DISSERTATION

MODELING TAX COMPETITION IN DEVELOPING COUNTRIES: A THEORETICAL AND EMPIRICAL ANALYSIS

Submitted by

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ABSTRACT

MODELING TAX COMPETITION IN DEVELOPING COUNTRIES: A THEORETICAL AND EMPIRICAL ANALYSIS

While much attention has been paid in the literature to tax competition in developed countries, little research has focused on tax competition among developing countries. These two groups of countries are very different, even opposite in many aspects of tax competition. One cannot apply research results in developed countries to developing countries. This dissertation fills that gap in current literature. The paper develops theoretical models of tax competition for developing countries and empirically tests the theoretical results using a sample of data from developing countries. The paper discusses an asymmetric tax competition model where countries are different in capital, labor, total factor productivity, investment in public inputs, unemployment rate and foreign aid. The paper provides insights into the existence of tax competition and the impact of the several variables on tax competition in developing countries. The empirical models test theoretical results with dataset from 63 developing countries. A spatial econometric model is used to estimate tax competition in developing countries.

The paper found several theoretical and empirical results related to tax competition in developing countries that have not been addressed in previous literature. Unemployment rate and foreign aid affect tax competition in multiple ways. Foreign aid can create both tax competition and fiscal competition. Tax competition is stronger in high unemployment rate countries. The results also confirm the existence of tax competition in developing countries in both statutory and effective corporate tax rates. Countries compete differently over these two rates. Productivity,

investment in public inputs, trade openness, education, exchange rate and population variables affect tax competition behavior in developing countries. With theoretical and empirical results, the paper presents several policy implications for governments in developing countries. Appropriate tax competition policies provide developing countries the opportunities to attract more investments and to gain faster economic growth.

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INTRODUCTION

There has been increasing interest in international tax competition in recent years. Because countries need capital to develop their economies, they seek different ways to attract investments. While there are several factors affecting investments, a capital tax on investment is one of the most important factors. According to the International Monetary Fund (IMF), tax competition occurs when countries lower capital taxes in order to attract investments. Countries have been increasingly involved in international tax competition over the last few decades. The increasing mobility of capital across countries has further increased tax competition.

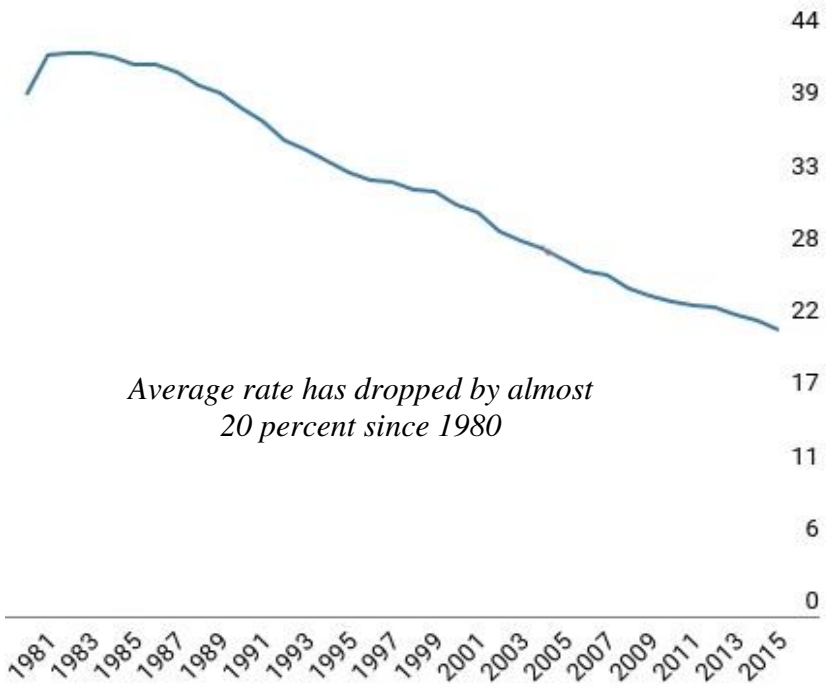


Figure 1: Corporate Income Tax rates in advanced economies

Source: Keen and Brumby, 2017

Advanced economies include: (i) high-income countries, (ii) upper middle-income countries as classified by the WorldBank.

Developed countries have realized that the new era of increased capital mobility has created both opportunities for countries to attract capital and the fear of loss of capital to developing countries. Several research papers have discussed tax competition in developed countries. Capital tax rates in advanced countries have decreased significantly in the last few decades. In the early 1980s, the average corporate tax rate among OECD (Organization for Economic Cooperation and Development) was around 40 to 50 percent (Devereux, Lockwood and Redoano, 2008). By 2017, the rate had decreased to 24.07 percent[1]. The United States and European countries, the richest, the most capital-abundant countries in the world, have been actively seeking to attract capital in various ways based on countries' strengths. They have, for example, invested in improvements in their business environments, offered citizenship for foreign investors such as EB-5 program in the United States, and engaged in tax competition. The recent United States tax reform bill lowered the corporate income tax rates from 35 to 21 percent. The purpose of the change was to stimulate more investment in the United States. This move by the world economic leader into tax competition might result in a greater degree of tax competition across the world. According to UNCTAD, nearly half of world Foreign Direct Investment stock is either invested in the United States or owned by United States multinationals (UNCTAD Investment Trend Monitor, 2018).

The main focus of this paper is to study tax competition in developing countries. While much attention has been paid in the literature to tax competition in developed countries little research has focused on tax competition among developing countries. Limited studies have focused on developing countries. This paper fills that gap in current literature. The paper develops

[1]Calculated by author, data from KPMG's corporate tax database.

a theoretical model of tax competition for developing countries and empirically tests the theoretical results using a sample of data from developing countries.

The dearth of existing articles focusing on developing countries might leave one with the impression that tax competition in developing countries is not important. However, I argue it is important for several reasons:

First, capital is scarcer in developing countries than in developed countries hence any policy tools to compete for capital such as tax competition should be studied thoroughly. Indeed, developing countries desire capital. While developed countries are capital-abundant and have labor

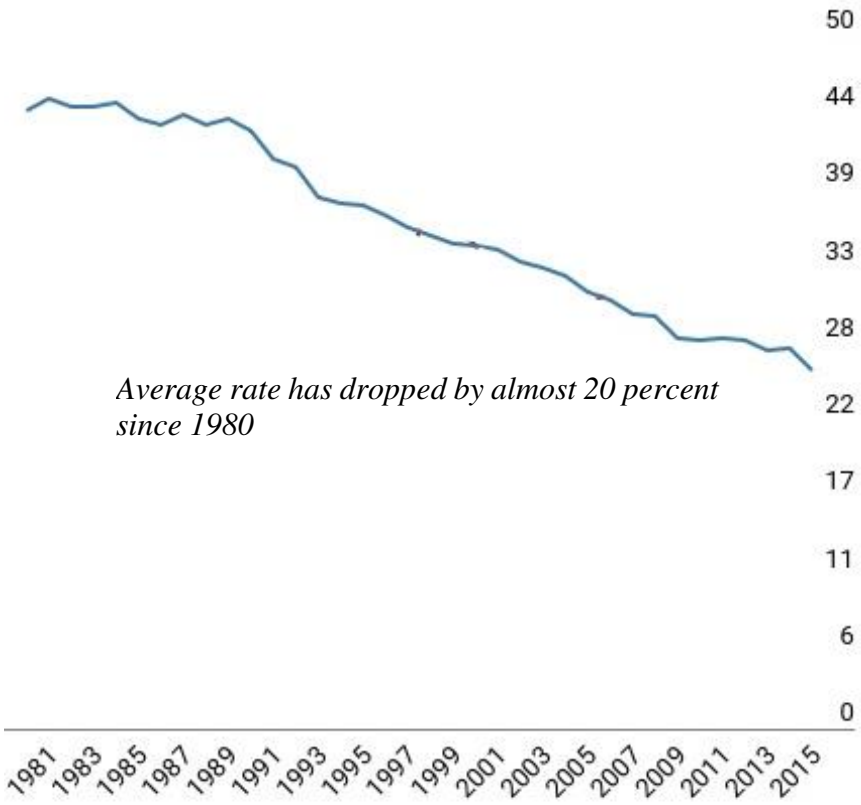


Figure 2: Corporate Income Tax rates in developing economies

Source: Keen and Brumby, 2017

scarcity, developing countries have capital scarcity and labor abundance. Developing countries

need capital and are likely to compete for capital even more. Taiwan and Singapore have moved from low income developing countries to developed countries by keeping capital tax rates competitively low to attract investment. Considering developing countries' need for capital, if developed countries undertake tax competition, developing countries undertake even greater tax competition. In fact, statistics show that developing countries have actively engaged in tax competition for capital over the last thirty years. Capital tax rates in developing countries have fallen gradually since 1980s.

Second, because tax competition is a fast and easy policy tool to use it may be a good option for developing countries. In practice, governments in developing countries have adopted many different measures to attract capital such as improving education, investing in infrastructure, increasing transparency, copyright protection and lowering capital taxes. Besides capital tax rates, all of these policy tools are far less attractive to investors when compared with developed countries. In addition, effectively implementing these policy tools takes a long time. On the other hand, corporate tax rates can be reduced very quickly, and the reduction is transparent to foreign investors. Thus, competing for capital from foreign investors using corporate tax rates is an important policy tool for developing countries.

Third, when analyzing the possible outcomes from tax competition between developed countries and developing countries, it is possible that developing countries will be more successful. Developed countries are the major source of capital. Developing countries, on the other hand, hold a small portion of capital source. In tax competition, with free mobility of capital over the world, developing countries have little to no capital to lose. Developed countries, on the other hand, have reasons to fear a large outflow of capital to developing countries since the potential benefit from attracting a tiny portion of capital from developing countries is small. In this context, developing

countries are more likely to succeed in attracting capital. In practice, most developed countries are calling for restrictions in tax competition or tax harmonization.

In analyzing tax competition in developing countries, my dissertation differs from the prior literature in several ways. *First*, unlike prior studies which have assumed symmetric tax competition (i.e., identical countries), this paper analyzes an asymmetric tax competition model for developing countries. The countries are different in total factor productivities and investment in public inputs. These variables allow us to analyze the impact of the fundamental characteristics of developing countries (such as low productivity and inadequate investment in public inputs) on tax competition behavior. *Second*, while most of the previous literature assumes full employment, I allow for unemployment. There are two main reasons for adding unemployment to the model. It is a common characteristic of developing countries. In practice, one of the most important reasons that a country competes for capital is to lower its unemployment rate. This is usually true in developing countries where unemployment is higher than that in developed countries. *Third*, my theoretical model includes foreign aid, which is a typical characteristic of developing countries. To the best of my knowledge, there has been no prior research that discusses the impact of foreign aid or Official Development Assistance (ODA) on tax competition. The paper seeks to advance our understanding of the relationship between foreign aid and tax competition. It is possible that they may be related. Foreign aid is usually used in public projects to provide public goods in developing countries. The extra income from foreign aid may expand government spending by that amount with no change in tax policy or change in tax competition. On the other hand, the extra income from foreign aid may help a government cut revenues from other sources such as business taxes. In this case, foreign aid increases tax competition.

The dissertation is divided into seven chapters. Chapter 1 introduces basic concepts of tax competition and other main variables used in my model and my empirical analysis. The chapter provides a background for understanding tax competition, foreign direct investment, unemployment and foreign aid in developing countries. Chapter 2 reviews the tax competition literature. To provide a good picture of the literature and to illustrate how I approach my research, I review the literature from its broadest narrowing it to the research issue that is closest to my model. Chapter 3 introduces a theoretical model of tax competition for developing countries from which several theoretical Propositions related to tax competition are presented. First, the model implies the existence of tax competition in developing countries. Second, it suggests that unemployment intensifies tax competition. Third, foreign aid has differential impacts on tax competition depending on capital's share of output. Fourth, the model implies several other results related to tax competition such as the impact of investment in public inputs and total factor productivity. Chapter 4 introduces two different econometric models used to provide insights into tax competition among developing countries. The first model estimates the determinants of capital flows to developing countries. This model focus on testing the existence of tax competition in developing countries. The second model estimates the determinants of corporate tax rates in developing countries. The primary purpose of this model is to estimate a tax response function among developing countries. It helps us answer the question: do developing countries respond to capital tax rate changes in other countries? Different estimation techniques are also used for each model. The chapter also introduces the sample data of 63 developing countries used in the estimation. Chapter 5 discusses estimation results. The empirical results provide insights into the existence (or nonexistence) of tax competition in developing countries. The results help to evaluate the extent of tax competition among developing countries. Chapter 6 discusses policy implications.

With empirical results in chapter 5 and theoretical results in chapter 3, the chapter discusses the possibility of applying results to developing countries. Chapter 7 concludes and presents limitations of my models, the weaknesses of my results, and suggests directions for further research.

CHAPTER 1: INTRODUCTION TO TAX COMPETITION FOREIGN DIRECT INVESTMENT, UNEMPLOYMENT AND FOREIGN AID IN DEVELOPING COUNTRIES

This chapter presents an overview of tax competition and other fundamental concepts of foreign direct investment (FDI), foreign aid and unemployment in developing countries. It provides a background for understanding key variables used in the theoretical and empirical models. It is divided into 4 sections. Section 1 presents definitions and effects of tax competition and international tax competition. Section 2 discusses the definition of FDI, and provides an overview of FDI and the benefits of FDI to developing countries. Section 3 introduces the concept of foreign aid and conditions necessary to receive foreign aid. Section 4 discusses the concept of unemployment and potential issues which arise when using reported unemployment rates in developing countries.

I. Fundamentals of tax competition

1.Defining tax competition

There are two common definitions of tax competition in the literature (Wilson and Wildasin 2004). Tax competition is non-cooperative tax policies by independent governments. This definition is very general. It includes competition among governments at different levels: local, state and federal level (vertical competition) and competition among governments at the same level (horizontal competition). In addition, the definition does not limit the purpose of competition. Different jurisdictions may lower taxes to compete for votes (yardstick competition) or to compete for mobile capital. Under a narrow competition, tax competition is non-cooperative tax policy by independent governments to attract capital across regions. This narrow definition limits the

purpose of tax competition: different governments change their tax systems in order to influence mobile tax bases or to influence the allocation of firms and capital investment. The definition also implies horizontal tax competition among independent governments. In this study, I use the narrow definition with some additional limits. I study competition between governments in different countries (not between regions within a country) with regard to capital tax rates.

International tax competition

Throughout the dissertation, reference to "tax competition" means international tax competition. This paper uses the concept of international tax competition by the IMF (IMF, 2001). Tax competition occurs when countries try to attract capital by lowering taxes on capital. There are several examples of tax cuts around the world to attract capital. Singapore lowered its corporate tax rate to 17 per cent in 2009. In late 2017, the United States introduced a new law TCJA (Tax Cuts and Jobs Act) that lowered the United States corporate income tax rate to 21 percent (as of May 1st, 2018, Tax Policy Center's web page listed: https://www.taxpolicycenter.org/briefing-book/how-did-tax-cuts-and-jobs-act-change-business-taxes). These types of tax cuts, which are intended to attract more capital, are tax competition.

International tax competition has arisen together with the mobility of capital across countries. Over the last few decades, capital has become more mobile across borders at very low cost or even free. Because a country that cuts its capital tax rate may attract capital from anywhere due to free movement of capital, tax competition worldwide has increased. There are five main reasons for the increasing mobility of capital. First, most countries have lifted financial controls after the end of the Bretton Woods system in the 1970s (Dietsch, 2015). Since the 1970s, most countries have abolished or reduced financial controls on the exchange of foreign currency and foreign investments (IMF, 2001). Fewer restrictions on currency convertibility encourages

investors to invest in foreign countries and convert their profits to their home currency. Second, the advancement of technologies has provided many new ways for the movement of capital and the management of capital overseas. Information technology, communication technology, transportation, and electronic transfer, for example, have reduced the obstacles associated with physical distance. Investors can invest and control their investments in foreign countries easily at low cost. Third, globalization and international integration worldwide have lowered the language and cultural barriers among different countries. Cultural and language barriers hinder effective communication between capitalists and workers. Fewer of these barriers encourage investors to move capital overseas. It also lowers the costs of investment management in foreign countries. Fourth, trade liberalization and currency convertibility promoted at all levels (from global to regional to bilateral) have boosted the movement of capital and financial flows. Every trade transaction is followed by a financial flow. At the global level, the WTO was established in 1995 with trade liberalization as its primary purpose. At the regional level, many free trade areas have been created around the world such as the EU single market in 1993, NAFTA (North American Free Trade Area) in 1994 and AFTA (Association of South-East Asian Nations Free Trade Area)- in 1992. At the bilateral level, hundreds of free trade agreements have been signed between countries: e.g., USA-Israel in 1985, USA-Korea in 2012, USA-Australia in 2004, USA-Singapore in 2004, Vietnam-Japan in 2009, Vietnam-Chile in 2016 and Vietnam-India in 2010. Fifth, the portion of intangible assets in capital has increased in recent years. Capital in the form of patent, knowledge, know-how, and trademarks can be located just about anywhere at zero cost.

This increased mobility has created opportunities for both investors and countries that need capital. Countries have sought different ways to attract foreign investments. Investors have more incentive and greater benefit to invest in foreign countries. The possibility of capital inflows to a

country has also created fears in other countries of capital outflows. For these reasons, international competition for capital through capital tax rates[2] has received much attention in the last few decades under this interconnected global economy.

Tax competition has been discussed extensively in developed countries in recent years. It is not surprising because developed countries are the major sources as well as main recipients of world capital. There has been very little attention paid to tax competition in developing countries. This study fills that gap and focuses on international tax competition in developing countries.

2. Tax competition vs. tax harmonization

Tax competition and tax harmonization are two opposite concepts in the tax competition literature. Tax competition refers to non-cooperative tax policies among countries. A country cuts their capital tax to attract investment to that country. On the contrary, tax harmonization (or tax coordination) refers to coordinated tax policies designed to restrict tax competition among members. An example was the EU's Common Consolidated Corporate Tax Base (CCCTB) (as of August 1st, 2017, European Commission's web page listed: https://ec.europa.eu/taxation_customs/business/company-tax/common-consolidated-corporate-tax-base-ccctb_en). In this plan, firms within the EU incur the same regulations to calculate corporate taxable income in the EU. However, attempts to harmonize the tax systems of EU countries have failed since 2011. In 2016, the EU Commission proposed to re-launch the CCCTB. Some countries that were actively involved in tax competition through lower corporate

[2] In the dissertation, capital tax rate and corporate tax rate are used interchangeably. In practice, the two terms generally refer to a tax on corporate profits. In the empirical chapter of the paper, I assume the same: the capital tax rate or corporate tax rate is a tax rate on corporate profit. In the theoretical literature, the two terms generally refer to a tax on investment. Some papers assume that the capital tax rate is a fraction of the amount of capital invested. Other papers assume that the capital tax is collected as a fraction of output produced by firms. In the theoretical model of the paper, I use the latter.

tax rates opposed the plan such as Hungary and Ireland (as of March 1st, 2018, Reuters' web page listed: https://www.reuters.com/article/us-hungary-ireland-taxation/hungary-ireland-oppose-eu-wide-tax-harmonization-efforts-idUSKBN1ET1ZY).

Some countries prefer tax harmonization since they believe that tax competition is harmful. Others believe that tax competition is beneficial. In the next section, I will briefly discuss the two opposite arguments on the effects of tax competition.

3. The effects of tax competition

Conclusions regarding the effects of tax competition are mixed. Some argue that tax competition is harmful. Others argue that tax competition is beneficial. To understand the complexity of tax competition, this section discusses both arguments.

Tax competition is harmful

There are two primary arguments against tax competition. First, tax competition results in less government revenue and under-provision of public goods. Less government revenue also decreases government's ability to redistribute income. Second, tax competition triggers a race to the bottom in that a lower capital tax in one country triggers decreases in capital tax rates in other countries. Ultimately, all countries are worse off as a result of this competition.

Coordination in tax policy limits tax competition and makes more investment in public goods possible. The coordination helps countries keep high capital taxes and more government revenue while not losing capital to other countries. The OECD has called for coordinated global action to limit tax competition (OECD, 1998). Most developed countries prefer to have tax coordination or to restrict tax competition. The reason is that these countries are the major sources of capital. Tax

competition from small and developing countries could lead to the outflows of capital from developed countries.

Tax competition is beneficial

There are several arguments favoring tax competition. *First,* tax competition reveals weaknesses in a country's tax system and puts pressure on governments to correct problems. Becker (1998) argues that the competition limit the ability of political groups to impose their will at the expense of their population. *Second,* tax competition is beneficial because it eliminates wasteful use of tax revenues. Without competition, government officials are likely to maximize tax revenue instead of social welfare. High tax revenue does not necessarily provide benefits to a country's residents. *Third,* the argument that tax competition causes negative externalities for other countries is weak. This argument assumes that investment to one country creates benefits to one country and losses to another. However, tax competition is not a zero-sum game. If tax competition forces a country to revise its ineffective tax system and other countries follow suit, world investment will rise and output will increase. *Fourth,* high tax rates create deadweight losses. More competition reduces this waste thereby increasing efficiency.

The next section discusses the important variables in my model: foreign direct investment (FDI), foreign aid and unemployment in developing countries. For FDI, it is the target of international tax competition: countries lower capital tax in order to attract FDI. Foreign aid and unemployment are two common characteristics of developing countries. There are reasons to expect a relationship between foreign aid and tax competition, as well as between unemployment and tax competition. The models in chapter 3 and chapter 4 shed light on these relationships.

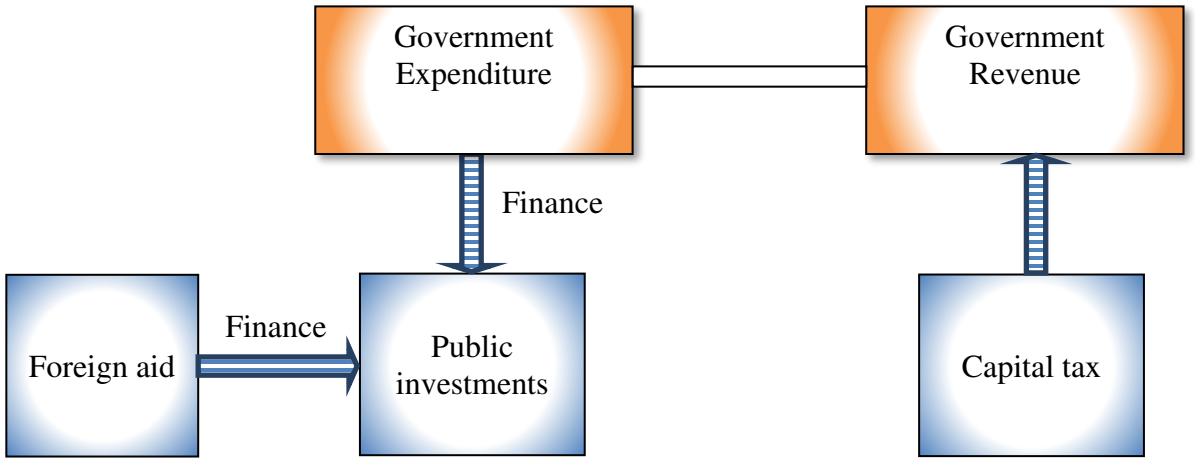


Figure 1.1 The possible effect of foreign aid on government spending and revenue

Foreign aid usually targets public projects which otherwise need funds from government expenditure. As a result, foreign aid lowers government expenditure in public investments. A decrease in government expenditure may result in a decrease in need for government revenue, which may be achieved through a lower capital tax. In this case, foreign aid may increase tax competition. The paper analyzes the role of foreign aid in tax competition in developing countries from both an empirical and a theoretical perspective.

The following diagram outlines the possible link between tax competition and unemployment.

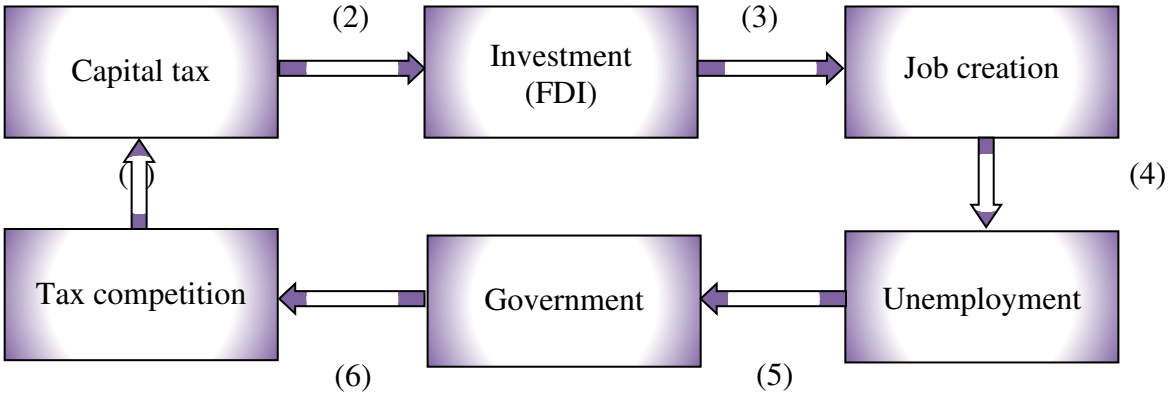


Figure 1.2 The possible link between tax competition and unemployment

A country involved in tax competition means that the country cuts capital taxes to increase investments [(1) and (2) in figure 1.2]. In most cases, more investment and more production often result in more jobs created in host countries [(3) in figure 1.2]. Tax competition is expected to lower unemployment [the relationship from (1) to (4) in figure 1.2].

In addition, high unemployment may be expected to increase tax competition [the relationship from (5) to (6) in figure 1.2]. A benevolent government may see a high unemployment rate as a pressure for them to seek different ways to promote investment. If they cut capital taxes, tax competition follows.

II. Foreign direct investment to developing countries

1. Overview of FDI to developing countries

Defining FDI

This paper adopts the UNCTAD definition of FDI. This definition is used by most international organizations (e.g. the IMF and OECD) and most countries for the purpose of calculating FDI statistics: "Foreign direct investment (FDI) is an investment involving a long-term

relationship and reflecting a lasting interest and control by a resident entity in one economy (foreign direct investor or parent enterprise) in an enterprise resident in an economy other than that of the foreign direct investor. FDI implies that the investor exerts a significant degree of influence on the management of the enterprise resident in the other economy. FDI may be undertaken by individuals as well as business entities. The entity undertaking the investment is referred to as the direct investor and the enterprise in which the investment takes place is referred to as the direct investment enterprise" (UNCTAD, 2007, page 245).

In the definition, a "lasting interest" means the investor owns at least ten percent of the FDI company. The threshold of ten percent distinguishes FDI from foreign portfolio investment. When ownership is between ten percent and fifty percent, the direct investment enterprise is called an associate. If the direct investor holds fifty percent or more, the FDI enterprise is a subsidiary. When ownership is one hundred percent, the entity in which the investment occurs is called a branch.

FDI flows to developing countries

This section highlights the overall trends of FDI to developing countries. In the last three decades, FDI to developing countries has increased considerably, from 34.6 billion dollars in 1990 to 671 billion dollars in 2017 (UNCTAD World Investment Report, 2018). The share of FDI to developing countries has also increased. In 1990, 17 percent of total FDI flows were to developing countries. In 2017, that share was 47 percent, more than double that of 1990. As outlined in Figure 1.3, over the last five years since 2013, FDI to developing countries has increased steadily while FDI to developed countries has fluctuated sharply. In 2014, FDI to developed countries fell, but that to developing countries still increased. As the result, developing countries with 53 percent total world FDI surpassed developed countries as the largest destination of FDI. From 2016 to 2017, FDI to developing countries remained stable while those in developed countries fell sharply.

As a result, developing countries received nearly 50 percent of total world FDI. Developing countries have become important players in the competition of capital in the world market.

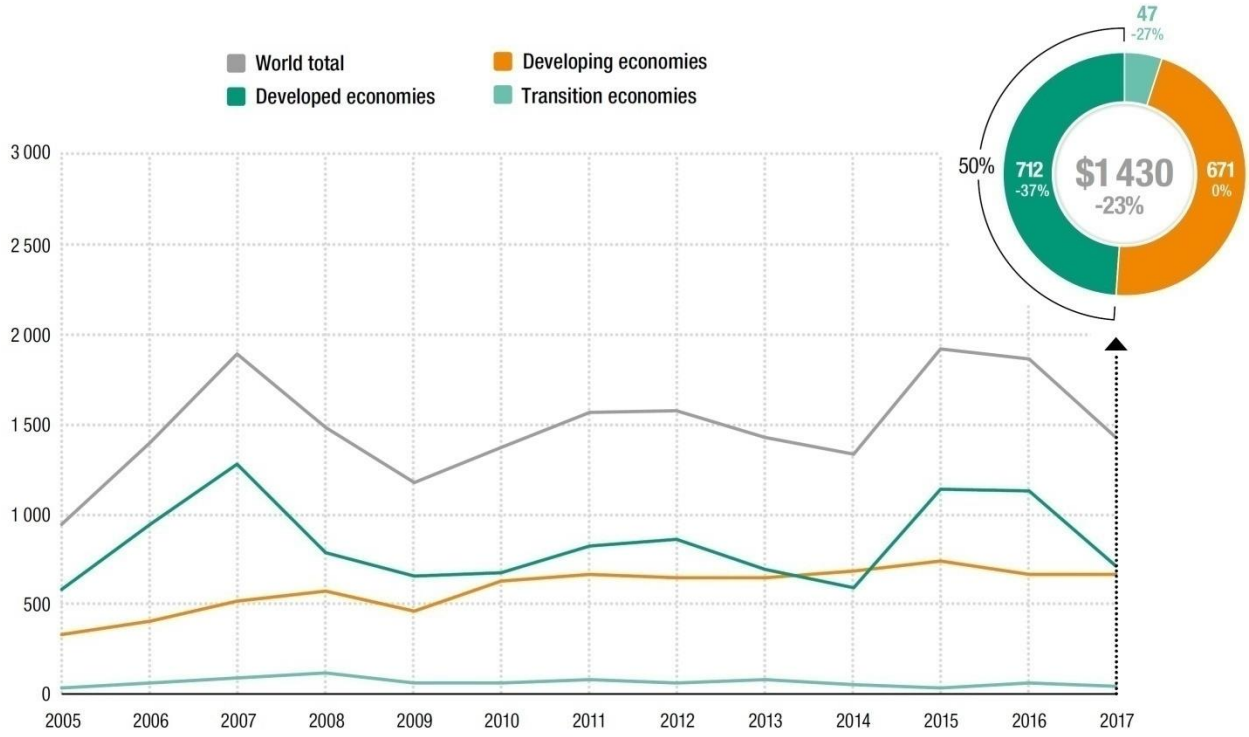


Figure 1.3 FDI inflows, global and by group of countries 2005-2017 (Billions of dollars and percent)

Source: UNCTAD - World Investment Report 2018.

