_{i,t-1} > w\tau_{i,t-2} > w\tau_{i,t-3}$.
2. The estimated coefficients for L, op, and *GE* turned out statistically not different from zero in the three cases.
3. The γ estimated coefficients resulted statistically not different from zero for the one and two period time lag regressions, while different from zero at the 90% level for the three period time lag equation.
4. Results for the one and two period time lag regressions show a statistically different from zero fd coefficient, where $fd_{i,t-2} > fd_{i,t-1}$. The estimated coefficient for the three period time lag regression was statistically not significant.
5. The estimated coefficient for *ER* resulted statistically significant in the two period time lag regression; nonetheless, its magnitude is relatively small. On the other hand, in the one and three period time lag regressions the coefficients were not different from zero.

Third, comparing Table D10, Table F3, and Table F7 using weight matrix W_3 the following conclusion arise:

1. Again, the $w\tau$ estimated coefficients were statistically different from zero for the three cases. They maintained a positive sign and the relationship among them show that $w\tau_{i,t-1} > w\tau_{i,t-2} > w\tau_{i,t-3}$.
2. The estimated parameter for L was statistically different from zero for the one period time lag regression. It was also different from zero at the 90% level for the two period time lag equation, and not statistically significant for the three period time lag regression.
3. The op, *ER*, and *GE* estimated coefficients resulted statistically not different from zero in the one, two and three period time lag regressions.
4. The estimated coefficients for γ were statistically not different from zero for the one and two period time lag regressions, but statistically significant for the three period time lag equation.
5. Results for the two and three period time lag regressions show a statistically not different from zero fd coefficients. To the contrary, the fd estimated parameter for the one period time lag equation was statistically significant.

Fourth, with weight matrix W_4 the comparison among Table D14, Table F4, and Table F8 show that:

1. For the three cases the $w\tau$ estimated coefficients were statistically different from zero and $w\tau_{i,t-1} > w\tau_{i,t-2} > w\tau_{i,t-3}$.

2. The estimated parameter for L was statistically different from zero at the 90% level for the one period time lag regression. For the cases of the two and three period time lag regressions, the L estimated parameters were not statistically significant.
3. The estimations for the op, *ER*, and *GE* coefficients were statistically not different from zero in the one, two and three period time lag regressions.
4. The γ estimated parameter was statistically different from zero in the three period time lag regression; nevertheless, for the one and two period time lag equations the parameters were not statistically significant.
5. Finally, the fd estimated parameter for the one period time lag was statistically different from zero, while for the two and three period time lag regressions the estimated coefficients were not different from zero.

Hence, from the four cases and three types of regressions, the $w\tau$ parameters showed to be higher for the one period time lag equation, than for the two and three period time lag equations. Parameters such as op and *GE* were never statistically different from zero, while L, *ER*, γ, and fd estimated coefficients changed their statistical significance depending on the time lags and weight matrix used in the regressions.

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VITA

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In May of 2002, Rene was invited to work for the Mexican Ministry of Finance and Public Credit as a Deputy Director of Analysis and International Statistics in the Direction General of International Financial Affairs, a position occupied until September, 2003. From October, 2003 to December, 2004, he held two different positions in the same Direction General. First, as a Coordinator of the Direction of International Economic Studies, and later as a Deputy Director of Multilateral Affairs with Latin America. In January, 2005, Rene started to work as a Director of Hydrocarbon Investment Projects in the Investments Unit of the Under-Secretariat of Expenditure of the Mexican Ministry of Finance and Public Credit.