Figure 1.4 shows the distribution of FDI across different group of countries and regions in 2016 and 2017. In 2017, developing Asia received the largest amount of FDI, followed by European Union and North America. The share of FDI to Asia increased from twenty five percent in 2016 to thirty three percent in 2017.

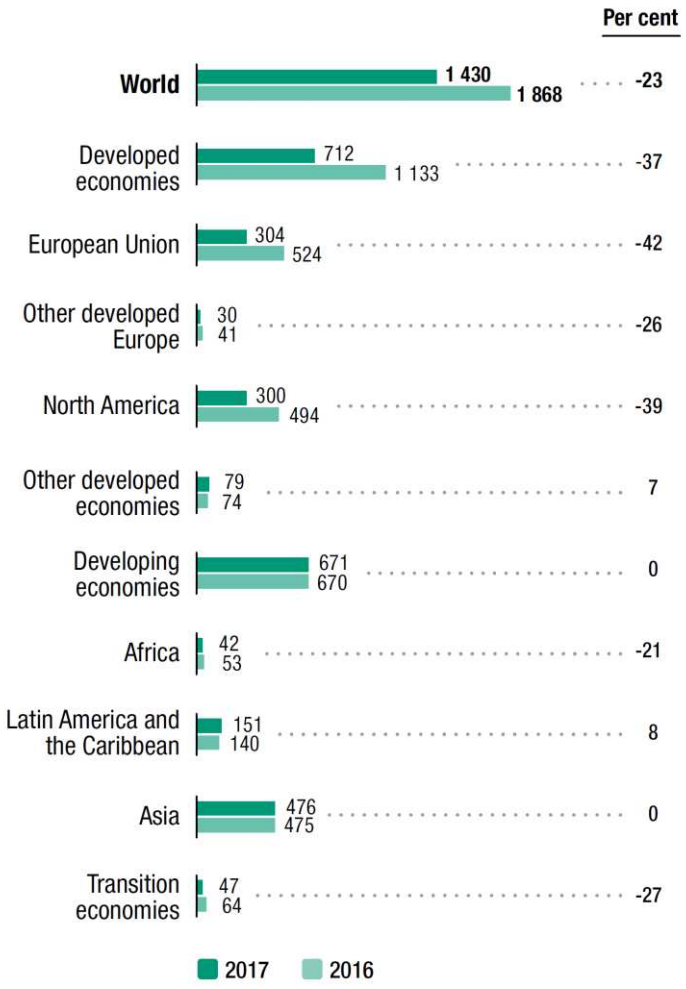


Figure 1.4 FDI inflows, by region, 2016 – 2017

Source: UNCTAD World Investment Report, 2018.

2. Benefits of FDI to developing countries

This section briefly introduces the main benefits of FDI to developing countries. It provides insights into why we should care about tax competition, why developing countries need to compete for capital or FDI, and whether FDI is necessary for developing countries. In my opinion, FDI is fuel for growth in developing countries. Clearly, economic development in developing countries also depends on their good internal engines and policy drivers. There are several reasons to justify

the benefit of FDI to developing countries. *First,* FDI is not only dollar money, but also technology and know-how. With FDI flows, developing countries have possibilities of getting access to technology that they cannot produce by themselves. Through FDI, local firms may try to imitate or, if that is not possible, they can benefit from their awareness of the new technology. The physical part of technology may be kept secret by FDI enterprises but the information part to some extent is a public good and is hard to keep secret. Mansfield and Romeo (1980) confirmed the existence of leakage of technology from FDI abroad. *Second,* FDI may create great spillover effects to domestic enterprises in developing countries. Görg and Greenaway (2001), Karpaty and Lundberg (2004) and Blomstrom (1991) concluded a positive relationship between FDI and spillovers. Spillover effects can be divided into two different channels: intra-industry and inter-industry spillovers. There are several ways in which intra-industry spillovers can occur. Efficiency spillovers –firms in the same industry may become more efficient through FDI competition. Foreign companies may increase competition in a host country market which may put pressure on existing inefficient firms in the same industry to reform and make more investment in technology and human capital. Mansfield and Romeo (1980) and Mansfield (1982) found that FDI technology abroad speeded up the appearance of competing products or process in host countries by at least 2.5 years in about one—third of their cases. Another possible way of intra-industry spillovers is that FDI enterprises may provide some training to workers and management people in host countries which become available in those countries. Later, those people may work in local firms or become entrepreneurs by themselves. Inter-industry spillovers can occur through the development of supporting industries in host countries that provide services, material and intermediate products for FDI enterprises. FDI enterprises benefit from local purchases of inputs due to low prices and transportation costs. In many cases, they are willing to support the

establishment, even some sort of technology, quality assurance to local suppliers. In addition, to promote the development of supporting industries, governments in host countries usually offer great incentives to FDI enterprises if these enterprises meet certain domestic contents in their final products. Those incentives encourage foreign investors to use more local suppliers which further benefit domestic industries. *Third,* FDI promotes trade, especially exports in developing countries. Over the last few decades, FDI has no longer been a substitute for trade to serve host countries' market but the opposite. FDI to a country has become a part of a wider network - global value change of a MNE (Multi-National Enterprise or MNC: Multinational Corporation). Products from one FDI enterprise in one country may be distributed all over MNE's global network. *Fourth,* FDI increases employment opportunity and quality of employment in developing countries. There may be some FDI projects that results in shedding of labor in developing countries, especially due to advanced labor-saving technology. However, that may only happen with direct employment and in the current period. FDI projects may have indirect, larger effects to employment in the long run. As pointed out by most previous studies, FDI helps to promote labor productivity and skilled labor force in developing countries. Higher productivity and quality labor force bring positive externality to labor market and increase job growth in the long run in developing countries. Several previous papers concluded that FDI overall increases employment in developing countries such as Waldkirch, Nunnenkamp and Bremont (2009), Hale and Xu (2016). In addition, overall consensus in previous FDI literature as discussed in Hale and Long (2011), Sjöholm and Lipsey (2006) and Huttunen (2007) shows that FDI improves working environment and increases income in developing countries. Higher incomes from foreign investment increases domestic consumption. Extra domestic consumption, in turn, induces extra domestic supply and production hence more employment. In addition, most developing countries has FDI screening policies in place which

restricts foreign M&A projects causing negative impact on domestic employment. Management tools are in hand of host countries. FDI projects have to go through the approval process to get a permit before an investment can be made in host countries. Governments in developing countries can deny a poor FDI projects and approve beneficial ones. So, for an FDI project which is approved, the benefits should be greater than the costs to that country. In addition, developing countries may have certain policy flexibility to reap benefits from FDI. In other words, host countries do not apply the same treatment to all FDI projects. For example, FDI projects in natural resource exploitation may be subject to additional fees, extra taxes and heavy regulations or limitations. On the other hand, FDI projects in high technology may receive additional extra incentives. Problems with FDI, if any, are mainly from host countries' management and institutions rather than the FDI itself. In practice, most countries and policy makers are well aware of that nature and place great importance on FDI.

3. Foreign Direct Investment and Portfolio Investment

In Foreign Direct Investment, foreign investors establish a long-term relationship and a lasting interest in foreign countries. Foreign portfolio investment instead refers to investments made in securities and other financial assets issued in another country. Portfolio investment is mainly about trading or exchanging financial assets from one person to another. Portfolio investment can fly in and out of a country quicky and easily. The following table compares the differences between the two investments in different aspects. I will then discuss the relevance of my results to foreign direct investments and portfolio investments.

Table 1.1 FDI and Portfolio Investment

	FDI	Portfolio investment
Owner of the investment project	An individual company usually owns the FDI project.	Group of investors
Investors' perspectives	More risks.	Less risks. Investors can invest in many companies across countries to diversify their risks.
	An investor fully realizes the impact of corporate tax laws in a host country. The investor fully incurs the burden of corporate tax rates of the host country.	Corporate tax laws only indirectly affect investors. Portfolio investors only incur part of corporate tax rates through dividends. Dividends only account for a small part in portfolio investors' income (other parts are price changes and risk diversification)
The investment project	Most FDI projects to developing countries usually creates new entities, new companies, new productions, a new physical presence in host countries.	Portfolio investments do not usually create a new company in host countries. The company exists with or without portfolio investments.
	Money capital usually comes with technology, management experience, distribution network.	Only money capital
Host countries' perspective	More stable, lasting interest.	More volatile.
	Create more jobs	May not create new jobs

A portfolio investor only owns a small part of a company in developing countries. A portfolio investor may not have any direct influence on the management of the company in which they invested. On the other hand, an FDI investor is the owner of the company established in a developing country. An individual company making FDI in developing countries fully bears the

burden of corporate tax rates (the subject of tax competition). An FDI investor directly pays all the taxes obligations to the host countries. Portfolio investors only incur a small burden of corporate tax rates (dividends to portfolio investors only account for a small part of the companies' profits or losses). The corporate tax rates in developing countries directly and fully affect an FDI investor in that country. The corporate tax rates indirectly and partly affect portfolio investors through dividends. As the result, tax competition may have a stronger impact on FDI than portfolio investment. In addition, Reichl (1998) indicates that empirical evidence shows that portfolio investors invest not exclusively on the basis of maximization of returns. The important determinant of portfolio investment is to diversify risks. Portfolio investors may hold equities in many companies in several countries with different rates of return simultaneously. That means that they care more about diversification and less on corporate tax rates (the subject of tax competition). My results are more relevant to FDI investment than portfolio investment.

The tax competition policies in host developing countries usually target FDI with long-term commitment and lasting interest in their countries. FDIs usually create new companies and more new jobs for developing countries. The core focus of tax competition is to get or to compete for more beneficial investment flows to the host countries. If an investment does not benefit a host country, they will restrict that investment (higher taxes, additional taxes, additions rules or regulations or even no permit given). In most countries, portfolio investments are under additional regulations or separate laws governing these investments. In tax competition, countries try to attract FDI that are more sensitive to tax obligations. Investments designed to minimize tax obligations are the target of tax competition (the essence of tax competition is to compete for investment through a lower corporate tax rate). In the real world, there will be some illegal and harmful investment activities. As I have mentioned in the previous section about the role of

institutions in screening out bad investments. (chapter 1, section II.2, page 18-21). These issues are related to management and institutions rather than tax competition.

III. Foreign aid to developing countries

1. Defining foreign aid

Foreign aid is private and public transfers from developed countries or international organizations to developing countries. The primary purpose of foreign aid is to support and promote development in developing countries. There are three different types of foreign aid. First, bilateral foreign aid is any transfer from developed countries' governments to developing countries. Second, multilateral foreign aid is any transfer from international organizations to developing countries. The most common international organizations providing foreign aid are United Nation agencies (e.g. FAO, UNDP, IFAD, WHO and UNICEF), the World Bank, IMF and ADB[3]. Third, private foreign aid is any transfer from individuals or non-governmental organizations (NGOs) to developing countries. Examples of private organizations providing aid include the Gates foundation, the Rockefeller foundation, Oxfam and churches. The first two sources of foreign aid account for the majority of total foreign aid to developing countries.

[3] FAO: Food and Agriculture Organization of the United Nations
UNDP: United Nations Development Programme
IFAD: International Fund for Agricultural Development
WHO: World Health Organization
UNICEF: United Nations International Children's Emergency Fund
IMF: International Monetary Fund
ADB: Asian Development Bank.

2. Conditions for receipt of foreign aid

The most common condition for a country to receive foreign aid is that it must be a developing country. A developing country has income per capita less than a threshold set by developed countries. The OECD maintains a list of developing countries eligible to receive foreign aid or Official Development Assistance – ODA (as of June 6th, 2018, OECD's web page listed: https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/daclist.htm). The list is frequently updated. In 2010, the per capita income threshold was below $12,276. This threshold is only a reference because each developed country may set its own conditions. Developed countries may also provide foreign aid to developing countries based on other criteria such as human rights, political reform, trade relationship with donor countries, and a colonial relationship.

The amount of foreign aid to developing countries depends solely on donors. For bilateral foreign aid, the United Nations suggests that developed countries use 0.7 % of their total national income to ODA. However, on average, developed countries devote around 0.2-0.4% GDP to ODA to developing countries (as of June 6th, 2018, OECD web page listed: https://data.oecd.org/oda/net-oda.htm). The United States ODA to developing countries has ranged from 0.1% to 0.22% GDP between 2000 and 2016.

IV- Unemployment in developing countries

Most previous tax competition models assume full employment. This paper analyzes the relationship between unemployment and tax competition in developing countries. This section discusses the concept of unemployment, the understanding of unemployment in practice, and an overall picture of unemployment in developing countries.

According to ILO - International Labor Organization, unemployment rate is the ratio of the labor force that is not working but available for work and seeking work (ILO, 2019). I use this definition of unemployment in my theoretical model. In practice, the measurement of unemployment rate may change across countries because of differences in criteria for people considered to be seeking work, wage level, working conditions, labor market information and labor mobility. For example, in developing countries, there may be people who want to work but do not seek work because they have limited access to job opportunity information or restricted labor mobility. These people are not counted in official unemployment rates in these countries. Hidden unemployment may be high while reported unemployment is low. In contrast, in developed countries, labor mobility and open access to job information encourage people to seek work. In addition, the availability of unemployment insurance, unemployment benefits and social safety nets in these countries encourage people to leave low wage or poor working condition jobs to seek a better job, thereby increasing unemployment rates. The reverse situation in developing countries, many people have to work under poor-quality employment and extreme working poverty. Most developing countries do not have unemployment benefits. Workers have to work in order to survive regardless of employment quality and low wages. According to statistics from the ILO (ILO, 2018), 41.2 percent of the working population are in extreme poverty (less than $1.90 per day) in developing countries. Working conditions and workers' income have gradually improved. The rate decreased to 38.9 percent in 2019. However, the ILO has projected that, in developing countries, more than one in three workers still work and live in extreme poverty. In addition, a large proportion of employment in developing countries is in vulnerable and informal forms of

employment[4]. In 2017, the share of vulnerable employment in emerging countries and developing countries was 46 percent and 76 percent, respectively. In developed countries, the share was much lower, at around 10 percent.

Table 1.2 World unemployment, poverty and vulnerable employment rate

Country/region	Unemployment rate 2007–19 (percentages)				Unemployment 2017–19 (millions)		
	2007–16	2017	2018	2019	2017	2018	2019
WORLD		**5.6**	**5.5**	**5.5**	**192.7**	**192.3**	**193.6**
Developed countries		5.7	5.5	5.4	34.1	32.8	32.4
Emerging countries		5.6	5.5	5.5	143.0	143.4	144.6
Developing countries		5.3	5.3	5.3	15.6	16.1	16.6
	Vulnerable employment rate 2007–19 (percentages)				Vulnerable employment 2017–19 (millions)		
	2007–16	2017	2018	2019	2017	2018	2019
WORLD		**42.5**	**42.6**	**42.7**	**1391.3**	**1409.0**	**1426.4**
Developed countries		10.0	9.9	9.9	56.7	56.5	56.3
Emerging countries		46.2	46.2	46.3	1122.8	1134.0	1144.8
Developing countries		76.5	76.4	76.4	211.8	218.5	225.3
	Extreme working poverty rate 2007–19 (percentages)				Extreme working poverty 2017–19 (millions)		
	2007–16	2017	2018	2019	2017	2018	2019
Total emerging and developing countries		**11.2**	**10.7**	**10.2**	**300.9**	**290.8**	**281.2**
Emerging countries		7.7	7.2	6.7	186.8	176.2	166.4
Developing countries		41.2	40.1	38.9	114.1	114.6	114.9
	Moderate working poverty rate 2007–19 (percentages)				Moderate working poverty 2017–19 (millions)		
	2007–16	2017	2018	2019	2017	2018	2019
Total emerging and developing countries		**16.0**	**15.5**	**15.1**	**430.2**	**421.8**	**414.0**
Emerging countries		14.7	14.1	13.6	357.5	346.9	336.7
Developing countries		26.2	26.2	26.2	72.7	74.9	77.3

Source: ILO, 2018 – World employment and social outlook

[4] Vulnerable employment is the sum of the employment status groups of own account workers and contributing family workers (definition from the United Nations: https://esa.un.org/unmigration/documents/retreat/UN%20WOMEN_Indicator_vulnerable_employment.pdf)

The reported unemployment rate may understate the actual unemployment rate in developing countries. In this paper, I estimate my empirical model using employment rate instead of unemployment rate.

The next chapter reviews prior research on tax competition. The chapter reviews the literature from its broadest narrowing it to the research issue that is closest to my model. The review also follows the timeline from earliest to the most recent research.

CHAPTER 2: LITERATURE REVIEW

TAX COMPETITION AND INTERNATIONAL TAX COMPETITION

The chapter reviews the tax competition literature starting from competition among different regions in a country to competition among different countries. In the tax competition literature, there are two main approaches used in analyzing tax competition. The first approach focuses on the competing interactions between regions (or countries). These models address tax competition using game theory. The second approach focuses on competition in terms of a country lowering its capital tax rate. Under this approach, a representative country maximizes its own national welfare by lowering its capital tax rate to attract more capital. That results in tax competition. The model developed in chapter 3 follows the second approach. This paper also estimates the competing interactions (or tax response functions) among countries in chapter 4, section III and chapter 5, section II. All aspects of tax competition are covered in this paper.

This chapter is divided into six sections. Section 1 reviews the foundations upon which most tax competition theories have been built. Section 2 reviews asymmetric tax competition, while section 3 reviews international tax competition and section 4 summarizes tax competition in developing countries. Section 5 discusses foreign aid to and FDI in developing countries. Finally, section 6 reviews tax competition in the presence of unemployment. Each section focuses on the mechanism of competition, welfare optimization and the tax competition process.

I. Standard – symmetric tax competition models

This section reviews some baseline tax competition models on which most of the literature relies. The initial model was presented in Tiebout (1956) in the context of provision of local public

goods and extended by Oates (1972). Zodrow and Mieszkowski (1986) made a second important contribution.

1. Tiebout and Oates model – setting the groundwork for the tax competition literature

The Tiebout and Oates models set the ground for tax competition or competition for mobile firms. The model assumes that household-voters are mobile. They will move to the community that they prefer most. In making their choice of residence, households have full knowledge about tax and expenditure policies of all communities. Local governments provide different tax rates and public goods. Households will choose the locations that fit their preferences for taxes and public goods. Households vote with their feet by moving across regions.

While Tiebout discusses government competition for mobile households, the tax competition literature discusses government competition for mobile firms. The competition of mobile labor in the Tiebout's model has been extended to the competition of mobile capital in tax competition literature.

Oates (1972) model

Oates (1972) assumes that capital is mobile and households are wholly immobile across regions. The total supply of capital in the country is fixed. If one jurisdiction receives more capital, capital in other jurisdictions will shrink. Local governments compete for capital by lowering taxes. The Oates (1972) model is among the first that discusses tax competition among different regions in a decentralized country. According to Oates, the competition for capital may result in possible harmful effects. The direct impact is that low taxes may result in inefficiently low levels of public goods. Some later studies have examined and confirmed Oates' conclusion about the harmful effects of tax competition. All those studies consider tax competition in developed countries.

2. Zodrow and Mieszkowski (1986)– a baseline model

The Zodrow and Mieszkowski (ZM) model is a workhorse model in the tax competition literature. Most of tax competition literature starts from this baseline model (reviewed by Keen and Konrad 2013; Genschel et al. 2015). I will briefly review the assumptions of the model, the core setup, and the main results of ZM model. Each region in a group of regions maximizes its own welfare for its representative household taking as given the tax rates set by other regions.

The model assumes:

- there are N identical (homogeneous) regions.
- labor is perfectly inelastically supplied by the region's residents (i.e., labor is immobile).
- capital is mobile across regions.
- each region chooses the capital tax t_i levied on each unit of capital. Tax revenue is t_iK_i.
- population is normalized to one, with full employment.
- capital and land are two production factors of the economy.
- residents own fixed endowments of capital. Their income is from the endowments of capital and from labor. The income is then used to buy a consumption good C and a public good P. Residents are identical. Their utility function is represented by U(C, P).

Their general model is analyzed under 3 different cases: (1) government provides public goods to residents; (2) government provides public inputs to firms; and (3) government provides both public goods and public inputs. Each case is considered in turn.

Case 1: Government provides public goods to residents

Government in each region collects a capital tax (t) and a head tax (H) to finance the public good (P). The input used to produce good P is the output from private production. The government control variables are P and capital tax rate t. The government's budget constraint is:

$$P = tK + H$$

The government maximizes the utility of a representative resident subject to a balanced budget constraint:

$$\underset{P,t}{\text{Max}}\, U(C, P) \text{ s.t. } P = tK + H$$

Private consumption is given by:

$$C = [F(K) - (r + t)\times K] + [r\times\frac{\bar{K}}{N}] - H$$

where: F(K) is the production function; r is the interest rate or return on capital; $\bar{K}$ is the total capital, N is the number of identical regions in the world. There are three main components in the above equation: [F(K) - (r + t)×K], return to land; [r×$\frac{\bar{K}}{N}$], return to capital; and H, head taxes. If H is fixed, the maximization problem is $\underset{t,H}{\text{Max}}\, U(C, P)$

s.t. P = tK + H and C = [F(K) - (r + t)×K] + [r×$\frac{\bar{K}}{N}$] – H

Profit maximization in perfect competition requires that:

$$r + t = F_K(K)$$

Differentiating the above equation, ZM shows that $dK/dt = 1/F_{KK} < 0$.

From the above equation, they conclude that the tax competition exists and capital tax has a distortionary effect. If a region imposes a lower property tax, the region will receive more capital.

From the utility maximization condition $U_P/U_C = 1$, they show that if the government can use a head tax on its residents, the capital tax rate is zero. In this case, the head tax finances public services. If the government cannot impose the head tax to this level, ZM show that $U_P/U_C>1$ or under-provision of public goods.

Case 2: Government provides business public services (public inputs to firms) – no public good to citizen

The model introduces public inputs to business. The production function becomes F(K, B) where B is the public inputs. ZM assume that $F_{KB}> 0$, $F_B> 0$, $F_{BB}< 0$

The government's budget constraint is: tK+H=B

Profit maximization in perfect competition requires: $F_K(K, B)= r + t$

The government maximizes the following function:

$$\text{Max } U\{[F(K, B) – (r+t)\times K + r\times \frac{\bar{K}}{N}] – H\}$$

In this case, their results are similar to case 1. If the government can impose head tax on its immobile residents, the capital tax rate equals zero. If the government cannot impose the head tax up to this optimal level, they will increase the capital tax rate above zero and production is inefficient. Lowering the head tax below the optimum level will result in decreasing public services provided to firms. Tax competition puts a constraint on the capital tax rate. They show that the capital tax is inefficiently low and under-provision of public services follows.

Case 3: Government provides both public inputs and public goods.

In this case, the government budget constraint is $tK + H = B + P$.

The public good available to citizen is $P = tK + H - B$. The government maximizes the following utility function of its representative resident:

$$\text{Max } U\{[F(K, B, P) - (r+t)\times K + r\times \frac{\bar{K}}{N} - H], (t\times K + H - B)\}$$

The third case produces similar results. The government budget relies fully on a head tax. If the government cannot impose a head tax up to this level, $U_P/U_C > 1$ and $F_B > 1$.The marginal rate of transformation U_P/U_C being greater than one indicates that the marginal utility from consuming one unit of public good is higher than that from consuming one unit of private good; the public good is underprovided[5]. The marginal product of the public input being greater than one indicates that one unit of private production collected and invested in public input by government results in a larger increase (more than one unit) in private production. In other words, if the government collects $1 tax from private production and invest that $1 into public input, the increase in public input will help private production to increase its output by more than $1. The public input is underprovided. In this case, tax competition results in public inputs to firms and public goods to individuals both being underprovided. Also, they show that $dB/dH > 0$, $dt/dH < 0$ and $dP/dH > 0$, a decrease in the head tax results in a reduction in both public goods and public inputs.

In all three cases, a head tax (if available) is optimal and the government budget relies fully on the head tax (if possible) and capital tax is zero. If a head tax is not available or is constrained

[5] The model was set up in a way that the conversion between output, private good, public good and public input is 1:1:1:1.

below its optimal level, the government will need to raise its capital tax above zero. However, the capital tax rate is still low due to tax competition. A low capital tax rates results in under-provision of public goods.

II. Asymmetric Tax Competition Models

The foregoing tax competition literature assumes that all regions are identical (or symmetric tax competition). A subsequent literature analyzes the case in which there is diversity among regions. The differences among regions affect the choice of capital tax as well as the welfare maximizing result. This section of the chapter reviews the standard analyses of tax competition in an asymmetric setting.

1. Regions are different in size

Asymmetric tax competition models typically assume that regions are different in size or different in population. Bucovetsky (1991), Wilson (1991), Wilson (1999), Kanbur and Keen (1993), Peralta and Ypersele (2005), Hindriks, Peralta and Weber (2008) and Chatelais and Peyrat (2008) are examples of models which allow region size to vary. I will review several models.

Bucovetsky (1991) assumes that regions are different in size (population) but have the same per capita endowments. The model identifies a Nash equilibrium in which regions set their tax rates to compete for capital. He shows that the small region is more motivated to sets a lower tax rate, attracts more mobile capital, and reaches a higher utility per-capita. On the other hand, the larger region sets a higher capital tax rate. The tax rate difference between the small and large regions causes a capital outflow from the large region to the small one.

Using the standard tax competition framework, the Wilson (1991) model also have a similar result as Bucovetsky's (1991) model. In tax competition, the small region is better off than

the large one. Wilson also extends the model by allowing governments to finance public service provision with both a labor tax and a capital tax. Wilson shows that in this case the smaller region continues to have an advantage over the larger one.

The Wilson (1999) model considers a system of many asymmetric regions. The model again confirms the benefits of small regions in tax competition "structural advantage of smallness". The larger region has less incentive to lower its capital tax rate and sets a higher tax rate than the smaller region. With a lower capital tax rate, the smaller region can attract more capital. As a result, the smaller region has higher capital per unit of labor, and has higher wage level than the larger region.

Peralta and Ypersele (2005) shows that when countries compete non-cooperatively, tax rates among countries do not converge. Tax rates are different among countries. In competition for capital, countries are better off than capital controls without competition. With regard to population, a country with a larger population sets a higher equilibrium tax.

2. Regions are different in initial endowments

Cai and Treisman (2005) analyze tax and fiscal competition among asymmetric regions. There are two different types of regions: well-endowed and poorly-endowed regions. They define "endowments" as any features that influence the productivity of capital in the region. Endowments, for example, include human capital, natural resources and infrastructure. They use total factor productivity A_i in a Cobb-Douglas function as the "endowment" in region i. A region with higher A_i is "well – endowed" while a region with lower A_i is "poorly-endowed". Their main finding is that differences in endowment discipline government action in both tax and fiscal activities. For fiscal activities, the poorly-endowed regions have less attractive business environment. These

regions will invest more in a public good (satisfying the demands of local citizens) and less in a public input (satisfying the demands of businesses). On the other hand, well-endowed regions invest more in a public input and, hence, have a better business environment. They call this a "polarization" with well-endowed regions ending up with more capital while poorly-endowed regions have a less attractive environment and receive even less capital.

For tax policies, they confirm that lowering a tax rate will attract more capital (tax competition exists). However, the polarization result still holds and differences in endowments affect the tax competition results. If endowment differences are large, the well-endowed regions set a higher tax rate but still receive most of capital. Poorly-endowed regions set tax lower rates, but may not attract enough investment.

3. Regions differs in political/government systems

Most research that considers the political aspect of tax competition concludes that tax competition is beneficial. The fundamental idea is that tax competition is likely to put pressure on government for more efficient public expenditures and less corruption of government officials. Johansson et. al (2008) argue that tax competition forces the governments to improve their tax systems to be more attractive to businesses and promote production in their region. They argue that a restrictive tax policy is an obstacle to businesses, production and economic growth. It is a harmful tax policy, not a harmful tax competition. A harmful tax policy distorts the market and create deadweight losses. Edwards and Keen (1996) and Brennan and Buchanan (1980) and also conclude that tax competition may reduce wasteful government expenditure and increase social welfare.

Sorens (2014) look at the effect of tax competition on the government administration. Their main finding is that jurisdictional competition for capital is associated with reductions in the administrative expense of government. Tax competition enhances efficiency, reducing waste and corruption; more competition is better.

4. Other typical asymmetric tax competition models

Hindriks, Peralta and Weber (2008) discuss a model of different regions that try to compete for capital using capital tax rates and investments in public inputs. Capital taxes and investment in public inputs have two opposite effects on capital investment: taxes drive away while investment in public inputs attract investment. The asymmetry of the two regions is reflected in differences in productivity in the production function. The main finding of the model is that tax competition exists: countries lower capital tax for more investments and tax functions are upward sloping. If region 1 lowers tax, region 2 will do the same and vice-versa. For the interaction between public investment and the tax rate, they found that at equilibrium, public investment in one region has a negative effect on tax rate of the other region.

$$\frac{\partial t_2}{\partial g_1} = \frac{\partial t_1}{\partial g_2} < 0$$

where t_i and g_i are the capital tax rate and public investment in region i respectively. The two regions compete for capital using both tools available to them. If region 1 increases investment in public input to attract capital, region 2 may compete for capital using the other tool, lowering capital tax rate. The asymmetry between the two regions also has an impact on the regional tax choice and allocation of capital. Region 1, with higher productivity, set a higher tax rate, invests more in public inputs and receive more capital.

Zissimos and Wooders (2008) and Baldwin and Krugman (2004) discuss tax competition in the context of one core region and other periphery regions. Baldwin and Krugman (2004) examine tax competition in the presence of an agglomeration effect. They found that the core regions set higher tax rates. Periphery (less industrialized) regions may need to set a lower capital tax rates than that in industrial core region in order to attract capital.

Zissimos and Wooders (2008) find similar results to Baldwin and Krugman (2004). The core region imposes a higher capital tax rates and invest more in public inputs than the periphery regions. Firms are willing to pay higher capital taxes in the core region because they have lower production costs in the core region.

III. International tax competition

While most articles discuss tax competition among different jurisdictions in a decentralized country, there has been increasing interest in international tax competition. The reason is that the mobility of capital across countries has increased over the last few decades. If capital is freer to move around the world, the elasticity of foreign investment with respect to capital tax rates across countries increases. A country that lowers its capital tax rate may receive more capital than before. As the result, international tax competition will increase. This section reviews the literature on international tax competition.

1. General discussion of international tax competition

Hines (1999) examines the effects of international taxation on foreign direct investment and on the international tax avoidance activity. They conclude the existence of international tax competition. Capital taxation strongly influences FDI and tax avoidance activities. For tax policy, the article suggests that governments seeking both economic performance and adequate tax

revenue should set competitive tax rates on mobile capital FDI. Industries with significant spill-over effects (such as R&D) are very responsive to taxation. Regarding tax avoidance activities, the article suggests policies that encourage businesses to report income domestically rather than shifting incomes to foreign countries. They may do so by using a tax credit system or setting tax rates below the rates of main trading partners. The possibility of using stricter regulation and spending more resources on tax collection and auditing to prevent profit shifting is also discussed. However, the paper suggests that a strict enforcement may work similar to a tax that drives the mobile capital away.

Altshuler, Grubert, and Newlon (2000) discuss the sensitivity of U.S. investment abroad to the differences in capital tax rates across countries. They find that U.S. investment has become more sensitive to lower capital tax rates. In their empirical work, data on investment abroad from American multinationals indicates that foreign countries which increase their tax rates by 10 percent received 30 percent less U.S. investment in 1992. The estimated tax elasticities for U.S. investment abroad are large. In addition, their results suggest that investment in manufacturing is more sensitive to tax differences. The elasticity of investment flows with respect to capital tax rates increases for more open trade countries.

Bénassy, Fontagné and Lahrèche-Révil (2001) discuss tax competition within Europe. They focus on business re-location of capital during European integration. The European Economic and Monetary Union (EMU) eliminated exchange rate risks, reduced obstacles to trade, labor mobility, capital mobility and FDI. The paper analyzes the impact of different corporate tax rates, and different tax schemes (tax credit or tax exemption) across locations on investment abroad. A tax exemption scheme means corporate income taxes are paid in host countries. A tax credit scheme is where investors pay their home country taxes if the host foreign country has a

lower profit tax than that of home country, with the investor paying the difference to the home country government. When tax exemption is implemented, there is a tendency for tax evasion. Investors have incentives to move their investments to low-tax countries. When a tax credit is applied, investors cannot evade the national tax system. They show that FDI have a negative relationship with both effective and statutory corporate tax rates. In addition, the empirical results show that the use of a tax credit system in Europe reduced FDI because it removed the ability to avoid high tax rates in home countries.

Devereux, Lockwood, and Redoano (2008) investigate how the government in one country responds to changes in the capital tax rates by other countries. Both theoretical and empirical analyses show that a country responds to changes in other countries' capital taxes. In contrast to previous studies, they discuss tax competition with respect to both statutory and effective tax rates. Because many countries offer foreign investors some incentive packages the effective tax rate is less than the statutory tax rate. In their theoretical model, they confirm existence of tax competition over both effective and statutory tax rates. Their empirical results indicate intense strategic interaction in both rates. The estimated reaction function is positively sloped which is consistent with their theoretical predictions.

Many other studies have confirmed the sensitivity of investment to capital taxation. Mutti and Grubert (2004) investigate the impacts of host country income taxation in the operations of the U.S. multinational corporations. Their empirical results show that production of U.S. MNC is geared toward countries with lower income tax rates. An (2012) finds that China's corporate tax law 2008 affected FDI inflows to China through the change in its incentives. The law removed special incentives to foreign investment. Foreign investors responded to the changes by reducing their investment in China. Kato (2015) confirm these impacts of capital taxes on FDI. The paper

also discusses the effects of the credibility of tax policies on FDI. Credible tax policies together with a strong commitment from governments also play crucial roles in attracting FDI.

2. The effect of trade costs and investment costs

Haufler and Wooton (1999) study international tax competition with differences in scale economies and trade costs. They show that the existence of trade cost is an advantage for a large country in tax competition. If the trade costs are sufficiently high, large countries win the competition for internationally mobile capital. With higher trade cost, firms prefer to invest in a larger country where they are able to charge a higher price. Firms face a trade cost disadvantage if they locate in a small market and then export to a larger market. When a second instrument is added such as tariff, the large country benefits even more. They can raise their capital tax and still be a preferred location for investment.

Darby, Ferrett and Wooton (2014) also analyze the impact of trade costs in a tax competition model. They find that trade costs have strong positive impacts on the capital tax rates set by different countries. Lower trade costs can lead to lower capital taxes in the large countries.

Redoano (2014) study the effect of investment costs on capital tax competition. The paper presents a model of EU member countries to illustrate the reduction in investment costs in connection with the increasing level of integration in EU. The model was built from the gravity model in trade. The EU has created a single market and a common currency (the Euro). The deep integration has contributed to a lower cost of intra-EU investment by facilitating capital mobility. They find a similar result as in the gravity model; foreign investment among countries has a negative relationship with cross-border investment cost. The cost of cross-border investment then has a positive relationship with distance and the level of integration. Foreign investments are

inversely related to distance and the level of integration. As the result, member countries react more to each other's capital taxes and less to non-members.

3. Large vs. small countries in tax competition

Genschel et. al. (2015) discuss a model with big and small countries. Each country has two classes the rich and the poor with two income sources from capital and labor. They show that the poor classes in the small country are the main driver of tax competition. The small country sets a lower tax rate and receive more capital. Capital inflows increase employment and raises wage level in the small country. The large country, on the other hand, faces fierce competition from the small country and are unable to attract a good amount of capital from the small country. Tax competition may not benefit the large country. They further conclude that the primary losers of international tax competition are the poor classes in the large country. The main winners are the poor in the small country.

Darby, Ferrett and Wooton (2014) discuss tax competition for capital among small countries and a large country (hub). The paper finds that large countries have an advantage in the competition game. Firms may still choose large countries to invest even with higher taxes. Firms that invest in the hub country can access foreign markets easier than firms located in the small countries.

4. Agglomeration effects in an international tax competition model

Kind, Knarvik and Schjelderup (2000) and Ludema and Wooton (2000) analyze the impact of agglomeration effects on tax competition. They find that an industrialized country with agglomeration has an advantage. Typically, firms earn an above-average return from agglomeration. As the result, the host country with agglomeration sets a higher tax rate without

driving investment away. The industrial cores can impose a higher capital tax rate than small countries and still receive capital inflows.

Baldwin and Krugman (2004) also confirm that agglomeration creates additional rents for firms and the government can impose a higher tax rate without inducing relocation of investment. Advanced countries can set a higher tax and a tax gap can be maintained between the advanced countries and small countries.

Baldwin and Okubo (2014) find similar results. In equilibrium, a large country charges a higher capital tax rate than a small country. With regard to firm size, larger firms are more sensitive to international tax differences. Lower trade costs spur international tax competition. Their finding of the effects of taxation on heterogeneous firms also implies that a small nation can improve its average productivity by lowering its tax rate. A lower tax may help attract larger (usually higher productivity) firms to the small nation because larger firms are more sensitive to tax differences. Tax competition therefore contributes to the convergence of productivity among large and small countries' industries.

Coulibaly (2008) empirically tests the previous theoretical results regarding agglomeration effects; namely, firms are willing to incur higher taxes in large countries because of extra benefits from agglomeration. Governments in large countries can impose higher corporate tax rates. Their results confirm the positive relationship between agglomeration rents and corporate income tax rates.

5. Endogenous world capital supply in a tax competition model

Most previous studies assume that world capital supply is exogenously fixed. Yakita (2014) discuss the importance of tax competition and tax policy coordination among countries on the

supply of capital. The paper assumes that savings and hence capital supply increase with the interest rate. Incorporating consumption-savings choices and endogenous capital supply into a tax competition model, the paper investigates the competitive equilibrium and compares it with the outcomes of tax coordination. They find that an equilibrium in tax competition is more efficient than a cooperative equilibrium.

IV. Tax competition in developing countries

Most of the tax competition literature is developed on the frame of a developed country. Although they mention "small" countries in those models, the core analysis focuses on developed countries. Little attention has been given to international tax competition affecting developing countries. In addition, those studies are all empirical work. This section reviews the limited work in this area.

Margalioth (2003) argues that developing countries can attract FDI by offering tax incentives. The author proposes that low corporate tax rates should be applied to investment with spillover effects. In tax competition, countries may consider an alternative tax revenue from consumption taxes. To reduce the harmful effects of tax competition, the paper suggests an international entity that can set a bottom corporate tax rate. Developing countries are not allowed to compete below this rate. While tax competition is a good policy for a developing country overall, an appropriate tax coordination may even be better. This international entity can help developing countries to coordinate tax rates among developing countries in order to increase developing countries' bargaining power against large international corporations. On the other hand, developing countries still remain in tax competition with developed countries.

Margalioth (2003) shows that developing countries can combine free trade polices and tax competition to attract FDI. FDI and trade will help to build a strong connection between developing countries and the industrial core. Technology transfer is an indispensable condition for the development of low-income countries. FDI is an important channel of technology transfer. Due to globalization and advanced technology, the traditional costs of cross-border investment such as communication, transportation and management have significantly decreased. Therefore, capital taxes have become the decisive part of the costs of investment and, hence, investment decisions. Lowering the capital tax rate or tax competition is a quick and effective tool to attract FDI to developing countries.

Azémara and Delios (2008) discuss tax competition in developing countries that receive FDI from Japan. They find that Japanese firms respond negatively to statutory corporate tax rates in developing countries. They conclude that developing countries involve in tax competition to attract FDI from Japan. Developing countries can use tax competition to compensate for their other weak economic factors such as low productivity or poor infrastructure. They also find that tax competition is strong in developing countries. Corporate tax rates in developing countries have decreased considerably. However, there will not be a race to the bottom in developing countries.

V. Foreign aid and foreign direct investment

To the best of my knowledge, there is currently no study that discusses the impact of foreign aid (ODA) on tax competition. The closest discussion available in literature is the relationship between foreign aid and foreign investment. Their conclusions are diverse, depending on different data and research methods. This section briefly reviews those studies.

Arazmuradov (2012) investigates the relationship between ODA and FDI in landlocked and transition economies of Central Asia. For the donor countries, they care whether their aid induces foreign direct investment. For receiving countries, it is crucial to design policies which favor ODA that brings more FDI and welfare improvements. They show that ODA and FDI are complementary flows. In addition, there is a crowding-in effect of domestic investment: domestic investment increases FDI but not foreign aid. In addition, they find that external financial flows help developing countries grow. The paper also finds a reverse effect that FDI attracts foreign aid.

Harms and Lutz (2006) investigate a similar topic with the data set from 76 developing countries. They also find that ODA and FDI are complementary. Bhavan, Xu, and Zhong (2011) investigate the impact of foreign aid on FDI in South Asian economies. They find that foreign aid works as a complement to FDI in these countries.

On the contrary, other studies find an opposite relationship. Caselli and Feyrer (2007) study groups of developed and developing countries, and conclude that foreign investment and foreign aid are substitutes. Some studies conclude that there is no relationship between ODA and FDI. Carro and Larrú (2010) investigate the impact of ODA in Brazil. They find that the main foreign direct investors are also the main donors but no systematic relations emerge between FDI and ODA flows, except for the Japanese case in Brazil. Kosack and Tobin (2006) also conclude that FDI and ODA have no relationship.

Margalioth (2003) discusses an alternative way to support growth in developing countries. He finds that foreign aid is not an effective way to support growth and encourage foreign investment in developing countries. The paper suggests creating an international tax mechanism to redistributes revenues from rich countries to developing countries. For example, developed countries should replace direct transfers such as foreign aid to developing countries with indirect

transfers through their tax policies to promote investment in developing countries. In other words, the paper suggests that developed countries should not tax income on a resident basis. If developed countries impose corporate income taxes on resident basis, any tax incentives offered by developing countries will fail to attract investment from developed countries. Low tax in developing countries is simply a tax revenue transfer from the developing countries to developed countries. Developed countries can support growth in developing countries through exempting incomes earned in developing countries. The author claims that this is an indirect transfer from developed countries which will help developing countries to attract more FDI.

VI. Tax competition with unemployment

Almost all of the tax competition literature assumes full employment. However, in the real world, one of the most important reasons for a country to engage in tax competition for more captal is to create more jobs and lower unemployment. There has been very little attention paid to linking tax competition and unemployment.

Ogawa, Sato, Tamai (2006)

Their model introduces a labor market imperfection into a symmetric (identical regions) tax competition to examine the equilibrium tax rate in the presence of unemployment. Their model extends Zodrow and Mieszkowski's (1986) model by permitting unemployment. In the labor market, they assume that the wage level is fixed. In the capital market, total capital in the economy is fixed and perfectly mobile across regions. Each resident in a region owns a fraction of capital in the economy. Residents' income includes wage income (for the employed worker), interest income from the capital ownership, and dividends from firms' profits. Both employed and unemployed workers pay the same head tax. A regional government uses both a capital tax and a head tax to

finance a public good. They seek to maximize the total utility of their residents (total utility for both employed and unemployed workers). In equilibrium, they show that when labor and capital are complementary in production ($F_{LK}>0$), a lower tax rate reduces the unemployment rate and increase resident's welfare. In this situation, the local government chooses to subsidize capital invested in the region. When capital and labor are substitutes in production $F_{LK}<0$, a decrease in the tax rate increases the unemployment rate. In this case, the government chooses a positive tax rate on capital to protect jobs.

Eichner, Upmann (2010)

The paper extends Zodrow and Mieszkowski's (1986) model by including unemployment and labor taxation. The model discusses regional tax competition in the context of symmetric tax competition. The main difference between Eichner, Upmann (2010) and Ogawa, Sato, Tamai (2006) is that the former allows a bargaining wage in the labor market, while the latter assumes a fixed wage. In every region, there are three groups of households: employed workers (they have full-time jobs), unemployed workers (maximal leisure time), and firm owners. An employed household receives a real labor income equal to the real wage income minus labor income tax. A firm owner receives profits from their investment. All three different types of households receive interest income from their saving. The model assumes a bargaining mechanism in the labor market: negotiations between a labor union and employers' association. The labor union acts on behalf of the interest of all workers (maximizes the sum of its member utilities). On the other hand, an employers' association acts on behalf of the firms (maximizes aggregate profits). The solution of the maximization (bargaining mechanism) is the employment level and wage rate in the labor market. Using the results, the paper analyzes tax competition when the governments compete over capital and labor taxes in the classical Zodrow and Mieszkowski (1986) model. They show that if

labor and capital are substitutes, tax competition and low capital tax rates result in under provision of public goods. The results of original Zodrow and Mieszkowski (1986) model are confirmed in the presence of the imperfection in the labor market and the introduction of labor tax. On the other hand, for some non-standard production functions featuring complementarity between labor and capital, tax competition can lead to overprovision of public good and in equilibrium the capital tax is negative (subsidy on capital). Their results suggest that optimal tax competition may vary by each country and its characteristics.

Egger and Seidel (2011)

Their model incorporates a labor market imperfection into a tax competition model with agglomeration effects. They find that unemployment increases the elasticity of capital investment with respect to tax rates. Unemployment increases tax competition. Imperfect labor markets reduce capital tax rates. The paper also shows that if a country tries to raise its capital tax, capital exports will increase and hence generate further unemployment. Higher tax rates also reduce net capital returns and lead to more relocation of capital. Their results imply that a decreasing capital tax attracts capital inflows and hence decreases unemployment.

The next chapter presents a theoretical model of tax competition with common characteristics found in developing countries. This model follows the standard set up from previous tax competition literature by Zodrow and Mieszkowski (1986), Cai and Treisman (2005) and Ogawa, Sato, Tamai (2006). My model however extends the current literature in several ways by adding different variables representing developing countries such as unemployment, foreign aid and productivity. In addition, this is an asymmetric tax competition model where all variables are allowed to vary across different countries. The model aims to address the most concerned

questions regarding tax competition in developing countries such as the existence of tax competition and different determinants of tax competition in developing countries.

CHAPTER 3 – THEORETICAL MODEL OF ASYMMETRIC TAX COMPETITION FOR DEVELOPING COUNTRIES

I. Introduction

Inadequate research in tax competition for developing countries

Over the last two decades, capital flows to developing countries have increased steadily. Developing countries have accounted for a larger share of total world FDI. According to UNCTAD, developing countries received 55 percent of total world FDI in 2014 while developed countries only received round 40 percent (UNCTAD – World Investment Report, 2015). The share of world FDI to developing countries was 36 percent and 47 percent in 2016 and 2017, respectively

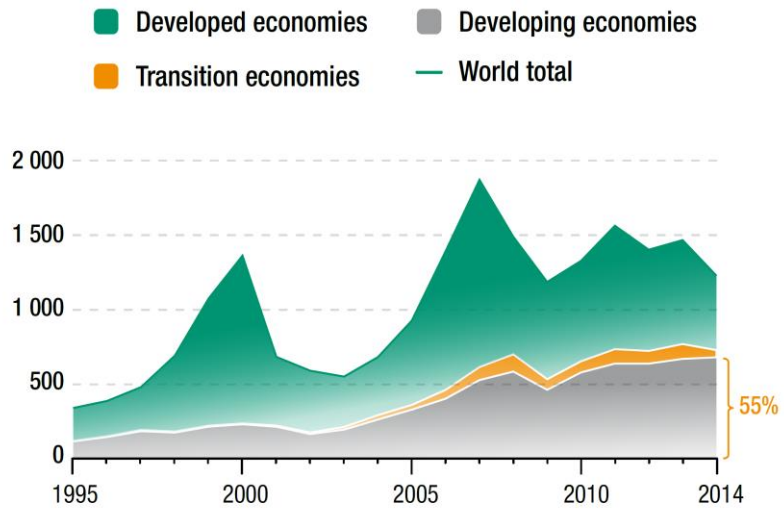


Figure 3.1 FDI Inflows, global and by group of economies 1995- 2014 (Billions of Dollars)

Source: UNCTAD – World Investment Report, 2015

(UNCTAD – World Investment Report, 2018). Although developing countries have accounted a relatively large share of world capital flows and have become active players in world capital

market, research on tax competition among developing countries is very limited. Most existing studies on tax competition have been focused on developed countries. Due to fundamental differences between developing and developed countries, results from research for developed countries may not be relevant to developing countries. Additional research in tax competition in developing countries is needed.

Tax competition – An important tool to compete for capital in developing countries

Among all instruments available to developing countries that affect FDI, the capital tax rate seems to be the quickest, easiest policy instrument that developing countries can use to attract foreign capital. Table 3.1 identifies several determinants of FDI. Much of the relevant literature has pointed out that most of these determinants are better in developed countries. In theory, developing countries could improve these determinants to compete for capital with developed countries. However, changing them is either too costly or takes too long to implement. With capital taxes, developing countries can quickly apply a tax cut to encourage FDI. Such policy is also transparent and quickly seen by foreign investors.

Table 3.1 Determinants of FDI

Determinants of FDI		Developing countries	Developed countries
Physical Infrastructure	Transportation system		√
	Telecommunication and IT system		√
	Electricity and water supply		√
Human capital	Education		√
	Skilled worker		√
Institution/ Legal system	Political stability		√
	Transparency, less corruption		√
	Law enforcement		√
	Copyright protection		√
Economic fundamentals	Low Inflation		√
	Productivity		√
	Foreign exchange stability		√
Tax competition (offering lower tax or tax incentive to foreign investors)		√	

Two main approaches of tax competition models

There have been two main approaches in the tax competition literature. The first approach focuses on competitive interactions between countries. These models use game theory to analyze the interaction between the two countries. The second approach follows the concept of tax competition in practice: tax competition occurs when a country lowers its capital tax rate in order to attract capital. In other words, a country sets a lower capital tax rates to receive more capital which implies tax competition. A common set up of this approach is to maximizes a country's national welfare with respect to its capital tax rate. This approach does not specifically model the

interactions between two competing parties using game theory as does the first approach, it does imply competition. A representative country sets its own capital tax rate from its welfare maximization problem considering tax rates by other countries as given. It is a noncooperative tax rate policy by the country or a Nash equilibrium. If a country lowers its capital tax rate and receive more foreign capital, it adversely affects other countries by lowering the capital available to them. Other countries respond in like fashion, producing competition.

My theoretical model in this chapter follows the latter approach. A representative country maximizes its own total welfare with respect to its capital tax rate. The possibility of lowering capital tax rate to attract FDI is discussed. Several theoretical results related to tax competition will also be analyzed. My empirical models in chapter IV estimate the response function of tax competition among countries. The response function tells us the interaction among countries

A new tax competition model with some common characteristics of developing countries

In this chapter, I develop a model of tax competition with some common characteristics that can be found in most developing countries: unemployment, receipt of foreign aid, and differences in total factor productivity. I add these variables to my model for several reasons. For unemployment variable, most of the previous tax competition literature assumes no unemployment. My model studies father by allowing unemployment, and seeks the relationship between unemployment and tax competition in developing countries. Both theoretical and empirical models in this paper will find out unemployment as a determinant of tax competition in developing countries. Unemployment variable disciplines developing countries' corporate tax policy. For foreign aid, developing countries commonly receive foreign aid. In my model, I include foreign aid as extra income that developing countries use to provide public goods or services. Figure 1.1 (chapter 1) outline the possible link between foreign aid and tax competition. My model

will discuss and make conclusion on this relationship. For total factor productivity, it is a fundamental parameter to represent the differences in levels of development across countries. In the model, I allow the total factor productivity to vary to study tax competition across countries with different development levels.

The paper closest to my model is Cai and Treisman (2005) and Ogawa, Sato and Tamai (2006). Ogawa introduces a labor market imperfection into the standard symmetric tax competition model to examine the equilibrium tax and its efficiency in the presence of unemployment. My model goes beyond the Ogawa model in several aspects. *First,* my model analyzes the effect of another common variable – foreign aid to developing countries. There have been no articles discussing the relationship between foreign aid and capital tax rates as well as foreign aid and tax competition. *Second,* while Ogawa assumes symmetric tax competition, my model allows total factor productivity to be a variable that characterizes the difference in the level of development among countries. Lower total factor productivity resembles a lower level of development. *Third,* while Ogawa assumes that countries have the same unemployment rate, my model allows different unemployment rates across countries.

II. The basic model

My model follows the approach adopted in Zodrow and Mieszkowski (1986) and Cai and Treisman (2005) models. These two models focused on utility maximization of a representative region and profit maximization in perfect competition. Competition among regions was modeled along Cournot-Nash lines. The government in each region acts on the assumption that all other regions do not respond to changes in its property tax rate (Zodrow and Mieszkowski,1986, page

359)[6]. A region sets its own tax rate where that rate is not based on the rate of other regions. Both models find the existence of tax competition when a region lowers its capital tax to receive more capital. This concept is widely used in tax competition literature: tax competition is present if a country lowers it tax rate to attract more capital.

Similar as Zodrow and Mieszkowski (1986) and Cai and Treisman (2005), I assume that there are N countries in the world (i = 1, …., N). Each country is different in total factor productivity, capital and labor endowment. Assume F_i is an aggregate production function for country i. F_i takes the standard Cobb-Douglas functional form:

$$F_i = A_i K_i^{\alpha} L_i^{\beta} \qquad [1]^{7}$$

where K_i, L_i and A_i are capital, labor and total factor productivity in country i respectively, and α and β are parameters.

I assume that production function has decreasing returns to scale ($\alpha+\beta<1$, $F_K>0$, $F_L > 0$ and $F_{KK} < 0$, $F_{LL}<0$). A country with a higher A_i has higher productivity because of, for example, more advanced technology, more educated human capital or better infrastructure. A country with a higher A_i is more developed than a country with a lower A_i. For capital K_i, I depart from the assumptions of the Ogawa, Sato and Tamai (2006) and Zodrow and Mieszkowski (1986) models. I assume that capital is fully owned and invested by capitalists (Laussel and Breton, 1998). Residents do not receive interest income from the capital ownership.

[6] Note that when we add more firms to the Cournot model and all firms acts non-cooperatively, the Cournot – Nash equilibrium converges to perfect competition.

[7] The production function specified in [1] is an aggregate production function with an aggregate capital K and an aggregate labor L in a country. In the Appendix D, I lay out a production function with two different types of capital K^1 and K^2. The main results regarding the existence of tax competition are unchanged. A country that lowers its capital tax rates receives more both types of capital. In addition, with two types of capital in the production function, a country prefers to attract a type of capital with a lower capital cost. In the optimal outcome, the country receives more capital with a lower cost and less capital with a higher cost.

To integrate unemployment into the model, I assume that the unemployment rate in the country i is μ_i, with the employment rate being $(1-\mu_i)$. For simplicity, I normalize the total population in the country to equal one. Since only the employed percentage of the population is involved in the production process the production function may be rewritten as:

$$F_i = A_i K_i^{\alpha}(1-\mu_i)^{\beta} \quad [2]$$

For simplicity, I assume that residents' utility function is linear with respect to public good G_i and private consumption x_i.

$$U_i(x_i) = x_i + \gamma_i G_i \quad [3]$$

γ_i is a parameter which reflects preference toward public good. Denoting the private consumption for employed worker as x_i^e and for unemployed worker as x_i^u, we have:

$$x_i^e = w_i \quad [4]$$

$$x_i^u = b_i \quad [5]$$

Employed workers earn wage income w_i. For simplicity, assume that the wage level is fixed and exogenously determined (w_i: fixed wage in country i). Unemployed people get unemployment benefits from the government b_i. I also assume that the price of the private good is 1 so that $x_i^e = w_i$ and $x_i^u = b_i$. The conversion rate between private and public good is 1:1; one unit of output can be converted to one unit of private or public good.

Assume that public good is freely available to anyone, and citizens have the same preferences for the public good. The utility functions for unemployed workers and employed workers are

$$u_i^u = x_i^u + \gamma_i G_i \rightarrow u_i^u = b_i + \gamma_i G_i \quad [6]$$

$$u_i^e = x_i^e + \gamma_i G_i \rightarrow u_i^e = w_i + \gamma_i G_i \quad [7]$$

Foreign aid to a developing country is usually provided through the government in that country. The aid is typically targeted at improving the developing country's capacity to provide public goods. We also assume that the foreign aid is controlled effectively without any corruption so that all the aid will be used toward public goods.

The government faces a balanced budget constraint

$$G_i + \mu_i b_i = t_i F_i + h_i(.) \quad [8]$$

where $t_i F_i$ is the tax revenue and $h_i(.)$ represents financial aid from developed countries or from international organizations. Following Cai and Treisman (2005), I assume that a capital tax is imposed on output and that there is no head tax. In practice, donor countries provide foreign aid to developing countries based on both economic and non-economic conditions. Common conditions include income per capita, security, political, human rights in recipient countries, promotion of trade for donor countries, and former colonial ties between donor and recipient countries (Alesina and Dollar, 2000; Meernik, Krueger and Poe, 1998). For simplicity, following Dudley and Montmarquette (1976), foreign aid is a function of income per capita. In my model, I assume population is 1, so foreign aid is a function of total output F_i. In fact, most foreign aid reported by countries, World Bank or other international organizations, are in percentage of GDP. I assume that the amount of foreign aid to a developing country is a simple linear function (or fraction) of GDP of that country. The foreign aid function to a developing country i is specified as

$$h_i(.) = \Omega F_i \quad [9]$$

Where Ω is a foreign aid parameter. In practice, developed countries (or donor countries) solely determine the amount of foreign aid. Once the threshold for income per capita in developing

countries is met, developed countries may consider many other factors to determine the amount of foreign aid to developing countries. For these reasons, I assume that the foreign aid parameter Ω is exogenous to the model. To model the impact of foreign aid, I assume that the aid is simply extra income (as a fraction of GDP) from outside which enters a developing country's government budget function and that the government in the developing country can use that extra income to provide public goods or services. Since my analysis is for developing countries receiving foreign aid, I assume that Ω is positive (Ω>0). It is also not necessary to integrate the condition of an income threshold into the model because we only limit the analysis to developing countries eligible to receive foreign aid. In the dataset for my empirical model, I only select countries which are currently eligible and have received foreign aid.

Substituting [9] into [8], we get:

$$G_i + \mu_i b_i = t_i F_i + \Omega F_i \qquad [10]$$

$$G_i = t_i F_i + \Omega F_i - \mu_i b_i \qquad [11]$$

The government in the developing country maximizes total welfare for its residents:

$$W_i = \mu_i u_i^u + (1 - \mu_i) u_i^e$$

From [6] and [7], equation [11] can be rewritten as:

$$W_i = \mu_i [b_i + \gamma_i G_i] + (1 - \mu_i)[w_i + \gamma_i G_i] \qquad [12]$$

Substituting [10] into [12], the total welfare function becomes

$$W_i = \mu_i [b_i + \gamma_i (t_i F_i + \Omega F_i - \mu_i b_i)] + (1 - \mu_i)[w_i + \gamma_i (t_i F_i + \Omega F_i - \mu_i b_i)]$$

which we may rearrange to get[8]

[8]Appendix A, section A.1.

$$W_i = \mu_i b_i + w_i - \mu_i w_i - \gamma_i \mu_i b_i + \gamma_i t_i F_i + \gamma_i \Omega F_i \quad [13]$$

The government maximizes total welfare equation [13] with respect to t_i. The production function F_i that is specified in equation [2] is a function of capital K_i. To solve the welfare maximization problem, we first need to solve for equilibrium capital K_i.

1. Equilibrium capital

In equilibrium, firms maximize profits and invest capital when the marginal product of capital equals the cost of capital:

$$\frac{\partial F_i}{\partial K_i} = r + t_i$$

For the assumed production function, we have:

$$\frac{\partial F_i}{\partial K_i} = A_i \alpha K_i^{\alpha-1} (1 - \mu_i)^{\beta} = r + t_i \quad [14]$$

We solve equation [14] for the equilibrium amount of capital invested in country i:

$$K_i^* = \left[\frac{A_i \alpha (1 - \mu_i)^{\beta}}{r + t_i} \right]^{\frac{1}{1-\alpha}} \quad [15]$$

Equation [15] gives some insights into the determinants of capital inflows to a developing country. I present these insights in several propositions.

Proposition 1: capital tax rate and investment

The capital tax rate is a determinant of capital flow. The capital tax rate in a country has an inverse relationship with capital invested to that country. A high capital tax rate hinders investments and a low capital tax rate attracts investments. According to tax competition concept by IMF, tax competition exists: countries that lower capital tax receive more capital.

Differentiating equation [15] with respect to t_i, we get:

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{1-\alpha}\left\{\left[A_i\alpha(1-\mu_i)^\beta\right]^{\frac{1}{1-\alpha}}[(r+\ t_i)]^{\frac{\alpha-2}{1-\alpha}}\right\}$$

Rearrange this equation to get[9]:

$$\frac{\partial K_i^*}{\partial t_i} = \left[\frac{-1}{(1-\alpha)}\right]\left[\frac{K_i^*}{(r+\ t_i)}\right] \qquad [16]$$

Since the second term of equation [16], $\left[\frac{K_i^*}{(r+t_i)}\right]$ is positive, the sign of $\frac{\partial K_i^*}{\partial t_i}$ depends on the first term $\frac{-1}{1-\alpha}$. Since $0 < \alpha < 1$, it follows that $-\frac{1}{1-\alpha} < 0$. The capital tax, in this regard, is similar to the capital cost.

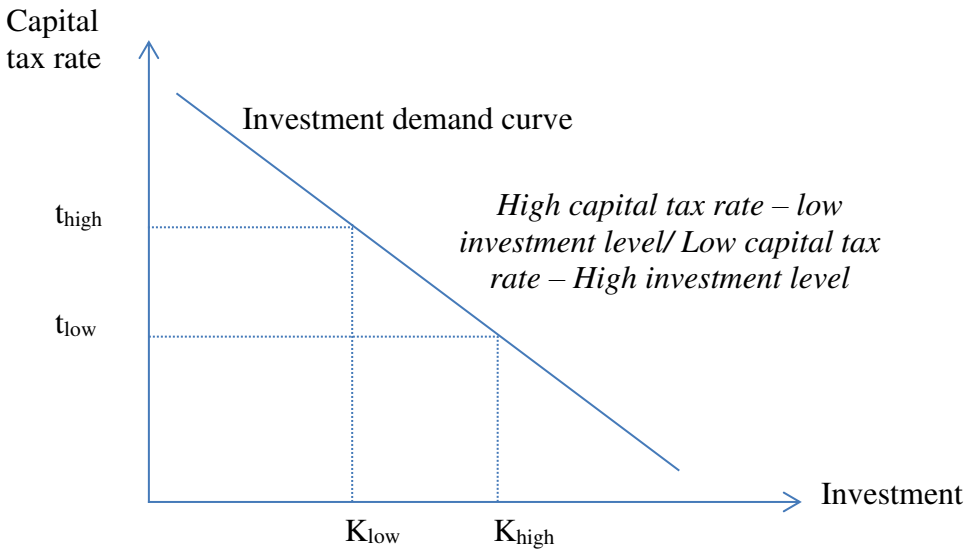


Figure 3.2 Capital tax rate is a determinant of investment inflows

This result reflects a standard result in the previous tax competition literature: countries compete for capital by lowering capital taxes. There are several examples across the world to

[9]Appendix A, section A.2.

illustrate tax competition. For example, Mooij and Ederveen (2003) found that the elasticity of a capital income tax with respect to FDI was -3.3. When Amazon has announced its plan to open the second headquarters in North America with an investment of $5 billion dollars. It received 238 proposals from 54 states and territories in the U.S., Canada and Mexico (as of October 23rd, 2017, Reuters web page listed: https://www.reuters.com/article/us-amazon-com-headquarters/amazon-receives-238-proposals-for-its-second-headquarters-idUSKBN1CS21O.). States offered billions in tax break as they compete to house Amazon headquarter 2. For example, New Jersey offered $7 billion tax incentives; California offered $300 million in incentives over several years and other benefits (as of October 19th, 2017, CNBC web page listed: https://www.cnbc.com/2017/10/19/amazon-offered-billions-in-tax-breaks-for-second-us-headquarters.html).

Proposition 2: unemployment rate and investment

- The unemployment rate is inversely related to capital invested in a country. If a country receives more investment, unemployment decreases. If investment flows out, unemployment increases.

  Differentiating equation [15] with respect to μ_i, we get[10]:

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha}\left\{[(1-\mu_i)]^{\frac{\beta+\alpha-1}{1-\alpha}}\left(\frac{A_i\alpha}{r+\ t_i}\right)^{\frac{1}{1-\alpha}}\right\} \qquad [17]$$

  The second term of equation [17], $\left\{[(1-\mu_i)]^{\frac{\beta+\alpha-1}{1-\alpha}}\left(\frac{A_i\alpha}{r+\ t_i}\right)^{\frac{1}{1-\alpha}}\right\}$, is positive. The sign of $\frac{\partial K_i^*}{\partial \mu_i}$ depends on the first term $-\frac{\beta}{1-\alpha}$.

[10]Appendix A, section A.3.

Since $0 < \alpha < 1$ and $0 < \beta < 1$, it follows that $-\frac{\beta}{1-\alpha} < 0$ and $\frac{\partial K_i^*}{\partial \mu_i} < 0$.

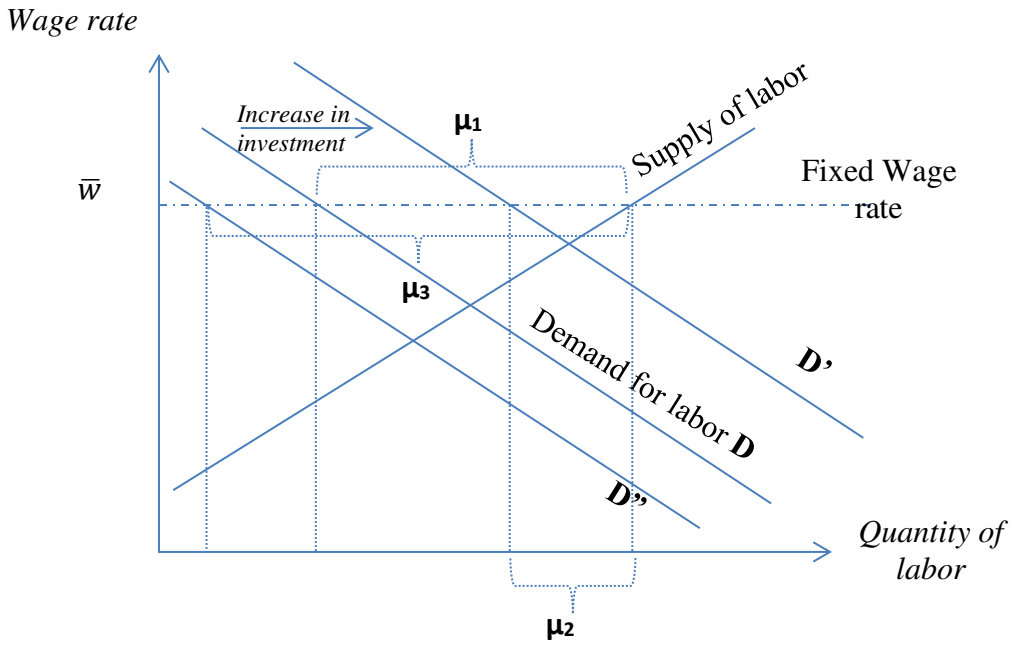


Figure 3.3 The impact of an increase in capital inflows (or an increase in investments) on labor market.

Intuitively, an increase in investments and more production will cause the demand for labor to shift rightward. In figure 3.3, the labor demand curve shifts from **D** to **D'**. If the wage rate is fixed at $\bar{w}$, unemployment decreases from μ_1 to μ_2. On the other hand, if investment flows out, there is less production and the demand curve for labor **D** shifts to the left to **D''**: unemployment increases from μ_1 to μ_3.

The result suggests that a solution to unemployment in a country is attracting more investment. In the case of developing countries, foreign investment is particularly important due to shortage of capital in developing countries. Foreign investment from developed countries comes with not only money capital but also tools, technologies and experiences. Foreign investment helps

to expand production capacity in developing countries. In addition, foreign investment with its worldwide distribution network helps to connect developing countries' producers with larger international market. Most of previous studies confirmed that FDI increases employment and decreases the unemployment rate for many countries and regions (Craigwell, 2006; Karlsson et al. 2009).

Proposition 3: Productivity and investment

- A country's ability to attract foreign capital depends on its total factor productivity. Specifically, a country with higher productivity will attract more capital than a country with lower productivity.

Differentiating equation [15] with respect to A_i, we obtain:

$$\frac{\partial K_i^*}{\partial A_i} = \frac{1}{1-\alpha}\left[\frac{\alpha(1-\mu_i)^{\beta}}{r+t_i}\right]^{\frac{1}{1-\alpha}} A_i^{\frac{\alpha}{1-\alpha}} > 0 \qquad [18]$$

The proposition suggests that a more developed country (higher productivity) receives more capital than a less developed country (lower productivity). This result is similar to Cai and Treisman (2005). A rich country (higher A_i) is more able to invest in public inputs, and, hence receive more capital. On the other hand, a poor country (with lower A_i) invests less in public inputs and receives less capital. FDI statistics have shown that developed countries with a small share of world's population hold most of world FDI stock. Africa, a region with lowest productivity, holds a tiny portion of total world FDI stock.

Table 3.2 FDI stock in different regions

Regions	2000		2010		2017	
	Millions	Percents	Millions	Percents	Millions	Percents
World	7,380,453	100.00%	20,279,391	100.00%	31,524,356	100.00%
Developed economies	5,782,408	78.35%	13,480,300	66.47%	20,331,171	64.49%
United States of America	2,783,235	37.71%	3,422,293	16.88%	7,807,032	24.77%
Developing economies	1,546,082	20.95%	6,123 095	30.19%	10,353,481	32.84%
Africa	152,801	2.07%	598,291	2.95%	866,817	2.75%
Developing Asia	1,052,674	14.26%	3,881,159	19.14%	7,262,946	23.04%
Latin America and the Caribbean	338,774	4.59%	1,629,249	8.03%	2,194,395	6.96%

Source: UNCTAD World Investment Report, 2018 and calculation by author

Proposition 4: labor share of output and investment

- Capital invested in a country has a negative relationship with labor share of output. In other words, if we assume a constant total share of both capital and labor (α+β = constant), then capital has a direct relationship with the capital share of output.

Differentiating equation [15] with respect to β, we have[11]:

$$\frac{\partial K_i^*}{\partial \beta} = \left\{ \left[\frac{A_i \alpha}{r + t_i} \right]^{\frac{1}{1-\alpha}} \frac{1}{1-\alpha} (1-\mu_i)^{\frac{\beta}{1-\alpha}} \right\} \ln (1-\mu_i) \qquad [19]$$

[11]Appendix A, section A.4.

The first part of equation [19], $\left[\frac{A_i\alpha}{r+t_i}\right]^{\frac{1}{1-\alpha}}\frac{1}{1-\alpha}(1-\mu_i)^{\frac{\beta}{1-\alpha}}$, is positive. In the presence of unemployment, $0 < \mu_i < 1$, $\ln(1-\mu_i) < 0$. It follows that $\frac{\partial K_i}{\partial \beta} < 0$. Capital has an inverse relationship with labor share of output.

This result implies that although a country receiving more capital increases its income, the majority of the extra income goes to capitalists and a smaller portion goes to labor. Productivity is the driver of the change in labor and capital share of output. In the proposition 3, a positive relationship between capital and productivity $\frac{\partial K_i}{\partial A_i} > 0$ indicates that an increase in capital drives up the productivity in the country. While workers have a higher productivity and produce more output, capitalists still pay workers the same wage. As a result, an increase in capital investment causes a decrease in labor share of output.

Decreuse and Maarek (2007) empirically test FDI flows and the labor share in developing countries. They show that capital has two opposite effects on the labor share. First, because foreign firms have monopoly power in the labor market, FDI decreases labor share. This negative effect dominates in early stages of financial openness. Second, foreign firms competing with each other to attract labor services raise the wage share of income. This positive effect dominates at the later stage of development.

2. The optimal capital tax

This section solves the optimal capital tax rate in a representative developing country. We use the optimal capital (K_i^*) from the profit maximization problem in the above section: equation [15]. The optimal capital tax rate t_i^* and capital K_i^* are the optimal combination for both profit and social welfare maximization. To set the optimal capital tax rate t_i^*, the social planner maximizes

the welfare of all residents (employed workers and unemployed residents) with respect to the tax rate. They face the balanced budget constraint in equation [8].

Specifically, the social planner maximizes the total social welfare function (specified in equation [13]) with respect to capital tax rate t_i:

$$\underset{t_i}{\text{Max}}\, W_i = \mu_i b_i + w_i(1-\mu_i) - \gamma_i \mu_i b_i + \gamma_i t_i F_i + \gamma_i \Omega F_i$$

The first order condition is

$$\frac{\partial W_i}{\partial t_i} = \gamma_i F_i + \gamma_i t_i \frac{\partial F_i}{\partial t_i} + \gamma_i \Omega \frac{\partial F_i}{\partial t_i} = 0$$

Using the chain rule, we have

$$\frac{\partial W_i}{\partial t_i} = \gamma_i F_i + \gamma_i t_i \frac{\partial F_i}{\partial K_i}\frac{\partial K_i}{\partial t_i} + \gamma_i \Omega \frac{\partial F_i}{\partial K_i}\frac{\partial K_i}{\partial t_i} = 0 \qquad [20]$$

We have seen that[12]

$$\frac{\partial K_i^*}{\partial t_i} = -\frac{1}{1-\alpha} K_i^* \frac{1}{(r + t_i)} \qquad [21]$$

From firm profit maximization, we have

$$\frac{\partial F_i}{\partial K_i} = r + t_i \qquad [22]$$

Substituting equations [21] and [22] and the production function [2] into the first order condition [20], we have:

[12]Appendix A, section A.5. equation [21]

$$\frac{\partial W_i}{\partial t_i} = \gamma_i A_i K_i^{\alpha}(1-\mu_i)^{\beta} + \gamma_i \mathrm{t}_i (r+t_i)\left[-\frac{1}{1-\alpha}K_i \frac{1}{(r+\ t_i)}\right]$$

$$+ \gamma_i \Omega (r+t_i)\left[-\frac{1}{1-\alpha}K_i \frac{1}{(r+\ t_i)}\right] = 0$$

Rearranging the above equation to get[13]:

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[A_i K_i^{\alpha-1}(1-\mu_i)^{\beta} - \mathrm{t}_i \frac{1}{1-\alpha} - \Omega \frac{1}{1-\alpha}\right] = 0$$

Since $K_i > 0$ and $\gamma_i > 0$, the second term must equal to zero. Substituting the equilibrium capital K_i^* in equation [15], we have:

$$\left[A_i \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r+\ t_i}\right]^{\frac{1}{1-\alpha}(\alpha-1)} (1-\mu_i)^{\beta} - \mathrm{t}_i \frac{1}{1-\alpha} - \Omega \frac{1}{1-\alpha}\right] = 0$$

Rearranging the above equation, we get[14]

$$\frac{1}{\alpha(1-\alpha)}[r - r\alpha - \alpha\Omega + t_i(1-2\alpha)] = 0 \qquad [23]$$

$$=> r - r\alpha - \alpha\Omega + t_i(1-2\alpha) = 0$$

$$=> t_i(2\alpha - 1) = r - r\alpha - \alpha\Omega$$

The optimal capital tax rate is:

$$t_i^* = \frac{r\,(1-\alpha) - \alpha\Omega}{(2\alpha - 1)} \qquad [24]$$

The insight of equation [24] is discussed in Proposition 5.

[13]Appendix A, section A.5.
[14]Appendix A, section A.5.

Proposition 5: optimal capital tax rate and foreign aid

Differentiate equation [24] with respect to the foreign aid parameter Ω to get:

$$\frac{\partial t_i}{\partial \Omega} = \frac{-\alpha}{(2\alpha - 1)}$$

The sign of $\frac{\partial t_i}{\partial \Omega}$ depends on the size of α. There are two possible cases.

The first case arises when the capital share of output is more than 50% ($\alpha > \frac{1}{2}$). In reality, this is a common case because the capital share of output of developing countries is greater than 50% (Dao et al. 2017). In this case, we have $\frac{\partial t_i}{\partial \Omega} < 0$. The capital tax rate has an inverse relationship with the amount of foreign aid. An increase in foreign aid helps the government in a developing country to lower their capital tax rate. Thus, foreign aid intensifies tax competition. For example, if the Australian government provided foreign aid to Indonesia in a clean water project, the Indonesian government might be able to reduce government expenditure in foreign aid projects and hence cut government revenue an equivalent amount per balance budget constraint. If the Indonesian government chooses to lower capital tax, foreign aid intensifies tax competition.

The second case is when the output share of capital is less than 50% ($\alpha < \frac{1}{2}$). In this case, $\frac{\partial t_i}{\partial \Omega} > 0$. The capital tax rate has a direct relationship with the amount of foreign aid. The result suggests that when α< 1/2 an increase in foreign aid results in greater provision of the public good. The increase in foreign aid is not followed by a capital tax cut. This situation can be explained in a situation of poor least developed countries. Those countries may give up tax competition. According to KPMG's corporate tax database, African countries have the highest capital tax rates. Those countries may not be able attract foreign investment even if they lower their capital tax

rates. They simply give up tax competition. Foreign aid simply serves domestic consumption. Tax competition is unaffected.

III. Model with both public input and public good

I now extend the model presented in the prior section to a developing country providing both a public input and a public good. The public good is available to consumers while the public input is used exclusively by firms to produce the final output. I employ the approach used by Dhillon, Wooders and Zissimos (2007) who identify the Nash equilibrium in a model where the public input enters the production function. The basic results of the model are described briefly below.

Denoting public input as I, the production function for a firm is $F_i = A_i K_i^{\alpha} L_i^{\beta} I_i^{\rho}$.

I again assume total population is normalized to equal one, of which $(1-\mu_i)$ is the percent employed and μ_i is percent unemployed. Since only the employment percent of the population is involved in production:

$$F_i = A_i K_i^{\alpha} (1-\mu_i)^{\beta} I_i^{\rho} \qquad [25]$$

where $0<\alpha<1$, $0<\beta<1$, $0<\rho<1$ and $0<\alpha+\beta+\rho<1$[15]

Perfect competition and profit maximization imply that the marginal product of capital equals the cost of capital.

$$\frac{\partial F_i}{\partial K_i} = A_i \alpha K_i^{\alpha-1} (1-\mu_i)^{\beta} I_i^{\rho} = r + t_i$$

[15] The assumption $0<\alpha+\beta+\rho<1$ reflects the fact that other fixed factors are not included in the production function such as land.

Solving for the equilibrium level of capital K_i, we obtain[16]

$$K^*_i = \left[\frac{A_i\alpha(1-\mu_i)^{\beta}I_i^{\rho}}{r+t_i}\right]^{\frac{1}{1-\alpha}} \quad [26]$$

With investment in public inputs, the budget constraint for government in country i:

$$I_i + G_i + \mu_i b_i = t_i F_i + \Omega F_i \quad [27]$$

The total social welfare function is

$$W_i = \mu_i u_i^u + (1-\mu_i) u_i^e$$

$$W_i = \mu_i[x_i^u + \gamma_i G_i] + (1-\mu_i)[x_i^e + \gamma_i G_i]$$

From [27], the public good is $G_i = t_iF_i + \Omega F_i - I_i - \mu_i b_i$. We substitute it into the total welfare function

$$W_i = \mu_i\{x_i^u + \gamma_i[t_iF_i + \Omega F_i - I_i - \mu_i b_i]\} + (1-\mu_i)\{x_i^e + \gamma_i[t_iF_i + \Omega F_i - I_i - \mu_i b_i]\}$$

and rearrange to obtain[17]

$$W_i = (\mu_i b_i + w_i - \mu_i w_i - \gamma_i\mu_i b_i) + \gamma_i t_i F_i + \gamma_i\Omega F_i - \gamma_i I_i \quad [28]$$

The social planner maximizes the total social welfare function with respect to the tax rate t_i and the investment in public input I_i.

The first order conditions are

[16]Appendix A, section A.6.
[17]Appendix A, section A.7.

$$\frac{\partial W_i}{\partial t_i} = \frac{\partial F_i}{\partial t_i} t_i \gamma_i + \gamma_i \mathrm{F}_i + \Omega \gamma_i \frac{\partial F_i}{\partial t_i} = 0$$

$$\frac{\partial F_i}{\partial t_i} t_i + \mathrm{F}_i + \Omega \frac{\partial F_i}{\partial t_i} = 0 \quad [29]$$

$$\frac{\partial W_i}{\partial I_i} = -\gamma \mathrm{i} + t_i \gamma_i \frac{\partial F_i}{\partial I_i} + \Omega \gamma_i \frac{\partial F_i}{\partial I_i} = 0$$

$$-1 + t_i \frac{\partial F_i}{\partial I_i} + \Omega \frac{\partial F_i}{\partial I_i} = 0 \quad [30]$$

We may solve these equations to get the optimal t_i[18]and I_i[19]:

$$t_i^* = \frac{(1-\alpha)r - \alpha\Omega}{2\alpha - 1} \quad [31]$$

$$I_i^* = A_i^{\frac{1}{1-\rho-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}} \rho^{\frac{1-\alpha}{1-\rho-\alpha}} \Big\{ (r - \alpha r - \Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} + \Omega(2\alpha - 1)^{\frac{\alpha}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} \Big\}^{\frac{1-\alpha}{1-\rho-\alpha}} \quad [32]$$

Proposition 6: Investment in public input and total factor productivity

From equation [32], take partial derivative of investment in public input I_i^* with respect to total factor productivity A_i to get:

$$\frac{\partial I_i^*}{\partial A_i} = \frac{1}{1-\rho-\alpha} A_i^{\frac{\rho+\alpha}{1-\rho-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}} \rho^{\frac{1-\alpha}{1-\rho-\alpha}} \Big\{ (r - \alpha r - \Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} + \Omega(2\alpha - 1)^{\frac{\alpha}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} \Big\}^{\frac{1-\alpha}{1-\rho-\alpha}} \quad [33]$$

All the components of the above equation [33] are positive:

[18]Appendix A, section A.8.
[19]Appendix A, section A.9.

$0 < \rho+\beta+\alpha < 1 \Rightarrow 1-\rho-\alpha > 0 \Rightarrow \frac{1}{1-\rho-\alpha} > 0$

$A_i^{\frac{\rho+\alpha}{1-\rho-\alpha}} > 0; (1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}} > 0; \rho^{\frac{1-\alpha}{1-\rho-\alpha}} > 0$

From equation [32], we have

$$A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}} > 0$$

If $I_i^* > 0$, it follows that the remaining part of the equation [32] (same as the remaining part of equation [33]) must be positive; i.e.,

$$\left\{(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}}(r-\Omega)^{\frac{-\alpha}{1-\alpha}} + \Omega(2\alpha-1)^{\frac{\alpha}{1-\alpha}}(r-\Omega)^{\frac{-\alpha}{1-\alpha}}\right\} > 0 \qquad [34]$$

As the result, $\frac{\partial I_i^*}{\partial A_i} > 0$. This equation indicates that investment in public inputs and productivity has as positive relationship.

Proposition 6: a country with higher productivity or more developed country (higher A_i) invests more in public inputs than a country with a lower productivity or developing country (lower A_i). As the result, a country with higher productivity has better business environment than a country with lower productivity.

This result suggests that by using public investment for infrastructure or creating a better business environment, developed countries can compete for capital. Developing countries, on the other hand, invest less in infrastructure, have less attractive business environments and receive less capital. This finding reflects real world observations. Developed countries have received most of capital even with higher capital tax rates than developing countries.

Proposition 7: unemployment and investment in public input

From the equilibrium investment in public input equation [32], we have:

$$\frac{\partial I_i^*}{\partial \mu_i} = A_i^{\frac{1}{1-\rho-\alpha}} \frac{\beta}{1-\rho-\alpha} (1-\mu_i)^{\frac{\beta+\rho+\alpha-1}{1-\rho-\alpha}} \rho^{\frac{1-\alpha}{1-\rho-\alpha}} \Big\{ (r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} + \Omega(2\alpha-1)^{\frac{\alpha}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} \Big\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

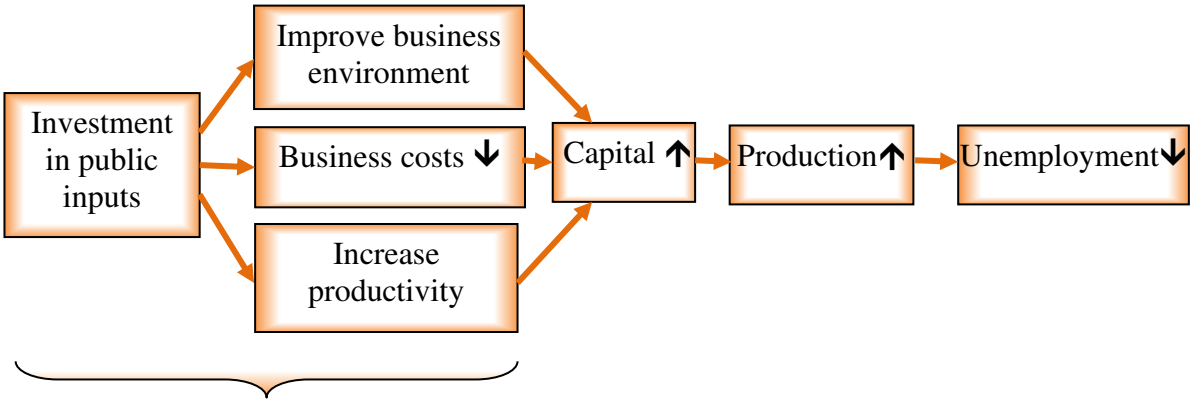
It is easy to verify that the first four components of the above equation are positive:

$$A_i^{\frac{1}{1-\rho-\alpha}} \frac{\beta}{1-\rho-\alpha} (1-\mu_i)^{\frac{\beta+\rho+\alpha-1}{1-\rho-\alpha}} \rho^{\frac{1-\alpha}{1-\rho-\alpha}} > 0$$

From [34], the last term of the equation $\frac{\partial I_i^*}{\partial \mu_i}$ is also positive. It follows that $\frac{\partial I_i^*}{\partial \mu_i} > 0$.

Proposition 7: Welfare maximization implies that a country with a higher unemployment rate should invest more in the public input.

Using the result in Proposition 6, we can explain the impact of investment in the public input on the unemployment rate. The finding in Proposition 6 ($\frac{\partial I_i^*}{\partial A_i} > 0$) indicates that a government which invests more in public inputs will increase productivity and improve its business environment. In turn, a country with higher productivity and better business environment can attract more capital. More capital or more investment will increase production. More production increases demand for labor reducing the unemployment rate.



Proposition 6: $\frac{\partial I_i^*}{\partial A_i} > 0$

Figure 3.4 Relationship between Investment in public inputs and unemployment

Proposition 8: Investment in public inputs and foreign aid

Rearrange the equation [32] to get[20]:

$$I_i^* = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(r-\Omega)^{\frac{1-2\alpha}{1-\rho-\alpha}}(2\alpha-1)^{\frac{2\alpha-1}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}} \quad [35]$$

Taking the partial derivative of this equilibrium investment in public inputs with respect to the foreign aid parameter Ω, we get[21]

$$\frac{\partial I_i}{\partial \Omega} = \left[A_i^{\frac{1}{1-\rho-\alpha}}\frac{1}{1-\rho-\alpha}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}\right]\left[(2\alpha-1)^{\frac{3\alpha+\rho}{1-\rho-\alpha}}\right]\left[(r-\Omega)^{\frac{\rho-\alpha}{1-\rho-\alpha}}\right] \quad [36]$$

It is easy to verify that the first term of equation [36] is positive.

$$\left[A_i^{\frac{1}{1-\rho-\alpha}}\frac{1}{1-\rho-\alpha}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}\right] > 0$$

[20]Appendix A, section A.10.
[21]Appendix A, section A.11. page 18 and 19

With regard to the third term, on average, foreign aid as a percentage of GDP is around 0.2% or less. The average worldwide lending interest rate is around 11 percent (as of June 1st, 2020, the global economy's web page listed: https://www.theglobaleconomy.com/rankings/lending_interest_rate/#:~:text=The%20average%20for%202019%20based,was%20in%20Hungary%3A%201.79%20percent.). These statistics suggest that the third term of equation [36] $(r-\Omega)^{\frac{\rho-\alpha}{1-\rho-\alpha}}$ is positive.

The sign of equation [36], thus, depends on the second term $(2\alpha-1)^{\frac{3\alpha+\rho}{1-\rho-\alpha}}$. The sign depends on the capital share of output α. There are two possibilities

Case 1: the capital share of output is more than 50% ($\alpha > \frac{1}{2}$).

In this case, the second term of equation [36] is positive. It follows that $\frac{\partial I_i^*}{\partial \Omega} > 0$; that foreign aid and investment in the public input have a positive relationship. An increase in foreign aid results in an increase in investment in the public input. In reality, this is a common case. Most countries have an output share of capital larger than 50%.

Using equation [31], we can also verify that $\frac{\partial t_i^*}{\partial \Omega} = -\frac{\alpha}{2\alpha-1} < 0$. An increase in foreign aid lowers the capital tax rate. In other words, foreign aid encourages tax competition in developing countries. These findings show that foreign aid increases both tax and fiscal competition for capital in developing countries.

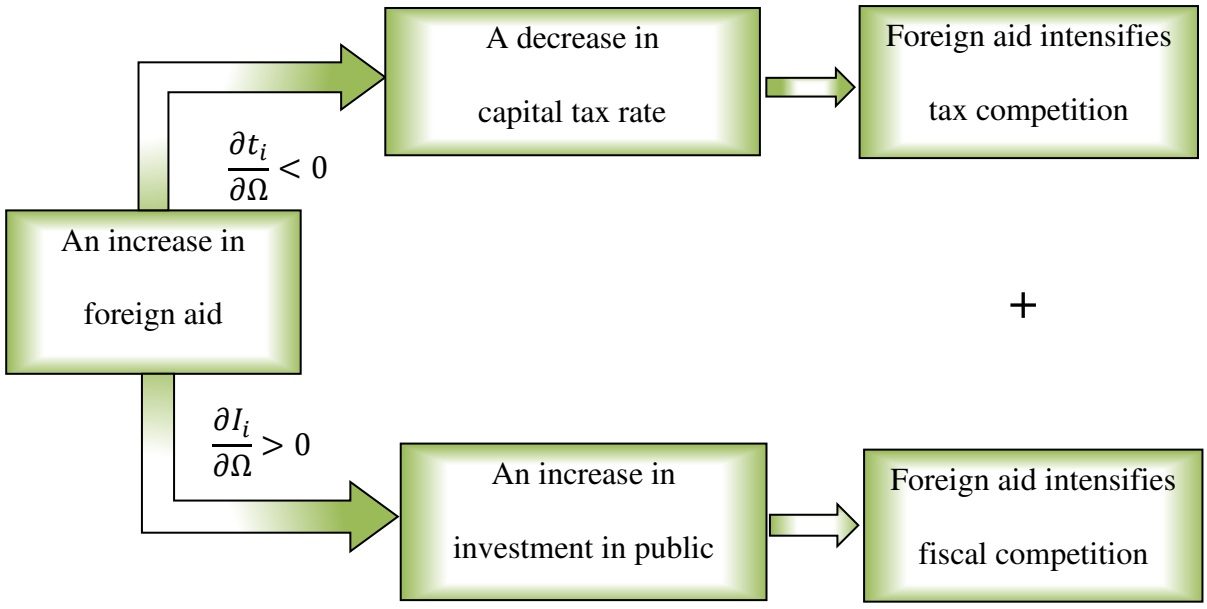


Figure 3.5 Foreign aid intensifies both tax competition and fiscal competition for capital in developing countries

Case 2: the capital share of output α is less than 50% ($\alpha < \frac{1}{2}$).

In this case, the second term of equation [36] is negative. It follows that $\frac{\partial I_i^*}{\partial \Omega} < 0$. This is not a common case for developing countries because most countries have an output share of capital greater than 50%.

This result suggests an alternative approach for use of foreign aid in developing countries. An increase in foreign aid leads to an increase in the provision of public goods but not an increase in public inputs. A developing country with a low capital share of output may be a poor country. The public good in that country may be limited to provision of necessities. More investment in the public good to satisfy basic needs for residents increases social welfare more than putting those resources into a public input.

The equilibrium capital equation [26], $K_i^* = \left[\frac{A_i\alpha(1-\mu_i)^\beta I_i^\rho}{r+t_i}\right]^{\frac{1}{1-\alpha}}$, provides some additional insights.

Proposition 9: investment in public inputs and capital flows

- A country that invests more in a public input attracts more capital. More public input improves the business environment and increases the marginal productivity of firms.

Using equation [26] $K^*{}_i = \left[\frac{A_i\alpha(1-\mu_i)^\beta I_i^\rho}{r+t_i}\right]^{\frac{1}{1-\alpha}}$, we have:

$$\frac{\partial K^*{}_i}{\partial I_i} = \frac{\rho}{1-\alpha}\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+t_i}\right]^{\frac{1}{1-\alpha}} I_i^{\frac{\rho+\alpha-1}{1-\alpha}} > 0$$

From the production function, we can get the marginal productivity of capital:

$$\text{MPK} = \frac{\partial F_i}{\partial K_i} = \alpha A_i K_i^{\alpha-1}(1-\mu_i)^\beta I_i^\rho$$

$$\frac{\partial MPK}{\partial I_i} = \alpha\rho A_i K_i^{\alpha-1}(1-\mu_i)^\beta I_i^{\rho-1} > 0$$

The above equation indicates that an increase in public input leads to an increase in the marginal product of capital. A country with productive capital will attract more capital flows.

South Korea, Singapore, Taiwan and China have made massive public investments in public inputs (telecommunications, industrial zones and transportation etc.). Foreign investments in those countries have increased significantly. Prior research has confirmed the role of public inputs in lowering the cost of private firms (e.g., Morrison and Schwartz, 1996; Bénassy, Gobalraja and Trannoy, 2007; Haughwout, 2001; Nadiri and Mamuneas, 1994).

This result and the result in Proposition 6 show that a high productivity country invests more in public inputs, which raises the marginal product of capital and attracts more investment

to the country. Both Propositions 6 and 9 confirm that differences in productivities play a role in fiscal competition for capital in developing countries.

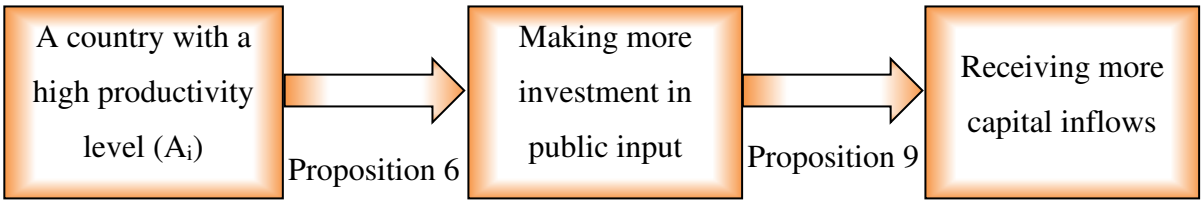


Figure 3.6 A high productivity country attracts capital inflows by investing more in public inputs:

The conclusions reached in the prior section where the government only provides public good carry over to the model with both a public input and a public good.

Proposition 10

Capital invested in country i has an inverse relationship with the capital tax rate in that country. A high capital tax restricts investments while a low capital tax attracts investments.

The partial derivative of equilibrium capital equation [26] with respect to the capital tax rate is[22]

$$\frac{\partial K_i^*}{\partial t_i} = -\frac{1}{1-\alpha}\left[A_i\alpha(1-\mu_i)^{\beta}I_i^{\rho}\right]^{\frac{1}{1-\alpha}}\frac{1}{(r+t_i)^{\frac{2-\alpha}{1-\alpha}}} < 0 \qquad [37]$$

Proposition 11

A country with a higher productivity receives more capital than a country with a lower productivity.

[22]Appendix A, section A.12.

$$\frac{\partial K_i^*}{\partial A_i} = \frac{1}{1-\alpha}\left[\frac{\alpha(1-\mu_i)^{\beta} I_i^{\rho}}{r+t_i}\right]^{\frac{1}{1-\alpha}} A_i^{\frac{\alpha}{1-\alpha}} > 0 \qquad [38]$$

A higher-productivity country (usually a developed country) receives more investments than a lower-productivity country (usually a developing country). In addition, as indicated in proposition 6, the higher-productivity country also invests more in public inputs and, hence, has a better business environment to attract even more capital.

Proposition 12

Capital invested in country i has an inverse relationship with the country's unemployment rate. Capital inflow lowers the unemployment rate, and capital outflow increases the unemployment rate.

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha}\left[\frac{A_i \alpha I_i^{\rho}}{r+t_i}\right]^{\frac{1}{1-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}-1} < 0 \qquad [39]$$

Proposition 13

Capital invested in country i has a negative relationship with output share of labor. In other words, capital invested in a country has a direct relationship with output share of capital.

$$\frac{\partial K_i}{\partial \beta} = \frac{1}{1-\alpha}\left[\frac{A_i \alpha (1-\mu_i)^{\beta} I_i^{\rho}}{r+t_i}\right]^{\frac{1}{1-\alpha}} \ln(1-\mu_i) < 0 \qquad [40]$$

This result is similar to Proposition 4 where the government only provides public good. Because capitalists have monopoly power in the labor market in developing countries wage income is relatively low. The majority of income goes to the capital owner. Dao, Das, Koczan and Lian (2017) show that the labor share of income has decreased in all developing, emerging and developed economies. The share is lower in developing countries.

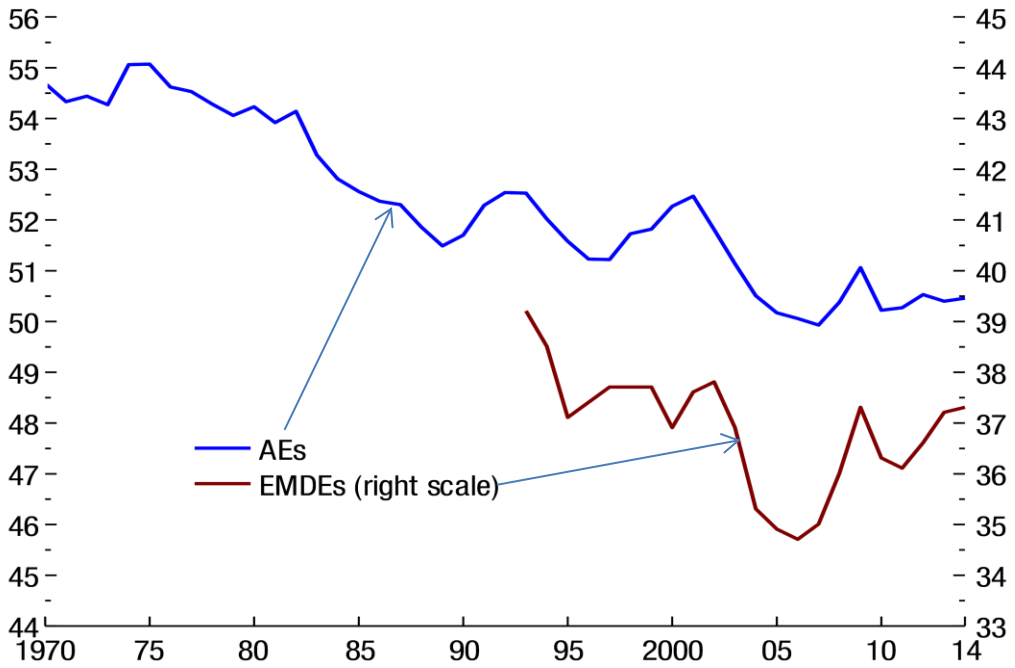


Figure 3.7 - Evolution of the Labor Share of Income

Sources: Dao, Das, Koczan and Lian, 2017

Proposition 14

A higher interest rate or cost of capital hinders investment flows while a lower interest rate or cost of capital attracts investment flows.

$$\frac{\partial K_i}{\partial r} = -\frac{1}{1-\alpha}\left[A_i\alpha(1-\mu_i)^{\beta}I_i^{\rho}\right]^{\frac{1}{1-\alpha}}\frac{1}{(r+t_i)^{\frac{1}{1-\alpha}+1}} < 0 \qquad [41]$$

This result reflects the standard economic theory: the inverse relationship between interest rate and investment. Lower interest rates stimulate investment and vice versa.

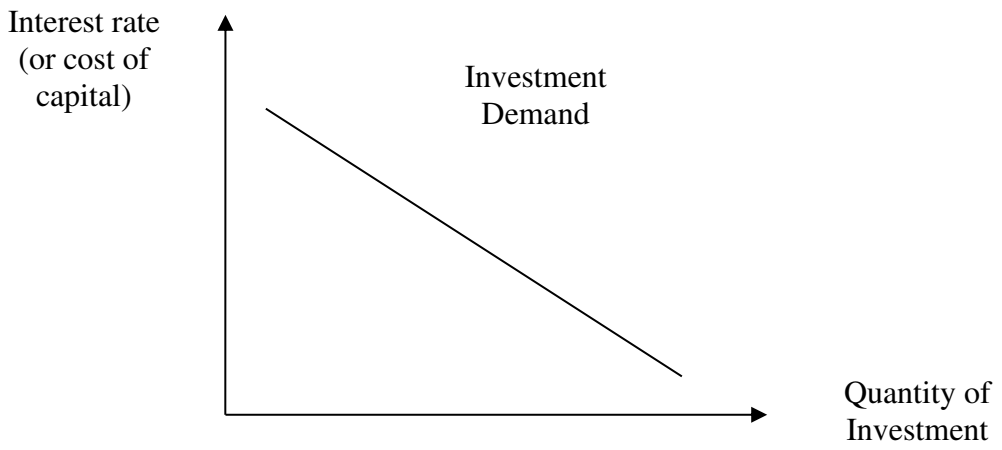


Figure 3.8 – Relationship between cost of capital and investment

For small developing countries, the world interest rate (or foreign investors' cost of capital) is exogenously set. Although the countries cannot directly influence that interest rate, observing it still plays an important role in attracting more investments. There are local investment costs and other incentives in the hands of the local government (e.g., utilities, land rents and tax rebates) which can be used to indirectly stabilize the fluctuation of the interest rate and hence maintain good capital inflows. For example, if the world interest rate increases (higher world interest rate discourages foreign investment), developing countries may still encourage foreign investment to their countries by provide more incentive to offset the increase in the world interest rate.

The theoretical results reached in this chapter suggest the possible presence of tax competition in developing countries. Developing countries lower capital tax rates to attract capital flows. In addition, my inclusion of the two new factors foreign aid to developing countries and unemployment rates in a tax competition analysis suggest how those factors might affect tax competition in developing countries. Specifically, a high unemployment rate lowers the capital tax

rate in developing countries (high unemployment rate intensifies tax competition)[23]. The impact of foreign aid on the capital tax rate in developing countries depends on the output share of capital. If the output share of capital is greater than one half, foreign aid intensifies both tax competition and fiscal competition for capital. On the other hand, if the share is smaller than one half, foreign aid increases provision of public goods instead of lowering the capital tax rate or increasing investment in public inputs. The next chapter empirically estimates the tax competition model in developing countries. It also investigates other related propositions from this theoretical chapter.

[23] This follows from Propositions 1 and 2. Proposition 1: lowering the capital tax rate increases investment. Proposition 2: an increase in investment lowers unemployment rates. It follows that in order to lower the unemployment rates developing countries may lower the capital tax rate.

CHAPTER 4: EMPIRICAL MODEL, METHODOLOGY AND DATA

I. Overview

Several empirical papers have discussed tax competition and corporate tax rates in OECD and developed countries, and there are handful of discussions regarding corporate tax rates and tax competition in developing countries. Based on the current literature, one may have the impression that there is little to no tax competition in developing countries while the competition is very intense in developed countries. On the contrary, considering the need for capital in developing countries, developing countries are hungry for capital. Indeed, their labor-abundance and capital-scarcity may push them to search and compete for capital even more. Developing countries need FDI not only for physical capital and foreign dollars but also, and even more importantly, for intangible assets such as technology transfer, ideas, skills, managerial knowledge, and access to worldwide distribution networks. Developing countries acquire not only the direct benefits of foreign enterprises but also indirect benefits from spillover effects to other domestic companies.

There has been limited attention paid to the study of tax competition and its effects on foreign investment flows to developing countries. Several unanswered questions in current literature are addressed. In this chapter, I aim to fill this gap. First, the impact of foreign aid on tax competition in developing countries is estimated. My theoretical results in the previous chapter indicate that foreign aid may intensify or restrict tax competition depending on the output share of capital in developing countries. Second, I analyze the effect of unemployment rates (a common issue in developing countries) on tax competition. Most previous studies on tax competition assume full employment. Third, the impact of capital tax rates on capital flows is estimated. The results allow us to reach conclusions about the existence of tax competition in developing

countries. Fourth, I estimate the capital tax response functions of developing countries. The response functions tell us how developing countries compete with each other. Several other theoretical results in the previous chapter are empirically investigated such as the relationship between productivity and tax competition, investment in public inputs and capital flows, and investment in public inputs and tax competition. I also include other related variables to estimate the model such as the inflation rate, the exchange rate, and population. I analyze the impact of these variables on tax competition and capital flows to developing countries.

To address these issues regarding tax competition, I estimate two econometric models. The first model, discussed in Section II, provides insight into the existence of tax competition in developing countries. By definition, tax competition exists if a tax on capital negatively affects capital flows. Thus, I must test whether capital taxes affect capital flows. The dependent variable in this model is FDI. If tax competition exists, the expected sign of the parameter of corporate tax rate variable is negative: lowering the capital tax rate attracts investments. To estimate the model efficiently, I test for the presence of first order serial correlation (AR1) and cross-sectional dependence in the model. If there are cross-sectional dependence and/or serial correlation in the model, an appropriate estimation model will be discussed.

The second model, discussed in section III, estimates the response function of tax competition among developing countries. It answers the question how a country responds to other countries' corporate tax rate changes. Specifically, if a country lowers its capital tax rate, will other countries compete by doing the same? To estimate the functions, a spatial econometric model is estimated. The dependent variable is the corporate tax rate. The main independent variable of this model is the spatial weighted corporate tax rate. The expected relationship between these two

variables is positive. The positive relationship shows that if a country lowers its corporate tax rate to compete for capital, other countries will follow suit by lowering their rates.

Section IV introduces the dataset used in my analysis and provides a statistical summary of the dataset.

II. Econometric model for investigating the necessary condition of tax competition in developing countries (model 1)

1. Overview

I aim to test the necessary condition for tax competition in developing countries. Specifically, I estimate the impact of corporate tax rates on FDI flows to developing countries. Proposition 1 and 10 of the theoretical results suggests an inverse relationship between the tax rates and investment flows. The proposition implies that when tax competition exists a country which lowers its capital tax rate will receive more investment. In practice, the corporate tax rate may have two opposing impacts on investment flows. The negative effect is that a corporate tax cut increases investment income, attracting investors for more investment. The positive effect is that the corporate tax increases government revenues which may be used to invest in public inputs and attract more investments. If the negative effect dominates the positive effect, a capital tax cut increases investment. If my theoretical result (Proposition 1) holds, we expect a negative sign on the estimate.

Besides providing insights into the necessary condition of tax competition, I also estimate other relationships implied by theoretical results in the previous chapter. Specifically, I test Propositions 2, 3 and 9 presented in chapter 3.

First, Proposition 2 indicates that investment flows have an inverse relationship with the unemployment rate. Investors see a high unemployment rate as a signal of an economic instability or a low-skill labor force in the host country and, hence, invest less in that country. In addition, more investment inflows create more jobs in host countries lowering unemployment rates. Second, Proposition 3 suggests that productivity has a direct relationship with investment flows in developing countries. Specifically, a theoretical result predicts that a high-productivity country attracts more investment, and a low-productivity country receives less investment. A high-productivity country usually has a high skilled labor force, better infrastructure, advanced technology and better business environment which may help investors lower their costs. High productivity, low cost and efficiency in production often result in more profits for investors. Third, Proposition 9 shows that a country that invests more in public inputs attracts more investment. Investment in public inputs is expected to improve countries' business environments and increase marginal productivities. If the theoretical result holds, the expected sign on the estimate is positive.

In addition to estimating these propositions from chapter 3, I also estimate the impact of other potential factors such as education, inflation, and population on investment flows to developing countries.

2. The econometric model

The following model will be estimated:

$$y_{it} = \beta^0 + \beta^1 \tau_{it} + \sum_{j=2}^{j=k} X_{it}^j \beta^j + \mu_i + \varepsilon_{it}$$

where:

y_{it} is total investment flows to country i at year t,

τ_{it} is the country i's corporate tax rate at year t.

X_{it}^{j} with j = 1, …., k are other independent variables of country i in year t,

ε_{it} is a disturbance term associated with country i at time t.

μ_i: country-specific fixed effects. In the random effects model, μ_i is uncorrelated with all variables X^j. In the fixed effects model, μ_i can be correlated with all variables X^j.

There are k independent variables, j=1, …, k. The first independent variable j=1 is the corporate tax rate ($X_{it}^{j=1}\beta^{j=1}$ is $\beta^1\tau_{it}$). There are k-1 other independent variables (j=2,…,k) which will be discussed in the next section.

3. Variables

Dependent variable

The dependent variable y_{it} is the investment flows to a developing country i in year t. To estimate the model, I use inward FDI in a country as the proxy for investment flow to that country. Section IV provides summary statistics for this variable.

Independent variables

1. Corporate tax rate

In practice, there are two types of corporate tax rates: a statutory tax rate and an effective tax rate. I estimate the model using both statutory tax rates and effective tax rates. For statutory rates, I use KPMG corporate tax database and government websites in some developing countries especially Ministries of Finance. For effective tax rates, I use the corporate tax paid as percentage

of commercial profits from World Bank databank. Both estimation results are reported. I briefly discuss the advantages and disadvantages of each type.

Statutory corporate tax rate

The statutory corporate tax rate (statutory rate) is the legal rate specified by laws. A corporate tax policy in a country may have multiple statutory rates depending on different corporate income levels. Different industries may also have different tax rates. KPMG, a world accounting – auditing firm with branches in most countries over the world, has maintained (and regularly updated) a reliable statutory corporate tax database that has been widely used in literature[24]. In their corporate tax database, every country has a footnote describing different statutory tax rates in that country. In general, they use the rate specified in a country's Corporate Income Tax law under normal investment conditions. Special rates are not reported in their database. For example, low tax rates that are applied for new technology enterprises, enterprises established in certain targeted regions, enterprises employing a large quantity of labor, or high tax rates that are applied for enterprises in natural resources exploitation are not reported in their database. Usually, KPMG has footnotes describing such situations.

Advantages:

Statutory rates are available in many countries. These rates are officially published and announced in tax laws. They are accessible and visible to anyone. If a firm plans an investment in a country, the statutory rate gives it a legal base to estimate its expected tax burden. Research

[24] KMPM corporate tax database has been listed for use in several academic institutions:
Princeton University https://faq.library.princeton.edu/econ/faq/11219,
New York University
http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/countrytaxrate.html
University of Pennsylvania https://guides.library.upenn.edu/c.php?g=475329&p=3254256

indicates that while the statutory rate is usually not the actual tax rate paid, it is an important determinant in the choice of investment location. In addition, there is no statistical error in measuring statutory rates because the rate is stipulated by law.

Disadvantages:

The statutory rate is not the actual tax rate paid. In fact, most businesses pay less than the statutory rate because they take advantage of deductions and tax incentives from governments.

Average effective corporate tax rate:

The effective corporate tax rate (effective rate) is the ratio of the total corporate tax collected to the aggregate corporate taxable income (corporate tax base or commercial profit). Although the effective tax rate theoretically reflects the actual tax rate, there are disadvantages associated with using effective corporate tax rates. The major disadvantage is that it is not readily available in most countries. Second, the rate, if any, may contain errors. In order to get effective tax rate, actual data must be collected. The process of calculating the average effective tax rate in a country involves collecting tax and profit data from several firms in that country. The process may contain statistical errors. Third, a low effective tax rate may indicate a weak tax collection system, not a government's purpose to attract investments. In this case, honest businesses end up paying a higher tax than dishonest businesses. The effective rate is also distorted by government's weak enforcement. Slemrod (2004) showed that an effective rate might not be a good indicator of the actual tax rate facing a business. Fourth, for any firm which plans to make an investment in a country (the target of tax competition), the average effective tax rate is still far from an actual tax rate because they cannot know their real rate until they actually make their investments and their businesses are under operation. In addition, different companies have different deductions and,

hence, pay different tax rates. Even the same company may have different effective tax rates in different years.

2. Unemployment rate

The unemployment rate has two possible opposing effects on FDI. On one hand, a high unemployment rate attracts resource-seeking FDI. A high unemployment is an indicator of an excess labor supply in the labor market or "labor abundance". Resource-oriented FDI is a type of FDI that seeks low-cost labor and raw materials. A positive relationship between this type of FDI and unemployment is expected. On the other hand, a high unemployment rate might be a signal of macroeconomic instability. In order to avoid the risk and uncertainty associated with that instability, foreign investors may direct their capital to a more stable economy. A negative relationship is expected. Our theoretical model developed in chapter 3 supports the latter possibility[25].

As discussed in chapter 1[26], reported unemployment rates in developing countries have several shortcomings. To account for these shortcomings, I estimate the model with employment rate instead of unemployment rate.

3. Inflation rate

The inflation rate is included in the model as another proxy for macroeconomic stability. A high inflation rate usually is the result of an inappropriate fiscal and monetary policy and is an indicator of macroeconomic instability. A low inflation rate indicates a stable economy, high consumer confidence and good monetary and fiscal policies. Also, the inflation rate has a direct effect on exchange rates and foreign investors' profitability. A high inflation rate can cause exports

[25] Proposition 2 in chapter 3.
[26] Section IV, chapter I, page 25

to decrease, imports to increase, domestic currency to lose its values and investors' profits to decrease. Inflation is expected to have an inverse relationship with FDI.

The results of prior research on the impact of inflation rates on FDI are mixed for different reasons and countries. Rashid, Looi and Wong (2017) found a negative relationship in Asia Pacific Countries. Dodangi (2016) found a positive relationship in Iran. Demirhan and Yilmaz (2015) found a negative relationship in Balkan countries.

4. Productivity

The theoretical model in the previous chapter indicates that a country with high productivity receives more capital than a lower productivity country. GDP per capita has been widely used in the previous literature as a proxy for country productivity. Generally, output per capita reflects the value of goods and services each person in a country makes. Therefore, it is a good indicator of productivity in a country.

5. Investment in public inputs

The theoretical results in chapter 3 indicate that a country that invests more in public inputs attracts more capital. More investment in public inputs improves the business environment and increases the marginal productivity of workers. If our theoretical result holds, investment in public inputs and capital inflows have a positive relationship. To estimate the relationship, I use the share of public fixed capital formation in GDP as investment in public inputs.

6. Population size

For market-seeking FDI, investors look for a market to sell their products. Population size, a proxy for market size, is expected to have a direct relationship with investment inflows. Prior empirical research has studied the impact of population size on FDI. Abdul and Makkawi (2012)

found a positive relationship between them. Their paper examines the impact of population on FDI in 56 African and Asian countries. Anyanwu (2011) studied FDI to African countries and found a positive relationship.

7. Exchange rate

Fluctuation of exchange rates in foreign countries directly affects investors' profitability. FDI enterprises are involved in many foreign exchange transactions in their everyday operations (e.g. export/import of material and final products and transfer of funds and profits between host countries and home countries). As a result, exchange rates are involved directly in FDI enterprises' cash flows, accounting activities and profitability. For example, if a host country's currency depreciates or the value of the currency decreases relative to the value of foreign currency, it will have two direct effects on FDI. First, production and labor costs in the host country are lower because FDI investors pay employees and other domestic suppliers in the host country with that depreciated currency. Lower costs result in a higher rate of return to foreign investors. Second, a depreciation of host country's currency raises the relative wealth of foreign investors. Foreign investors can acquire host country's assets at a lower price in investors' home currency. Foreign investors have more incentives to invest in the host countries especially in the form of Mergers & Acquisitions (M&A). Prior empirical papers have studied the impact of exchange rates on FDI. For example, Klein and Rosengren (1994) concluded a significant relationship between FDI and the exchange rate in the United States[27].

[27] FDI in the United States decreased with a strong dollar (appreciation) and increased with a weak dollar (depreciation).

8. Education

An education variable is included to estimate the effect of the quality of human capital on FDI. In this paper, I use the gross enrollment ratio of tertiary education as a proxy for the quality of human capital. Tertiary education includes to all post-secondary education, including both private and public colleges, universities, technical training institutions and vocational schools (as of February 1st, 2020, the World Bank's web page listed: http://www.worldbank.org/en/topic/tertiaryeducation).

Previous studies have examined the impact of education and quality of human capital on FDI. Alfaro et. al. (2006) found that the quality of workforce has a positive impact on FDI. Mustafa and Vlad (2011) also found a direct relationship between FDI and the quality of human capital in middle income European countries.

III. Econometric model to estimate the tax competition in developing countries (model 2)

1. Overview

The primary focus of this model is to investigate capital tax competing behavior of developing countries. I seek to estimated countries' tax competition response functions. In addition, as I noted earlier, I will test other theoretical results from chapter 3. Specifically, the following research questions will be addressed: (1) How tax competition responds to changes in unemployment or employment rates, (2) How differences in productivity affect tax competition, (3) How foreign aid affects tax competition, (4) How investment in public inputs affects corporate tax rates in developing countries.

Besides testing the theoretical results in chapter 3, this model also includes other potential variables affecting corporate capital tax rates in developing countries such as population/ market size and trade openness. These variables will be discussed in detail in a later section.

2. Specification of the econometric model

The model aims to evaluate how the corporate tax rate in one country responds to corporate tax rate changes in other countries (a tax reaction function or tax response function). To study such interaction and dependence, a spatial model has been widely used in the literature. A spatial model takes into account the different levels of dependence among countries by weighting the relationships between pairs of countries differently (See e.g.; Braid 2000; Karkalakos and Kotsogiannis, 2007; Overesch and Rincke, 2011). The most common country characteristic that is used in spatial tax models is geographical distance dependence. Countries that are closer to each other are more responsive to each other's actions and hence have higher weights. Countries that are farther away from each other are less responsive to each other's actions and hence have lower weights. A spatial weight has an inverse relationship with a geographical distance. Observing worldwide corporate tax rates across countries indicates that corporate tax rates from countries that are close to each other, indeed, follow a similar pattern. For example, Canada's tax policy is more responsive to changes in US tax policy than to changes in Japan's tax policy. Vietnam's tax policy should respond more to Malaysia's or Thailand's tax rate changes than Mexico's tax rate changes. There are several reasons to justify that assumption. First, countries that are close to each other usually have similar characteristics that attract similar types of investment. Similar characteristics include natural resources, human capital, culture, and transportation distance to main consumption (import) market. Similar characteristics will attract similar types of investment hence encouraging them to compete more with each other in attracting foreign investment. Second,

countries that are close to each other may enter into agreements that make them more dependent on each other's policies. For example, these agreements may include customs unions, monetary unions, free trade areas and visa-free entry. Third, close countries also have lower travel, transportation and communication costs which may result in more economic interdependence. Fourth, close countries may also have interconnected transportation systems, such as railroad tracks, highways, airways and river transports, which may further increase economic interdependence. In addition, as a rule of thumb, countries that are close to each other tend to observe each other more closely than countries that are far away[28].

There may be some other possible dimensions to construct a weight matrix, such as natural resource reliance, labor intensity, the size of the economy and foreign trade dependence. However, there are either technical difficulties associated with calculating a weight matrix or there is a lack of practical evidence and prior literature discussion to relate these variables to tax competition. For example, natural resource, labor intensity and foreign trade are time variant variables while standard method of geographical distance bases on time invariant distance to calculate weights. Spatial models, with estimated (rather than fitted) weights have not fully been developed. In this paper, I use this standard method of geographical spatial weight matrix for the corporate tax dependence among developing countries.

The following spatial econometric model will be estimated:

$$t_{i,t} = \alpha + \gamma \sum_{j \neq i} s_{ij} t_{j,t-1} + \sum X_{i,t-1}\beta + \varepsilon_{it}.$$

I will discuss the elements of the model.

[28] Moroccan Proverb: Either do as your neighbors do, or move away.

$t_{i,t}$ is the country i's corporate tax rate in year t.

$t_{j,t-1}$ is the country j's corporate tax rate in year t-1.

γ is the spatial parameter to be estimated. It captures how country i's tax rate responds to tax rates of other countries. It is the coefficient of the response function of tax competition. A positive γ suggests that countries compete with each other in setting corporate tax rate. Specifically, if a country reduces its corporate tax rate to attract investments, other countries also lower their corporate tax rates to compete for capital.

s_{ij} is the spatial weight of country j with respect to country i. The weight depends on the distance between country i and country j. Specifically, the weight has an inverse relationship with the distance between countries. If country j is closer to country i, the weight is higher. I use the distance among capital cities as the distance among countries. In the next section, I will discuss the mathematical method used to create the spatial weight matrix.

The spatial weight matrix is NxN matrix (N is the number of countries) with zeros in the diagonal ($s_{ij} = 0$ if i = j). The weight s_{ij} is specified at i^{th} row and j^{th} column. The spatial matrix is row standardized. The summation of all elements across row i equals to 1: $\sum_{j=1}^{N} s_{ij} = 1$. The independent variable $\sum_{j \neq i} s_{ij} t_{j,t-1}$ is the weighted average tax rates of all countries other than country i in year t-1.

$X_{i,t-1}$ are other explanatory variables relating to country i. Explanatory variables are lagged one period to reflect policy lags. When an event happens, tax policy will take time to adjust. I will discuss the explanatory variables in greater detail in a later section.

The ε_{it} are disturbances. I assume that the ε_{it} are i.i.d. independent and identically distributed with a normal distribution [$\varepsilon_{it} \sim i.i.d.\ N(0,\sigma_{\varepsilon}^{2})$]. To avoid possible bias in standard errors associated with failure of the i.i.d. assumption, robust standard errors will be reported.

3. Dependent Variables

The dependent variable for this model is the corporate tax rate. As discussed earlier, I use two measures of corporate tax rates: a statutory tax rate and an effective tax rate. For statutory corporate tax rate, I use KPMG's corporate tax database. For effective corporate tax rate, I use profit tax (corporate tax paid as percent of commercial profit) from the World Bank databank. Section IV provides data summary for both statutory and effective rates. The correlation between the two series is also discussed in Section IV.

I add time lag to statutory corporate tax rates. My estimation results can capture the impact from a policy lag. It is possible that a country may take time to change its tax rates from observing the tax rate changes by other countries. In my model, I lag the corporate tax rate for one period or one year. Countries' tax rates are announced and updated yearly. In most developing countries, government may issue a Decree or an Order to announce any changes (if any) in corporate tax rates in a year. The Decree or Order from the government entity (a supplement to the law) does not require to pass through the National Assembly. The Decree or Order usually takes into effects the following period or following year.

4. Independent variables

Weighted average of lagged corporate tax rate

The independent variable $\sum_{j \neq i} s_{ij} t_{j,t-1}$ is the weighted average of corporate tax rates of all countries other than country i in year t-1. This variable is used to estimate tax competition among countries (or tax response function). The variable is lagged by one period to reflect a policy lag: if country j changes its corporate tax rate, country i observes the change and may adjust its own corporate tax rate in the subsequent period.

Population

A country with a large population may collect its agglomeration rents through a higher corporate tax rate. A large population attracts foreign investors because they hope to sell their products in the host country's market. Population size is expected to be an important factor in attracting market-seeking investments. Data for population is obtained from the World Bank data bank.

Unemployment rate

Corporate tax rates and unemployment rates are expected to have an inverse relationship. If a country has a high unemployment level, the country is expected to lower its corporate tax rates to attract more investment. The estimated parameter, thus, is expected to be negative. As I noted earlier, reported unemployment rates in developing countries may understate the number of people who try to find jobs. As a result, I use employment rate instead of unemployment rate to estimate the model.

GDP per capita

GDP per capita can affect a corporate tax rate in two ways. First, GDP per capita is the purchasing power of each resident in a country. Countries with high GDP per capita are likely to consume more than countries with low GDP per capita. The large consumption advantage allows a high-income country to impose a higher tax rate than a low-income country. Second, a country with high GDP per capita is usually a country with higher productivity. My theoretical model indicates that higher-productivity countries invest more in public inputs and, hence, have a better business environment. A better business environment, in turn, allows the countries to collect rents from investors through a higher corporate tax rate. If our theoretical results hold, the estimated parameter for this variable is expected to be positive.

Foreign aid

No prior research has discussed either the effect of foreign aid on corporate tax rates or the impact of foreign aid on tax competition. Prior research only studied the relationship between foreign aid and total tax revenue (including both income and sale taxes). The results are mixed. Benedek, Crivelli, Gupta and Muthoora (2014) found that foreign aid has a negative impact on total tax revenue. Other papers such as Clist and Morrissey (2011), and Carter (2013) found a positive impact. Ouattara (2006) found that the relationship is not statistically significant.

This paper studies the impact of foreign aid on corporate tax rates and tax competition in developing countries. To estimate the model, I use total ODA (Official Development Assistance) to a developing country as a proxy for foreign aid.

Investment in public inputs

Our theoretical results indicate that investment in a public input has a positive relationship with productivity. It means that an increase in investment in a public input raises the productivity of firms. In turn, higher productivity will attract more foreign investment.

We expect positive relationship between investment in public inputs and corporate tax rates. First, investment in public inputs helps firms to increase their productivity, output and profits. With higher profits, a government may set higher corporate tax rates without driving investors away. In addition, to balance the government's budget, an increase in investment in a public input or an increase in expenditure requires an increase in the revenue side of the budget equation. The increase in revenues may be achieved through increases in corporate tax rates. If our theoretical results hold, the estimated parameter on this variable is positive. To estimate the model, I use the share of public fixed capital formation in GDP as investment in public inputs.

Openness: Import + Export / GDP

Trade openness is associated with financial flows. Trade transactions are followed by financial transactions. In addition, countries with a high level of openness integrate more into the world economy and international financial markets. Those countries are likely to be more active in tax competition for capital.

5. Estimation technique

As discussed earlier, spatial dependences of corporate tax rates among different countries may be observed. In order to control for the distance-interdependence, a spatial econometric model and geographic weighting matrix are used. Specifically, the following weights are calculated:

$$s_{i,j} = \frac{\frac{1}{d_{i,j}}}{\sum_{j=1}^{N} \frac{1}{d_{i,j}}} \; for \; i \neq j$$

$s_{i,j}$=0 if i =j

where $d_{i,j}$ is the distance between country i and country j capital cities; $s_{i,j}$ is the spatial weight assigned to country j depending on the distance between j and i. If countries are farther away from each other, the weight $s_{i,j}$ is smaller. The above equation of $s_{i,j}$ indicates that spatial weight has an inverse relationship with the distance between country i and j.

IV. Data Summary

This section provides a preliminary examination of the sample data used to estimate the model. Data set of 63 developing countries in 15 years from 2003 to 2017 is used to estimate the models[29]. Appendix B lists all developing countries in the world (IMF - World Economic Outlook, 2019). The countries in my dataset are underlined. I only exclude (i) certain countries that may not satisfy the requirement of capital mobility due to international economic sanction or political unrest (such as Syria, North Korea, Iran, Libya, Lebanon, Iraq and Sudan), and (ii) any developing countries that do not have available data.

[29] In my theoretical model, I assume there are N countries in the world. Because optimization problem is the same in all countries (output is produced by perfectly competitive firms and government in each country maximizes total welfare.), I solve the problem for one representative country. It is not necessary to repeat the same process for other countries. However, my theoretical results actually imply several countries. In my empirical models, I estimate the model with 63 developing countries. The previous literature has adopted the same approach. For example, Knight (2002) had a theoretical model involving one representative region and an empirical model involving several regions. His theoretical model is also based on the Zodrow and Mieszkowski (1986) model.

I compare the developing countries in my dataset and the developing countries not in my dataset in terms of GDP per capita and median age in Appendix G. The countries in my dataset differ from the developing countries not in my dataset. My sample dataset seems focus on developing countries with higher income and higher median age. Thus, my empirical results are more relevant to this group of developing countries (higher income and higher median age).

In this section, I describe the four main sources of data. Second, I present descriptive statistics of all variables in both models. I focus on describing the increasing or decreasing trend of the variables. Other important values such as minimum, maximum, mean, median, standard deviation and correlation coefficient are also reported.

1. Panel data for developing countries

There are three main sources of data used in the model. First, World Development Indicators, World Bank (WDI) is the main source of data for this paper. WDI is the most current and reliable source of world development data. Data is available at the national, regional and global levels. Second, KPMG's tax database is used for corporate tax rates. KPMG has been collecting and publishing international data on tax rates since 2003. Third, the United Nations Conference on Trade and Development (UNCTAD) provides extensive data and analysis on foreign direct investment for all countries over the world. The Division on Investment and Enterprise of UNCTAD is the world central point for all issues related to FDI and multinational companies. Besides these three main sources, data for the paper is also collected from the IMF - World Economic Outlook Database, World Productivity Database of the United Nations Industrial Development Organization (UNIDO), the World Atlas (for distance between countries data) and the Websites of Ministries of Finance and Ministries of Trade in developing countries.

Panel data of 63 developing countries from 2003 to 2017 is used to estimate the models. There was a financial crisis in this period. To take into account of the crisis, I use year dummy variables in my regressions. An appropriate test is also used to check the significance of year dummies and to conclude whether year dummies should or should not be included in the model. In addition, several variables in our models are measured in nominated dollar value. To eliminate the impact of inflation over time, variables measured in term of money, data is collected in real /constant dollars.

In the next sections, I summarize the sample dataset and provide descriptive statistics of the variables in the models.

2. Corporate tax rate trend

2.1. The overall trend of corporate tax rates across regions

Figures 4.1 and 4.2 and Table 4.1 summarize the corporate tax rates across different regions and average corporate tax rates of the 63 developing countries in our dataset:

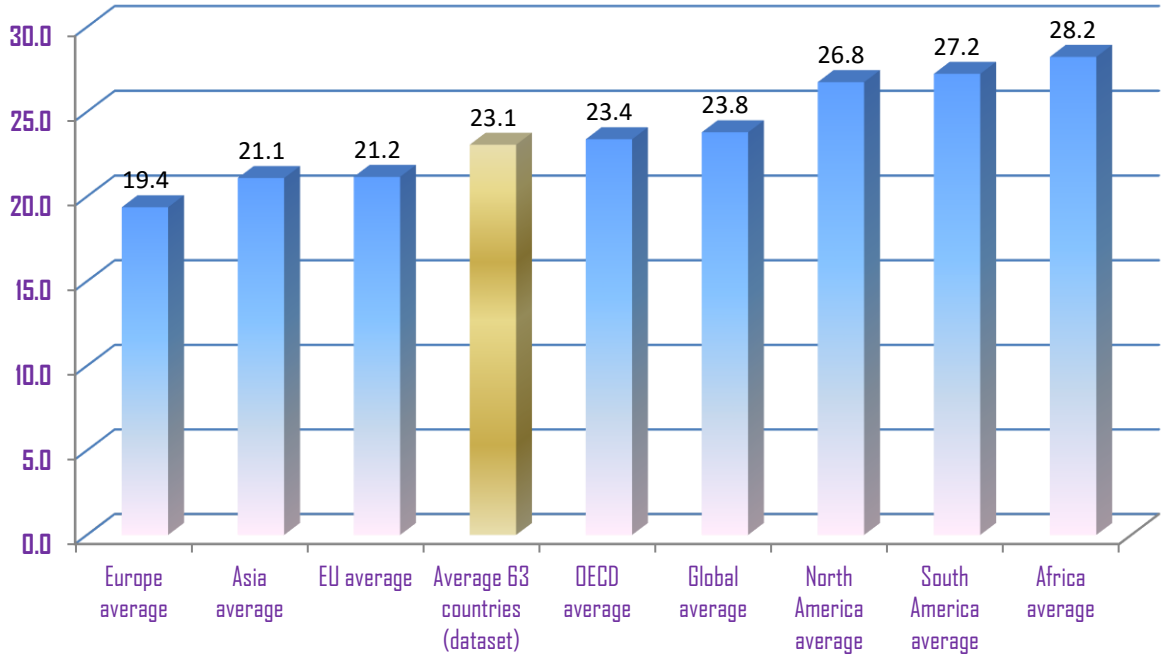


Figure 4.1 Corporate tax rates across regions in 2019

Data source: KPMG's corporate database – Calculation and Graph by author.

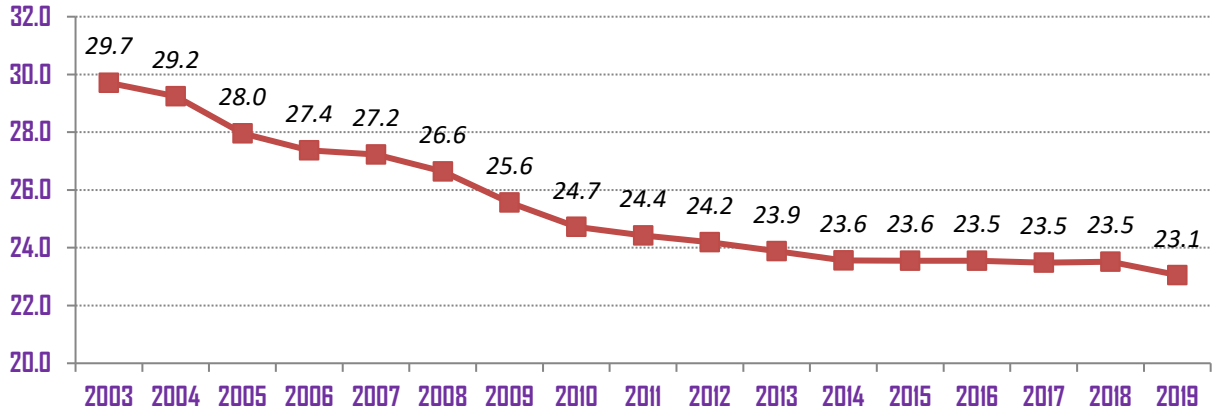


Figure 4.2 Average corporate tax rates of 63 developing countries in dataset

Data source: KPMG's corporate database – Calculation and Graph by author.

Table 4.1 Corporate tax rates across regions from 2003 to 2019

LOCATION	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Africa average	32.36	32.36	30.79	30.73	30.52	28.75	28.83	28.49	28.64	29.07	28.33	27.83	28.14	28.03	28.21	28.26	28.24
Americas average	31.29	30.55	30.52	29.97	29.27	28.84	28.82	28.28	29.31	28.67	28.35	27.77	27.61	27.71	28.29	27.97	27.21
Asia average	30.19	30.35	29.79	28.99	28.34	26.24	25.37	23.72	22.91	22.72	22.13	22.00	21.98	21.41	21.08	21.21	21.09
EU average	27.95	26.69	25.15	24.83	23.97	23.17	23.11	22.93	22.70	22.51	22.75	22.39	22.15	22.09	21.33	21.29	21.16
Europe average	26.72	25.60	24.03	23.70	22.99	21.95	21.64	21.46	20.83	20.44	20.60	20.42	20.05	19.97	19.53	19.48	19.37
Global average	29.42	28.95	28.00	27.55	26.96	25.66	25.32	24.65	24.52	24.38	24.17	23.88	23.77	23.62	24.06	24.02	23.79
Latin America average	30.81	30.02	29.68	29.07	28.30	27.96	27.96	27.52	28.88	28.30	27.96	27.31	27.16	27.29	27.98	28.05	27.24
North America average	35.30	35.05	38.05	38.05	38.05	36.75	36.50	35.50	34.00	33.00	33.00	33.25	33.25	33.25	33.25	26.75	26.75
OECD average	30.08	29.28	28.37	27.67	27.00	25.99	25.64	25.70	25.42	25.18	25.32	24.98	24.77	24.69	23.95	23.53	23.38
South America average	30.81	30.02	29.68	29.07	28.30	27.96	27.96	27.52	28.88	28.30	27.96	27.31	27.16	27.29	27.98	28.05	27.24
Average 63 countries (dataset)	29.08	28.65	27.77	27.22	27.09	26.54	25.46	24.72	24.44	24.21	23.88	23.56	23.55	23.55	23.48	23.52	23.06

Source: KPMG's corporate tax rate database – calculation by author.

Corporate tax rates varied across the regions. Regarding tax competition, Europe and Africa were at opposite extremes. Africa seemed not to engage in tax competition, having the highest corporate tax rates (around 4.45 percentage point above the global average in 2019). Africa also received the least foreign investment. On the other hand, European countries had the lowest capital tax rates. Europe's average corporate tax rate has been consistently the lowest rate among all other regions' rates since 2003. In 2019, the average corporate tax rate in Europe was 4.42 percentage points below the global rate.

Between 2003 and 2019, corporate tax rates across all regions exhibited a declining trend. In 2003, the worldwide average rate was around 29.4 percent. In 2019, the average rate was 23.79 percent. In our dataset of 63 developing countries, the average rate has decreased steadily from 29 percent to 23 percent.

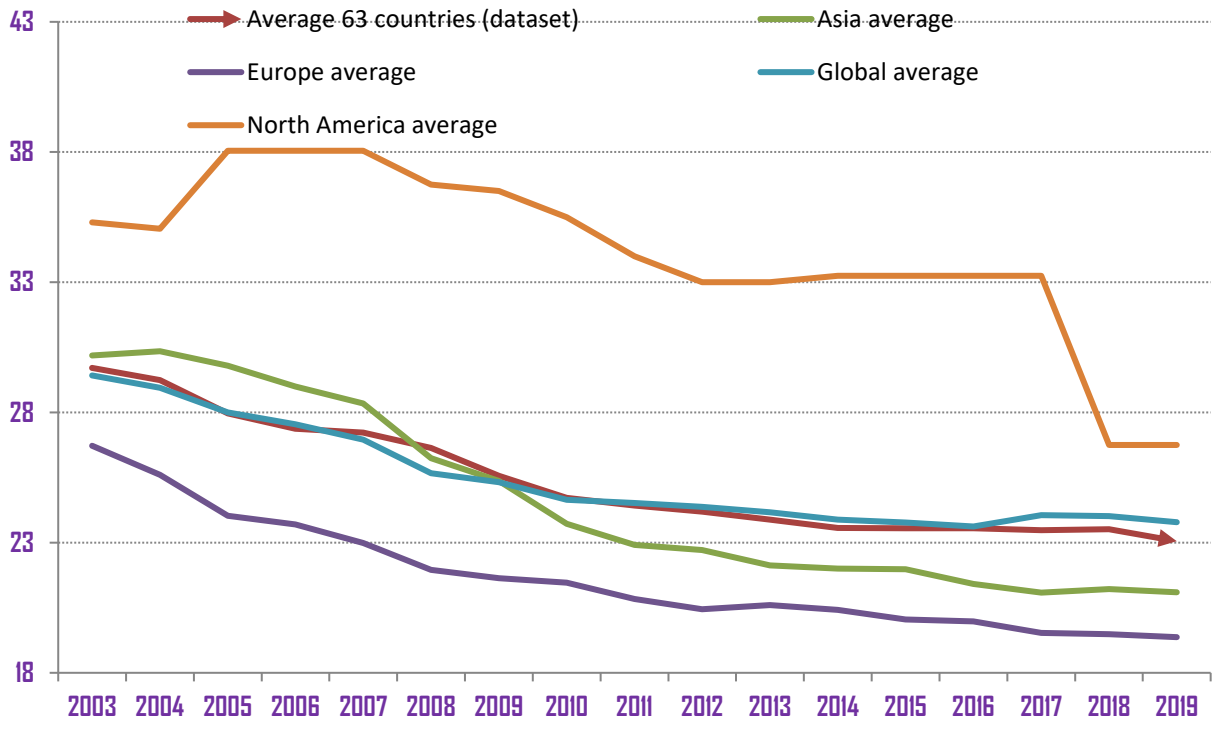


Figure 4.3 Corporate tax rates have been declining across regions

Source: Data from KPMG corporate tax database – calculation and graph by author.

Table 4.2 summarizes capital tax cuts across regions in the period from 2003 to 2019. The largest drop of corporate tax rates 11.3 percentage point was in North America which fell from 38.05 percent to 26.75 percent. South America and Africa had the lowest cuts in corporate tax rates, falling 3.65 and 4.53 percentage points respectively.

Table 4.2 Corporate tax rates drop from 2003 to 2019 across regions

Location	Corporate Tax drop %	Maximum corporate tax rate	Minimum corporate tax rate
North America average	11.3	38.05	26.75
Asia average	9.27	30.35	21.08
Europe average	7.35	26.72	19.37
OECD average	6.7	30.08	23.38
Average 63 countries (dataset)	6.65	29.71	23.05
Global average	5.8	29.42	23.62
Africa average	4.53	32.36	27.83
South America average	3.65	30.81	27.16

Source: Data from KPMG corporate tax database (calculated by author)

2.2. Descriptive statistics of corporate tax rates in the dataset of 63 developing countries

Most developing countries in the dataset have decreased their corporate tax rates over time. Figure 4.4 shows the corporate tax rates among those countries in 2003 and 2019.

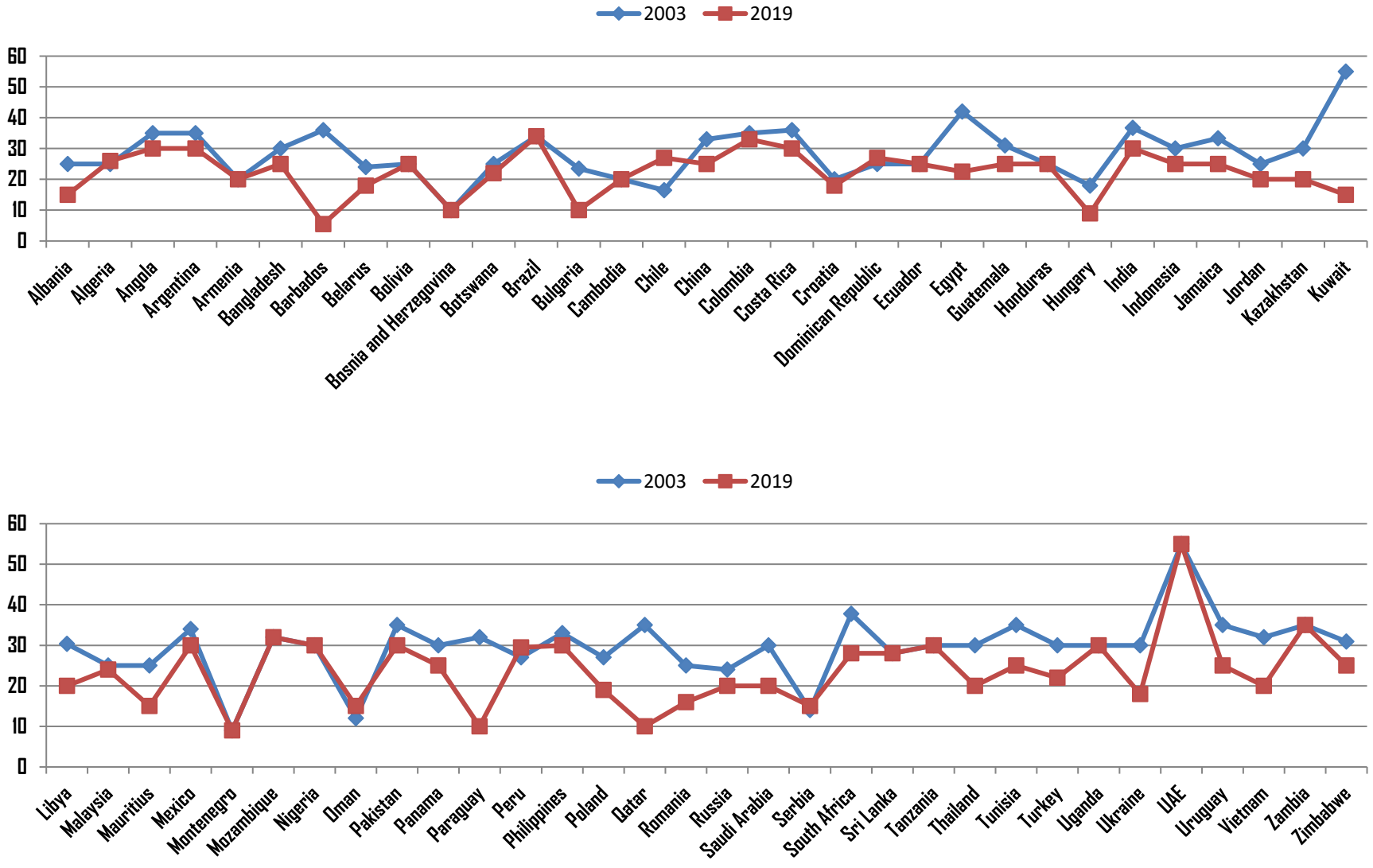


Figure 4.4 Corporate tax rates of 63 developing countries (dataset) in 2003 and 2019

Although most countries have decreased their corporate tax rates, some have not changed their rates, and others have increased their rates. The following tables show different groups of countries in our dataset with different corporate tax rate changes.

Table 4.3 Changes in corporate tax rates between 2003 to 2019 for countries with at least 10 percentage point decreases.

Countries	2003 (corporate tax rate %)	2019 (corporate tax rate %)	Change (percentage points)
Kuwait	55	15	-40
Barbados	36	5.5	-30.5
Qatar	35	10	-25
Paraguay	32	10	-22
Egypt	42	22.5	-19.5
Bulgaria	23.5	10	-13.5
Ukraine	30	18	-12
Vietnam	32	20	-12
Libya	30.38	20	-10.38
Albania	25	15	-10
Kazakhstan	30	20	-10
Mauritius	25	15	-10
Saudi Arabia	30	20	-10
Thailand	30	20	-10
Tunisia	35	25	-10
Uruguay	35	25	-10

Table 4.4 Changes in corporate tax rates between 2003 to 2019 for countries with less than 10 percentage point decreases.

Countries	2003 (corporate tax rate %)	2019 (corporate tax rate %)	Change (percentage points)
South Africa	37.78	28	-9.78
Hungary	18	9	-9
Romania	25	16	-9
Jamaica	33.33	25	-8.33
China	33	25	-8
Poland	27	19	-8
Turkey	30	22	-8
India	36.75	30	-6.75
Belarus	24	18	-6
Costa Rica	36	30	-6
Guatemala	31	25	-6
Zimbabwe	30.9	25	-5.9
Angola	35	30	-5
Argentina	35	30	-5
Bangladesh	30	25	-5
Indonesia	30	25	-5
Jordan	25	20	-5
Pakistan	35	30	-5
Panama	30	25	-5
Mexico	34	30	-4
Russia	24	20	-4
Botswana	25	22	-3
Philippines	33	30	-3
Colombia	35	33	-2
Croatia	20	18	-2
Malaysia	25	24	-1

Table 4.5 The 15 countries which have not changed their corporate tax rates between 2003 and 2019

Countries	2003 (corporate tax rate %)	2019 (corporate tax rate %)	Change (percentage points)
Armenia	20	20	0
Bolivia	25	25	0
Bosnia and Herzegovina	10	10	0
Brazil	34	34	0
Cambodia	20	20	0
Ecuador	25	25	0
Honduras	25	25	0
Montenegro	9	9	0
Mozambique	32	32	0
Nigeria	30	30	0
Sri Lanka	28	28	0
Tanzania	30	30	0
Uganda	30	30	0
UAE	55	55	0
Zambia	35	35	0

Table 4.6 The 6 countries which have increased their corporate tax rates between 2003 and 2019

Countries	2003 (corporate tax rate %)	2019 (corporate tax rate %)	Change (percentage points)
Algeria	25	26	1
Serbia	14	15	1
Dominican Republic	25	27	2
Peru	27	29.5	2.5
Oman	12	15	3
Chile	16.5	27	10.5

Table 4.7 Summary statistics of corporate tax rates 63 developing countries over the 15-year period analyzed

Observations	Mean	Median	Standard deviation	Minimum	Maximum
944	25.5	25	8.7	9	55

Hungary had the lowest corporate tax rate in 2017 at 9 percent. UAE and Kuwait had the highest rate at 55 percent.

2.3. Average effective corporate tax rates in 63 developing countries

The average effective corporate tax rate (effective rate) is the ratio of the total corporate tax collected to the aggregate corporate taxable income. In this paper, I use corporate tax rates as percent of commercial profits from the World Bank databank as a proxy for effective corporate tax rates. Figure 4.7. shows the overall declining trend of the average effective corporate tax rates from 2005 to 2007. Due to data availability, rates for two years 2003 and 2004 are not included.

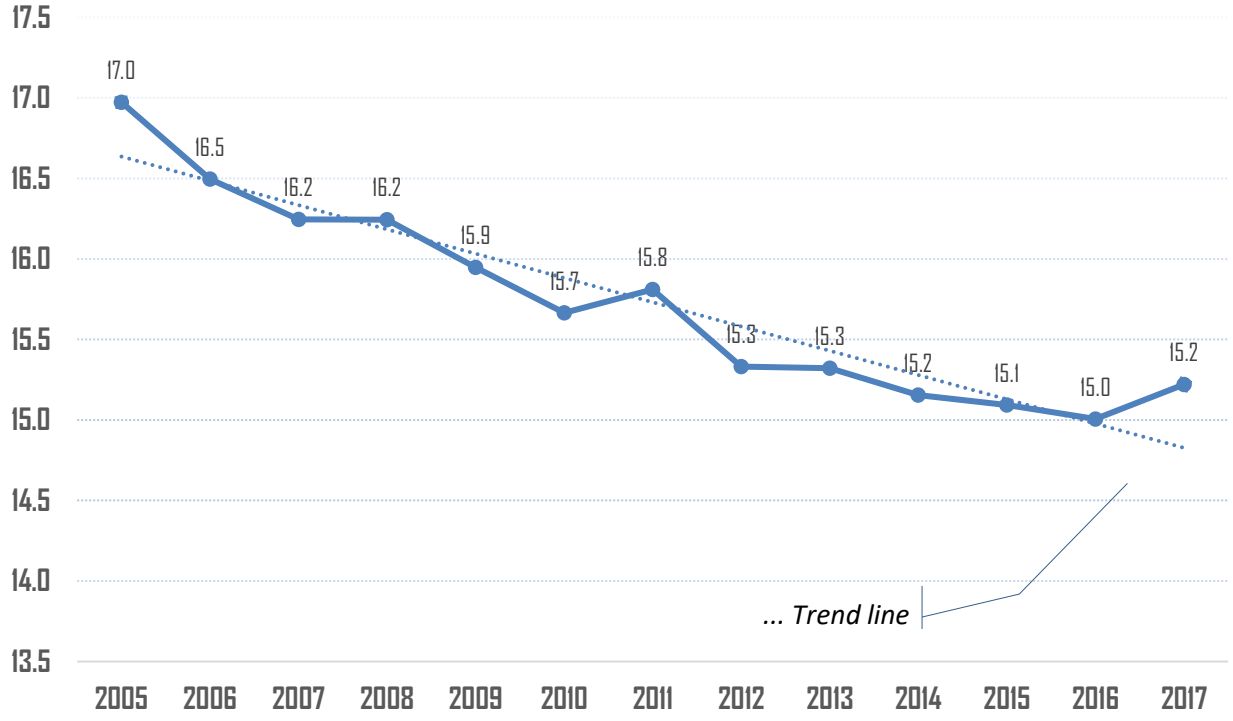


Figure 4.5 Average effective corporate tax rates[30] in 63 developing countries

Source: World Bank, databank – graph and calculation by author

2.4 Correlation between statutory and effective corporate tax rates.

The correlation coefficient between statutory and effective corporate tax rate is 0.393. A positive coefficient indicates that as statutory rate increases, so does the effective rate. Table 4.8 provides additional comparation for these two variables.

[30] Simple average is calculated for each year = $\frac{Sum\ of\ all\ 63\ effective\ corporate\ tax\ rates\ in\ a\ given\ year}{63}$

Table 4.8 Summary statistics of statutory and effective corporate tax rates of 63 developing countries

Variable	Mean	Standard deviation	Minimum	Maximum	Observation
Statutory corporate tax rate (tax)	25	8.6	9	55	944
Effective corporate tax rate (etax)	15.7	8.4	0	31.6	811

Source: KPMG corporate tax database – calculation by author

Data for effective corporate tax rates was only available from 2005. Data for statutory corporate tax rates was available from 2003. The average effective corporate tax rate is approximately 9 percentage points less than the average statutory corporate tax rate which means that the actual tax paid is less than the tax required by laws. Most businesses take advantage of tax deductions and tax incentives. Figures 4.6 and Figure 4.7 compare statutory and effective corporate tax rates in 63 developing countries[31]. Figure 4.6 shows a declining trend of both rates. The gap between the two average rates ranges from 9 to 10 percentages points from 2005 to 2017. Figure 4.7 shows the differences between the two rates in every country in 2017.

[31] Simple average is calculated for each year = $\frac{Sum\ of\ all\ 63\ effective\ (or\ statutory)\ corporate\ tax\ rates\ in\ a\ given\ year}{63}$

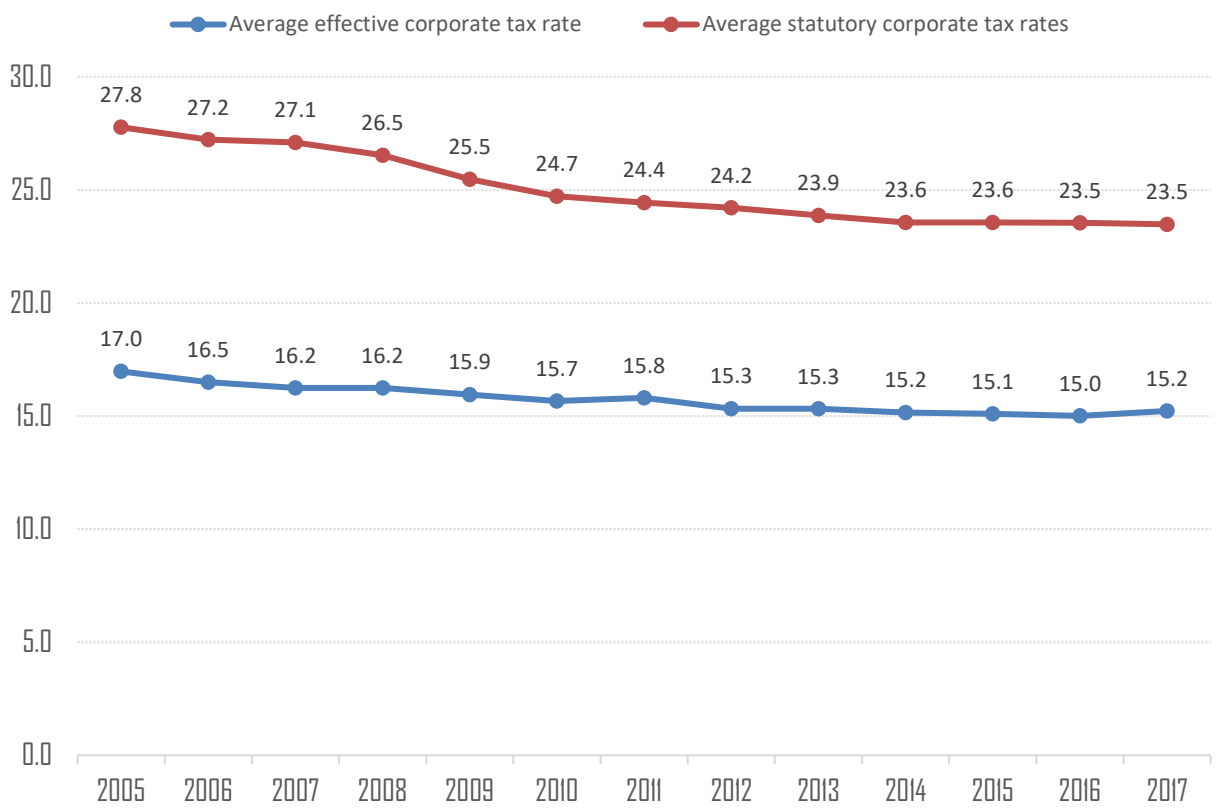


Figure 4.6 Average effective and statutory corporate tax rates from 2005 to 2017 of 63 developing countries

Source: KPMG corporate tax database, World Bank databank – calculation and graph by author

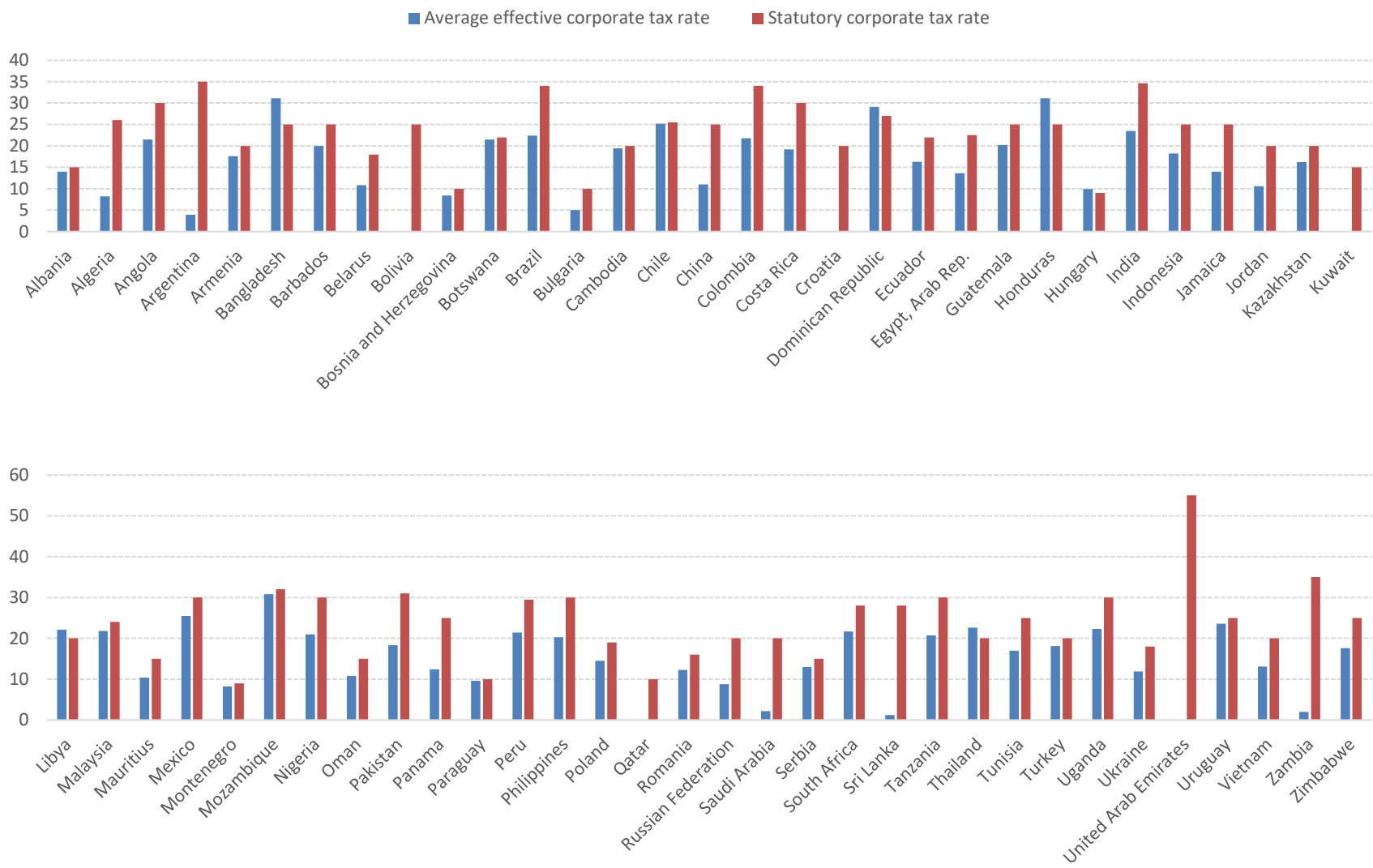


Figure 4.7 Effective and statutory corporate tax rates in different developing countries in 2017

3. Statistical summary of FDI and FDI per capita to developing countries

Figure 4.8 shows the overall trend of the total and average FDI to 63 developing countries in the period 2003 to 2017. FDI increased sharply from 2003 to 2008. From 2008 to 2009, FDI dropped significantly due to the 2008 financial crisis. From 2009 to 2017, FDI fluctuated without a clear trend of increasing or decreasing.

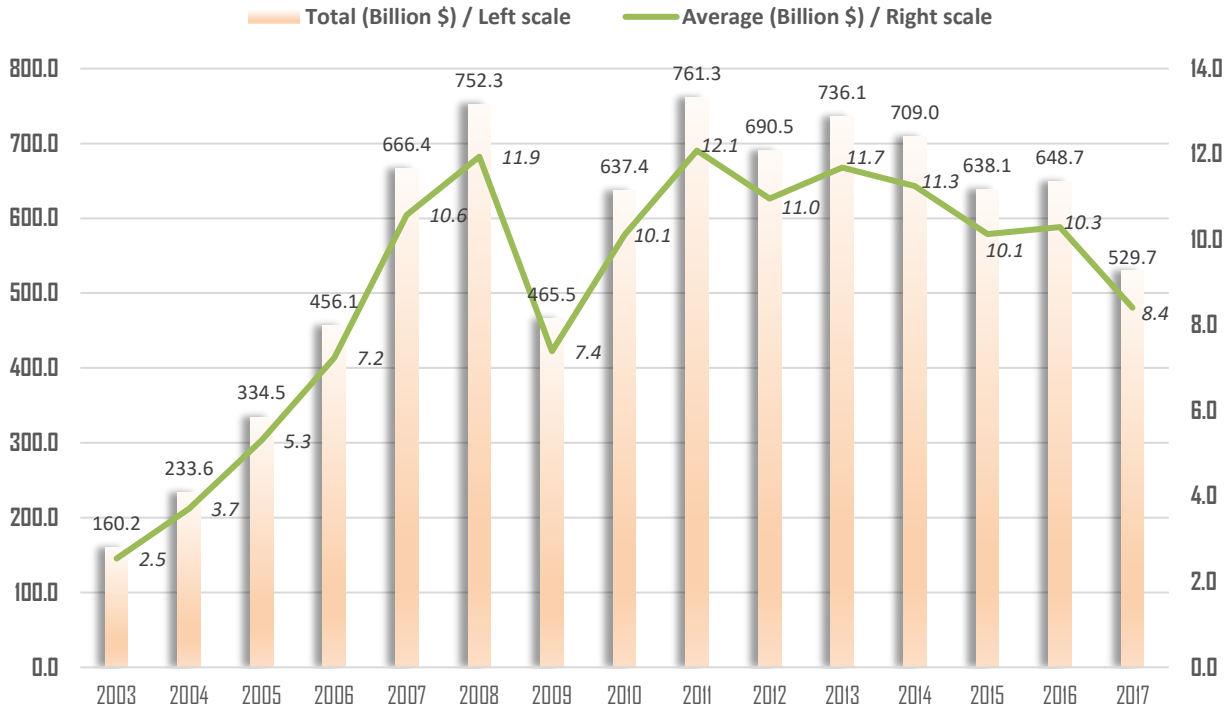


Figure 4.8 Total and average FDI [32]to 63 developing countries (Billion dollars)

Source: World Bank databank, calculation and graph by author

Figure 4.9 which reflects average FDI per capita shows a similar pattern as Figure 4.8. FDI per capita increased sharply from 2003 to 2008. On average, each person received $35 FDI inflow per year in 2003. The amount increased by 450 percent to $157 in 2008. Due to the financial crisis,

[32] Average FDI = $\frac{Total\ FDI\ to\ 63\ countries}{63}$

FDI per capita dropped significantly by 40 percent to $96 in 2009. From 2009 to 2017, FDI per capita fluctuated with no clear pattern.

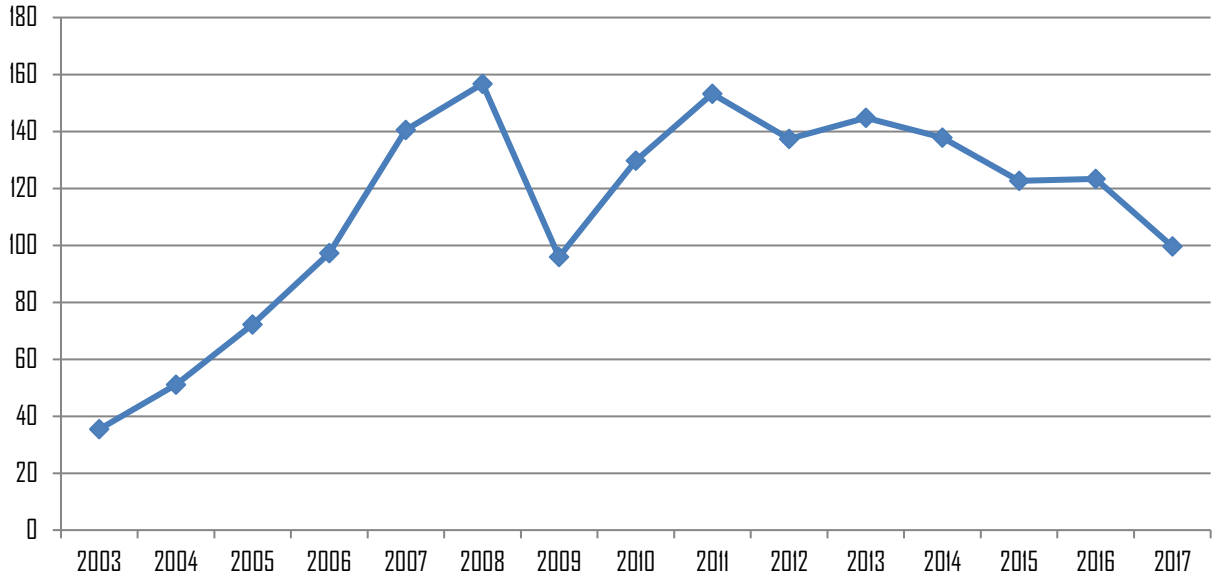


Figure 4.9 The average FDI per capita in 63 developing countries[33].

Source: World Bank databank, calculation and graph by author

Figure 4.10 graphs total FDI and average corporate tax rates of the 63 developing countries. From 2003 to 2008, corporate tax rates decreased while FDI increased. From 2008 to 2017, corporate tax rates continued their declining trend while total FDI fluctuated over the period.

[33] The average FDI per capita in 63 developing countries = $\frac{Total\ FDI\ to\ 63\ developing\ countries}{Total\ population\ of\ all\ 63\ developing\ countries}$

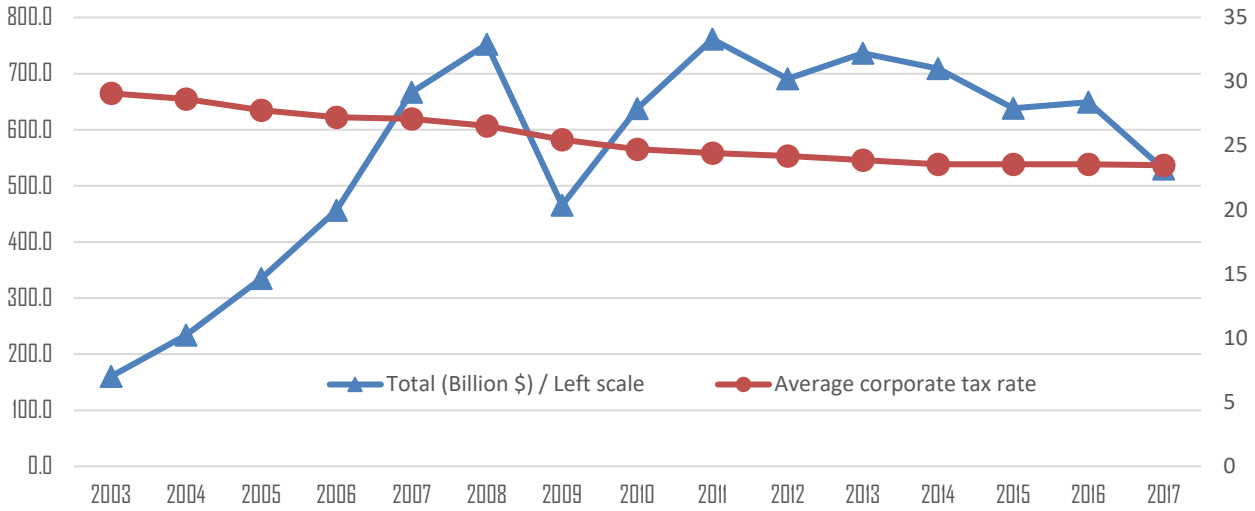


Figure 4.10 Total FDI and average corporate tax rates in 63 developing countries

Source: World Bank databank, calculation and graph by author

The following tables include different FDI-related statistics for the 63 developing countries in the dataset.

Table 4.9 Summary statistics of total FDI (in Billion $)

Observations	Mean	Median	Standard deviation	Minimum	Maximum
945	8.909363	1.841	26.63734	-20.93351 (Hungary)	290.9284 (China)

In table 4.9, Hungary received the minimum amount of FDI in 2010 with -20.93 billion dollars (net FDI outflow). China received the maximum amount of FDI in 2013 with 290.9 billion dollars. China, Brazil, Russia, Mexico and India received the largest total FDI in the 15 years from 2003 to 2017.

Table 4.10 provides descriptive statistics of FDI per capita. Hungary, an European country with population approximately 10 million people, had the both extreme of minimum and maximum

of FDI per capita among 63 developing countries. In 2010, net FDI per capita outflow is $2093. In 2008, net FDI inflow is $7472. Besides Hungary, 13 countries also had net capital outflows in the period 2003 – 2017. These countries are Angola, Oman, Uruguay, Qatar, Indonesia, Algeria, Egypt, Uruguay, Saudi Arabia, Bolivia, Kuwait, Paraguay and Barbados.

Table 4.10 Descriptive statistics of FDI per capita ($)

Observations	Mean	Median	Standard deviation	Minimum	Maximum
945	299.56	136.5	605.5	-2093 (Hungary)	7472 (Hungary)

4. Descriptive statistics for other independent variables

4.1. Employment and Unemployment

Figure 4.11 reflects a general decreasing trend in average unemployment rates in developing countries (left vertical axis in percent) from 2003 and 2017. Total FDI (right vertical axis in billion $), on the other hand, shows an overall increasing trend. From 2003 to 2009, the unemployment rate and total FDI graphs have a strong negative relationship between FDI and unemployment rates. From 2009 to 2017, the unemployment rate remained stable.

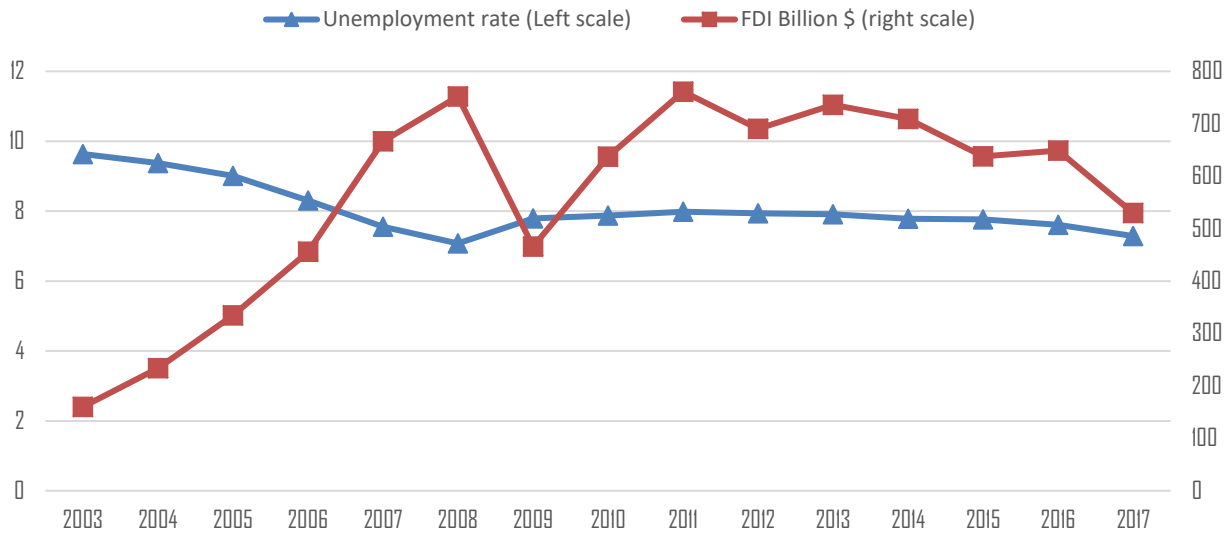


Figure 4.11 Average unemployment rate (percent) and total FDI (billion $) to 63 developing countries

Source: data from World Bank, databank – calculation and graph by author.

Figure 4.12 graphs the average employment rate (left vertical axis in percent) and total FDI (right vertical axis in billion $). From 2003 to 2009, employment rate and total FDI followed the same increasing trend. From 2009 to 2017, while total FDI fluctuated, the employment rate increased steadily.

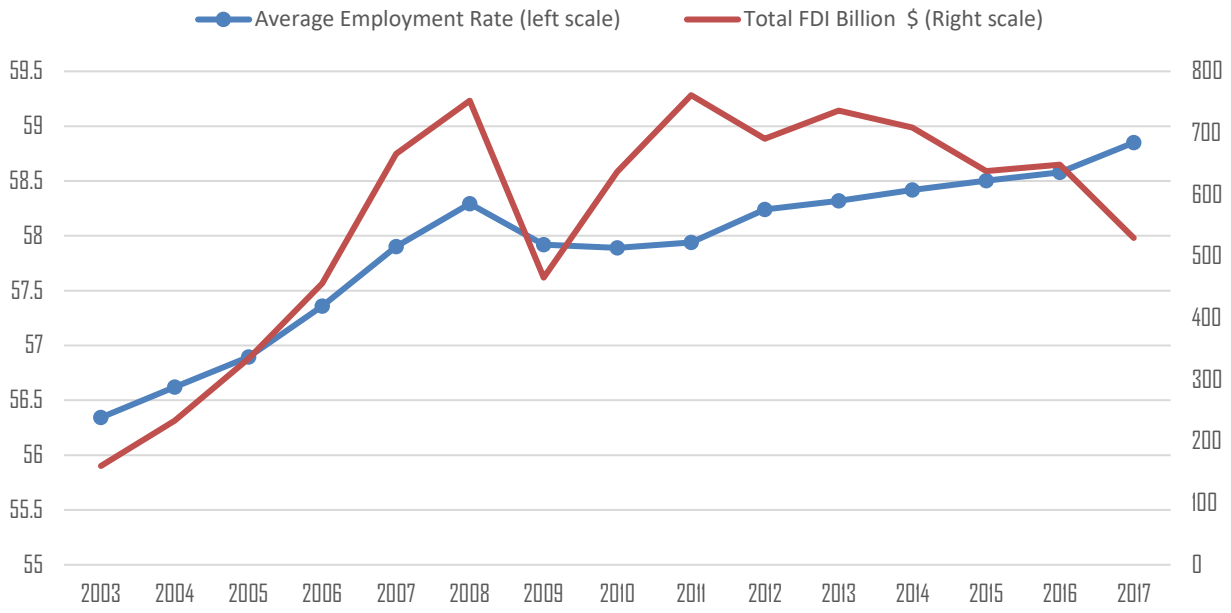


Figure 4.12 Average employment rate (percent) and total FDI (billion $) to 63 developing countries

Source: Data from World Bank, databank – calculation and graph by author.

4.2. Total GDP, average GDP and GDP per capita

Figure 4.13 shows total GDP (billion $, left vertical axis) and GDP per capita[34] ($, right vertical axis) across all 63 developing countries. Total GDP and GDP per capita has increased steadily since 2003. The average annual GDP growth rate was approximately 5.6 percent. In 2007, the growth rate was highest with 8.1 percent. Total GDP in 2017 was 28,711 billion USD which was more than double that of 13,386 billion USD in 2003.

[34] In this figure 4.13, GDP per capita = $\frac{\text{Sum of all 63 countries}' \text{total GDP}}{Sum\ of\ all\ \ 63\ countries'\ population}$

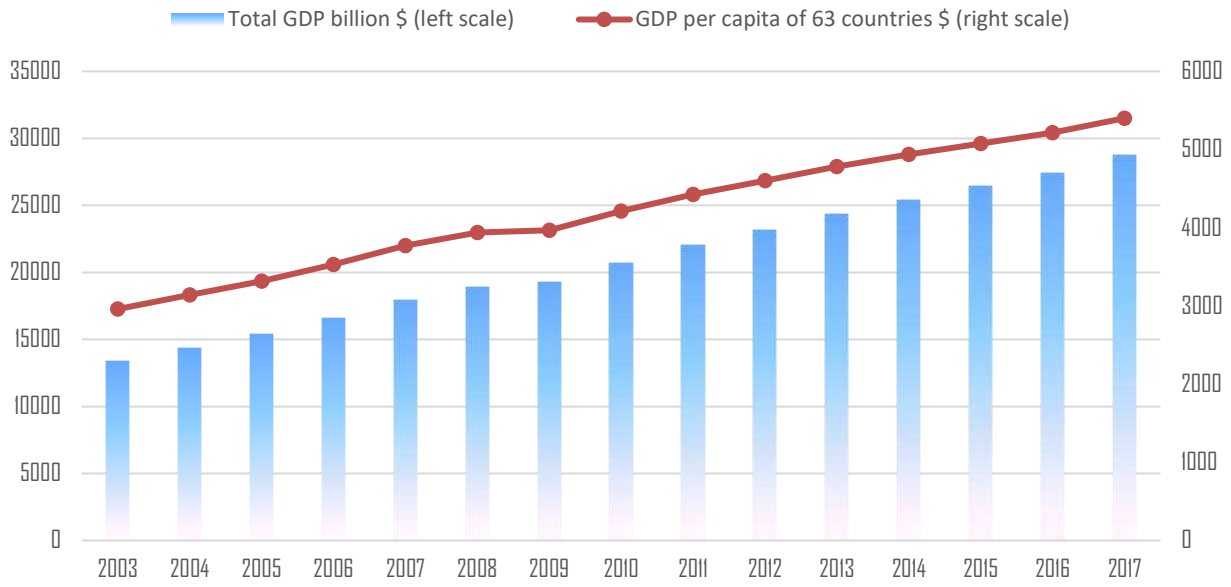


Figure 4.13 Total GDP and GDP per capita of all 63 developing countries from 2003 to 2017

Source: data from World Bank, databank – calculation and graph by author.

Figure 4.14 graphs average GDP per capita by countries[35], the median and the minimum of GDP per capita of the 63 countries. The overall trend is increasing. The median line is far below the average line, indicating sknewness or asymmetry in the distribution of GDP per capita. The majority of people have income far less than the average level. The bottom line shows the minimum income per capita. It represents Mozambique's lowest income per captita.

[35] In this figure 4.13, Average GDP per capita = $\frac{Sum\ of\ all\ 63\ countries'\ GDP\ per\ capita}{63}$

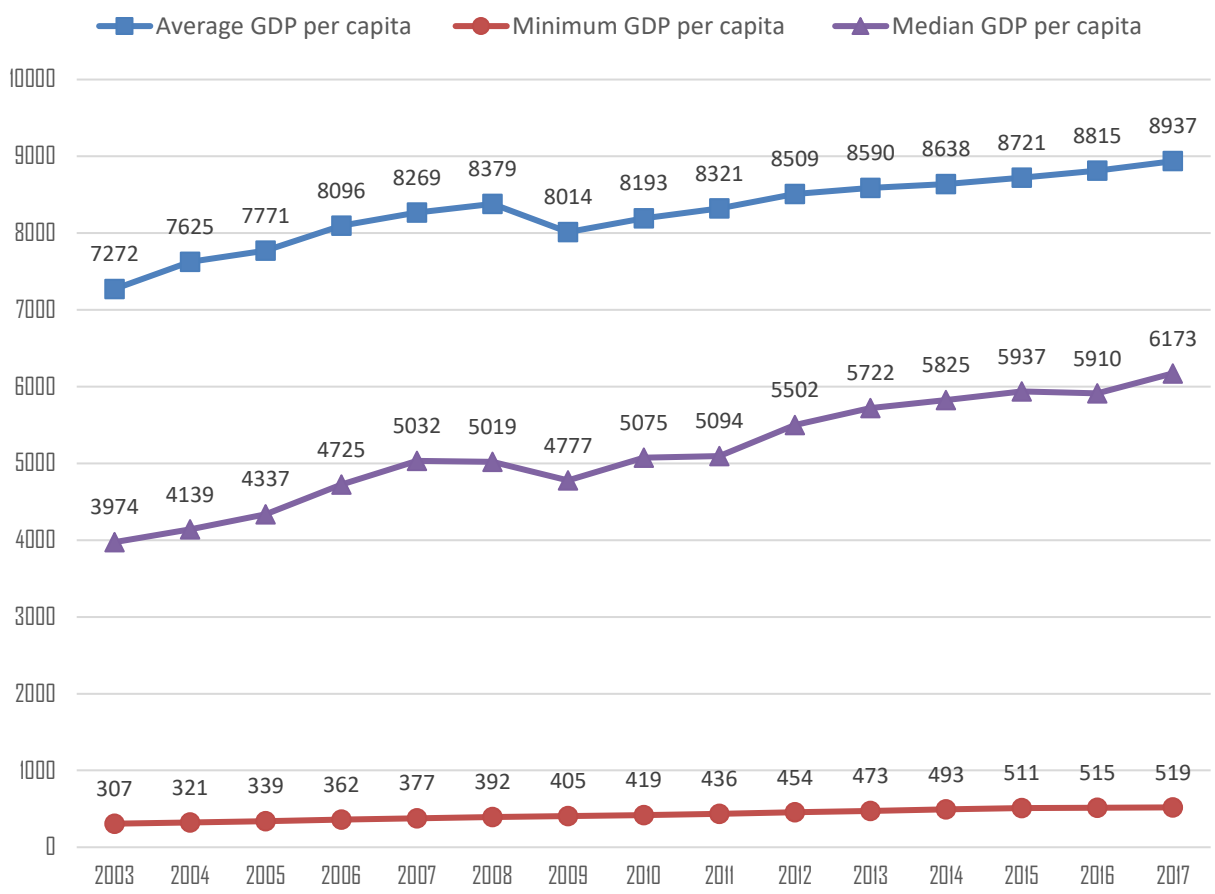


Figure 4.14 Average, median and mimimum GDP per capita of 63 developing countries (in dollar)

Source: data from World Bank, databank – calculation and graph by author.

4.3. Official Development Assistance – ODA

Figure 4.15 shows average ODA per capita (in $ - left scale) and total ODA (in billion $ - right scale). Both graphs fluctuate over time without a clear pattern of change.

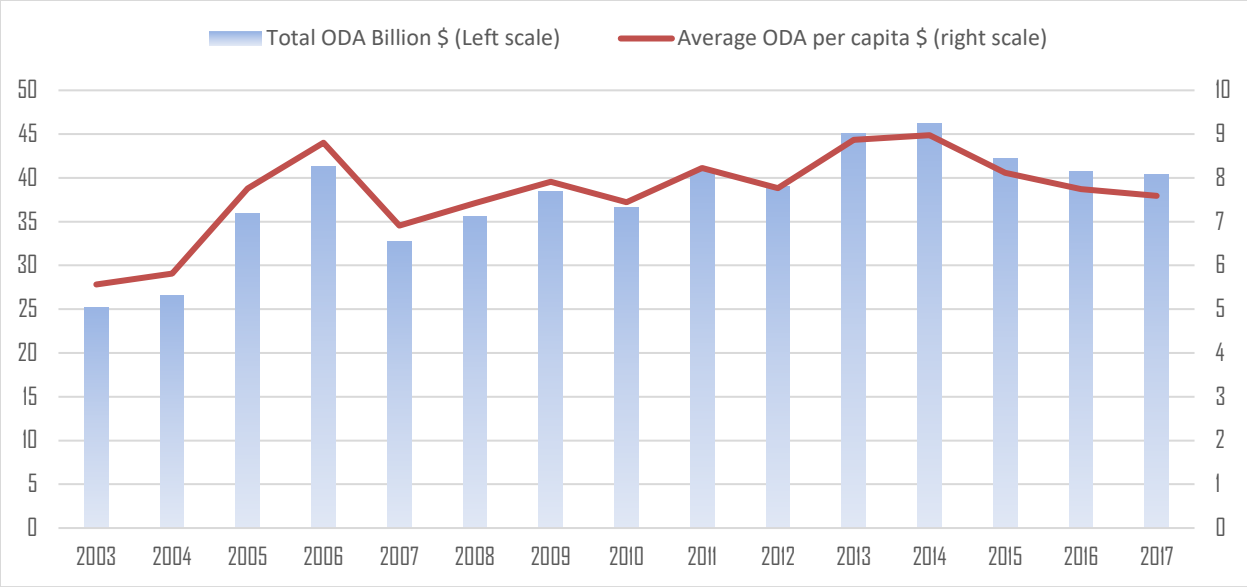


Figure 4.15 Average ODA per capita and total ODA to 63 developing countries

Source: data from World Bank, databank – calculation and graph by author.

In the dataset of 63 developing countries, most countries have received foreign aid. There are only 8 countries that have not received foreign aid in entire period. These countries are Bulgaria, Hungary, Kuwait, Poland, Qatar, Romania, Russia and UAE.

4.4. Summary statistics of other variables

Table 4.9. provides summary statistics of other variables for both models discussed in section II and III. Variable abbreviations are in parentheses.

Table 4.11 Summary statistics of independent variables

Variables / Measurement unit	Mean	Median	Standard Deviation	Minimum	Maximum	Obs
Corporate tax rate (tax) / percent	25.5	25	8.7	9	55	944
Average Effective tax rate (etax) / percent	15.7	17.6	8.4	0	31.6	811
Unemployment rate (uemp)/ Percent	8.1	6.3	6.19	0.14	32.46	945
Vulnerable employment rate (vemp) / Percent	35.1	29.9	23.8	0.14	87.8	945
Employment rate (empl)/ Percent	57.9	58.1	12.4	32.7	87.4	945
Inflation rate (infl)/ Percent	7.2	5.8	8.9	-25	95.4	945
GDP per capita (gdpc) / Constant $	8277	5155	10928	307	72671	945
Total GDP (gdp)/ Billion constant $	332.1	71.8	905	3.2	10161	945
Investment in public inputs per capita/ constant $	1820	1277	2141	18	14324	945
Population (pop) / Million people	78	15.8	225	0.28	1386.4	945
Exchange rate (exch)/ foreign currency unit per US Dollar	7.11e+07	14.7	6.88e+08	0.2	6.7e+09	945
Foreign aid (oda)/ million, constant $	599	235	928	-1045	11432	945
Foreign aid per capita (odapc) / constant $	30.8	13.3	45.5	-49.5	371.5	945
Openness = (Import+Export)/GDP / percent	0.81	0.74	0.36	0.16	2.5	945

CHAPTER 5: REGRESSION RESULTS REGARDING TAX COMPETITION AMONG DEVELOPING COUNTRIES

This chapter presents estimates of the econometric models presented in chapter 4. The estimation results for model 1[36] verify the necessary condition for tax competition[37]. The estimation results for model 2[38] concern the tax response functions or the tax competition interaction among developing countries. The results provide insights into how a developing country responds to a tax reduction by other countries. This chapter also empirically verifies several other theoretical results in chapter 3, such as the impact of foreign aid, employment, and investment in public inputs on tax competition (which have not been considered in the previous literature).

Section I of this chapter presents empirical results for model 1. This section first presents test results concerning the presence of possible cross-sectional dependence and first order autocorrelation in the data. The paper then discusses appropriate econometric models when cross-sectional dependence and serial correlation are present. Section I.5 presents estimation results from those appropriate models and section I.6. presents partial effects. Section II presents empirical results for model 2. This section starts with different tests to confirm the existence of spatial dependence. The spatial regression results provide a corporate tax response function among developing countries. This section also discusses the effects of different regressors to tax competition in developing countries.

[36] Specification of the model is presented in section II, chapter 4
[37] As defined earlier, throughout the dissertation, tax competition implies international tax competition.
[38] Specification of the model is presented in section III, chapter 4.

I. Regression results for econometric model 1 – the necessary condition for tax competition in developing countries

The main purpose of this section is to test for the necessary condition of tax competition in developing countries. Tax competition only exists if the corporate tax rate is a determinant of FDI and lowering the corporate tax rate is followed by an increase in FDI. Thus, tax competition will exist if the estimated coefficient on the corporate tax variable is negative.

The dependent variable is total FDI to a developing country in a year. To estimate the model, I use a moving average of total FDI for two main reasons. First, any changes of the independent variables (tax rate and investment in public inputs) may affect FDI to a country over a time interval, not just only a specific year. Second, as outlined in Figures 4.7 and 4.8 chapter 4, total FDI to developing countries fluctuates over short time period especially during a period of financial crisis from 2008-2009. A moving average is a common method to smooth out short term data fluctuations and focus on long term trends. In addition, to address the impact of the financial crisis shock I regress the models with year dummy variables for all years except the first base year. There are nine independent variables in the model: the corporate tax rate[39], the inflation rate, productivity, investment in public inputs, population, the exchange rate, the employment rate[40] and education.

This section starts with two different tests: a test for cross-sectional dependence and a test for the presence of serial correlation. Based on the rest results, I present the appropriate econometric model and parameter estimates.

[39] The models are estimated with both statutory corporate tax rates and effective corporate tax rates.

[40] Proposition 2 and 7 present theoretical results about unemployment rates. However, the unemployment rate data in developing countries has several shortcomings (see section IV, chapter 1). The models are estimated with employment rate data instead of unemployment rate data.

1. Test for cross-sectional dependence

Cross-sectional dependence is non-zero covariances between disturbances in a cross-section. As discussed in section II, chapter 4, the econometric model that I estimate is:

$$y_{it} = \beta^0 + \beta^1 \tau_{it} + \sum_{j=2}^{j=k} X_{it}^{j} \beta^j + \varepsilon_{it}$$

With cross-sectional dependence, the covariance $(\varepsilon_{it}, \varepsilon_{jt}) \neq 0$ for some t and some i ≠ j. Driscoll and Kraay (1998) showed that an estimation fails to account for the dependence results in inconsistently estimated standard errors.

Table 5.1 presents results of Pesaran tests for cross-sectional dependence for the models with statutory and effective tax rates.

Table 5.1 Pesaran Cross-sectional dependence tests

Model with statutory corporate tax rates	Model with effective corporate tax rates
Pesaran's test statistics: 18.3 p-value = 0.0000	Pesaran's test statistics:2.230 p-value = 0.0258
Null hypothesis: no cross-sectional dependence.	
Pesaran test rejects the null at a one-percent significant level.	Pesaran test rejects the null at a five-percent significant level.

Test results in table 5.1 confirm that cross-sectional dependence exists for both models.

2. Test for first order serial correlation (AR1 autocorrelation)

Serial correlation (also called autocorrelation) is where error terms in a time series are correlated for a given observation. To test the serial correlation in the model, I use Wooldridge test for AR1 (Wooldridge 2002). The null hypothesis is there is no AR1 process. The test results confirm the presence of first order serial correlation.

Table 5.2 Wooldridge test for first order autocorrelation

Wooldridge test	Model with statutory corporate tax rates	Model with effective corporate tax rates
F-statistics	11.97	5.4
p-value	0.001	0.02
Hypothesis testing	*Null hypothesis H_0: No first order autocorrelation*	
Conclusion	Wooldridge test rejects the null hypothesis at a one-percent level.	Wooldridge rejects the null hypothesis at a five-percent level.

3. Estimation models with cross-sectional dependence and autocorrelation

To estimate the model with both autocorrelation and cross-sectional dependence, I employ a regression model with panel-corrected standard errors or panel specific AR1 autocorrelation model (Beck and Katz 1995). The regression results are in table 5.3. The dependent variable is a moving average of total FDI measured in billion constant dollars. In table 5.3, models (3) and (4), I estimate the models with year dummy variables for all years except for one base year to control for year effects (financial crisis shocks) in the model. In table 5.3, the dummy variables for 5 years from 2006 – 2010 (with 2007-2008-2009 financial crisis in the middle) are statistically significant at a five percent level in both models (3) and (4). The test results show that all year dummy variables are jointly significant at a one percent level[41].

[41] Test the joint significance of year dummy variables for model (3): $\chi 2$ (14) = 168.64, Prob > $\chi 2$= 0.0000 ; and for model (4): $\chi 2$(12) = 218.76, Prob > $\chi 2$= 0.0000

Table 5.3 Estimation outputs – Prais-Winsten panel specific AR(1) regression, panels corrected standard errors (PCSEs) correction of first order autocorrelation and cross sectional-dependence

Estimation method		(1) Statutory tax rate – panel specific AR1 model with panels corrected standard errors (PCSEs)		(2) Effective tax rate - panel specific AR1 model with panels corrected standard errors (PCSEs)		(3) Statutory tax rate - panel specific AR1 model with panels corrected standard errors (PCSEs) and year dummy variables		(4) Effective tax rate - panel specific AR1 model with panels corrected standard errors (PCSEs) and year dummy variables	
Independent variable	Meas. Unit	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Statutory corporate tax rate (tax)	Percent	-.0885433***	.0280936			-.070758**	.0295147		
Effective tax (etax)	Percent			-.17565***	.0340813			-.14272***	.0314708
Employment rate (empl)	Percent	.09098***	.0295039	.16698***	.032207	.0808**	.0336516	.15764***	.0282535
Inflation rate (infl)	Percent	.0035652	.0088718	.001079	.014575	.0099439	.0074344	.0074764	.0101342
Productivity (gdpc)	Dollar	.000175***	.0000366	.00017***	.0000365	.000205***	.000038	.00017***	.0000329
Investment in public inputs (fcap)	Percent of GDP	.13459***	.0311206	.15037***	.0273032	.10564***	.03773	.1323***	.027418
Population (pop)	Million	.0633***	.0172586	.1228***	.0176957	.0644***	.0172259	.12421***	.017496
Exchange rate (exch)	Foreign currency per US dollar	7.09e-11	8.54e-11	2.5e-10***	9.52e-11	-1.20e-11	1.19e-10	1.99e-10**	8.84e-11
Education (edu)	Percent	.09759***	.0279326	.13155***	.0274607	.09382***	.029824	.14609***	.0243444
Constant	-	-8.945***	2.872659	-16.023***	3.108	-9.63***	3.427837	-15.78***	2.46546

Year dummy									
	2004					0.3842**	.18326		
	2005					1.0398***	.2723		
	2006					2.4104***	.3513	1.0951***	.34
	2007					2.5714***	.4423	1.0878**	.4619
	2008					2.9702***	.5197	1.1021**	.5635
	2009					3.8215***	.5242	1.6559***	.5944
	2010					3.5584***	.5519	1.3591**	.6456
	2011					3.1767***	.5917	.82797	.6833
	2012					3.6656***	.6298	1.0218	.7372
	2013					3.3642***	.6733	1.0146	.7286
	2014					2.7504***	.6873	.36894	.7253
	2015					2.1117***	.7055	-.36869	.7508
	2016					1.6043**	.7279	-1.0167	.7877
	2017					1.0792	.7276	-1.6892**	.8326
Test of the regression		Wald $\chi2$ =47.8/ Prob> $\chi2$=0.000		Wald $\chi2$ =125/ Prob> $\chi2$=0.000		Wald $\chi2$ =306/ Prob> $\chi2$=0.000		Wald $\chi2$ =831/ Prob> $\chi2$=0.000	

, ** and * next to estimated coefficients indicate statistical significance levels of 10 percent, 5 percent and 1 percent respectively.*

The test results presented in this table are two-sided z-tests.

In all four models, both statutory and effective corporate tax rates are statistically significant and negative at a five percent significant level in two-sided z-test. I also perform one sided z-test in order to further confirm the sign of the estimates.

Table 5.4 One-sided z-test for the sign of corporate tax rate coefficients

Model (1)	Model (2)	Model (3)	Model (4)
p-value = .00081153	p-value = 1.276e-07	p-value = .00825601	p-value = 2.882e-06
Null hypothesis H_0: Estimated coefficient of corporate tax rate is positive			
Reject the null at a one percent level	Reject the null at a one percent level	Reject the null at a one percent level	Reject the null at a one percent level

The one-sided tests confirm the negative coefficients of both statutory and effective corporate tax rates. They indicate that countries that lower corporate tax rates receive more FDI. This result proves the necessary condition of tax competition among developing countries.

Parameter estimates on the employment, productivity, investment in public inputs, population and education variables are all statistically significant and with same signs as predicted in my theoretical results in chapter 3. The next subsection presents effects for different explanatory variables.

4. Effects of other explanatory variables to FDI

This section discusses regression results in table 5.3. It addresses both first-order autocorrelation and cross-sectional dependence. My test results indicate that year dummy variables are jointly statistically significant in both models (3) and (4). I focus on the regression results in the model (3) and (4) to discuss the effects of explanatory variables to FDI in developing countries.

The estimates indicate that the statutory corporate tax rate is an important factor to attract foreign investment in developing countries. The negative signs on the estimates indicate an inverse

relationship between statutory corporate tax rate and FDI flows. This empirical result supports the theoretical results in Proposition 1 chapter 3. Specifically, when a developing country lowers its statutory corporate tax rate by one percent, FDI to that country increases approximately 70.7 million USD. On average, it represents an increase of 0.722% of FDI[42]. Turning to the model with the effective corporate tax rate variable, the negative estimated coefficient of -0.1427 indicates that if a developing country offers tax incentives and deductions and lowers its effective corporate tax rate by 1 percent, FDI to that country is expected to increase by 143 million USD (approximately, an increase of 1.5% on average). The impact of the effective corporate tax rates on FDI is almost double the impact of the statutory corporate tax rates. The parameters estimated on the tax rate variables suggest the presence of the necessary condition for tax competition in developing countries regarding both statutory and effective corporate tax rates.

I will now consider parameter estimates on the other independent variables. In all four models, the employment rate variable is statistically significant at a five-percent level and positive. This implies that the unemployment rate has a negative impact on FDI flows to developing countries. This result supports the Proposition 2 in chapter 3 (the unemployment rate is inversely related to capital invested in a developing country). The coefficient estimate of 0.157 [table 5.3, model (4)] indicates that if the employment rate increases by one percent, FDI is expected to increase by 157 million dollars (an increase of 1.62% on average).

In all regression models in table 5.3, productivity is statistically significant at a one-percent level. The estimates are positive indicating that productivity has a positive effect on FDI flows to developing countries. Foreign investors prefer to invest in a higher productivity country. This empirical result supports Proposition 3 in chapter 3 (a country with higher productivity will attract

[42] Mean FDI of 63 developing countries: 9.7 billion dollars.

more capital than a country with lower productivity). The estimated coefficient of 0.00017 [table 5.3, model (4)] indicates that if productivity in a developing country increases by one dollar, FDI to that country will increase by 0.17 million (170,000) dollars. On average, if productivity increases by one percent, FDI will increases by 0.15%.

Investment in public inputs is statistically significant at a one-percent level in all estimation models and all estimated coefficients are positive. The positive sign indicates that an increase in investment in public inputs attracts more FDI to developing countries. This empirical result supports our theoretical finding Proposition 9, chapter 3 (a country that invests more in a public input attracts more capital). The estimated coefficient of 0.132 [table 5.3, model (4)] suggests that if a developing country increases investment in public inputs by one percent of GDP, the country is expected to receive an addition of 132 million dollars FDI (an increase of 1.4%).

Parameter estimates on the population variable are statistically significant in all models at an one percent level and have a positive sign. A country with a larger population will receive more FDI. The estimated coefficient of 0.124 [table 5.3, model (4)] suggests that a country with one million more people receives 124 million dollars more in FDI. On average, it implies that if population increases by one percent, FDI will increases approximately 1.01 percent. A larger population implies investors have larger consumer demand and larger market for their products and services. In addition, investors have a larger pool of labor and lower wages.

The parameter estimate on the exchange rate variable is statistically significant at a five-percent level in models (2) and (4). The positive estimates indicate that if the currency of a host country depreciates (an increase in the exchange rate: one US dollar exchanges for more host country currency units), the country receives more FDI. The depreciation of a host country's currency increases the wealth of foreign investors. When foreign investors bring their foreign

currency money to the host country to invest, the investors can exchange that amount of money in foreign currency for more money in host country currency. The increase in wealth of foreign investors increases FDI to the host country. In addition, for export-oriented FDI, investors get extra benefits from host country currency depreciation. Investors receive income in world currency from export (for example US dollar). With the depreciation, investors' income in world currency exchanges for more host country currency. The investors pay for costs of production in host country currency. In this case, the investors get extra profits from the depreciation, hence they increase their investments.

Parameter estimates on the education variable are statistically significant at a one-percent level. The positive estimates indicate that improving education attracts FDI to developing countries. Education increases the quality of labor. Foreign investors may be attracted by the quality of labor in developing countries. Nowadays, investment and production are geared toward more advanced technology which requires more skilled and educated labor force. As the result, education is increasingly an important determinant of FDI.

II. Regression results for econometric model 2 – tax competition in developing countries

The estimates for this model provide insights into how developing countries compete with regard to their corporate tax rates. The primary focus of the model is the tax competition response function among developing countries. In order to estimate this model, I employed a spatial econometric model. This model allows me to estimate the interdependence of countries' corporate tax rates. In this model, the dependent variable is the corporate tax rate of a country. The main explanatory variable is a weighted average corporate tax rate of all other countries. A spatial weight matrix is used to calculate the weighted average corporate tax rates. The estimated coefficient on this explanatory variable provides insights into how a country sets its corporate tax rate in response to tax rates of other countries. Other explanatory variables help us to verify other theoretical results related to tax competition. These variables are population, the employment rate, productivity, foreign aid, investment in public inputs and trade openness.

1. Test for spatial dependence

Before using a spatial econometric model, I employ three common tests for the existence of spatial dependence: (i) Moran's I test, (ii) the Lagrange Multiplier spatial lag dependence test, and (iii) the Lagrange Multiplier spatial error dependence test. Tables 5.5 and 5.6 summarize the results of these tests for statutory and effective corporate tax rates, respectively.

Table 5.5 Spatial dependence test (model using statutory tax rate)

	(i)	(ii)	(iii)
Test-statistics	18	220.195	123.696
p-value	0.000	0.000	0.000
Null hypothesis	*No spatial dependence*	*No spatial lag dependence*	*No spatial error dependence*
Test result	Reject the Null	Reject the Null	Reject the Null
	There is spatial dependence	There is spatial lag dependence	There is spatial error dependence
Conclusion on an appropriate regression model	This is a general test of spatial dependence. More specific tests should be implemented.	Spatial lag model	Spatial error model

Table 5.6 Spatial dependence test (model using effective tax rate)

	(i)	(ii)	(iii)
Test-statistics	13.4	144	65.1
p-value	0.000	0.000	0.000
Null hypothesis	*No spatial dependence*	*No spatial lag dependence*	*No spatial error dependence*
Test result	Reject the Null	Reject the Null	Reject the Null
	There is spatial dependence	There is spatial lag dependence	There is spatial error dependence
Conclusion on an appropriate regression model	This is a general test of spatial dependence. More specific tests should be implemented.	Spatial lag model	Spatial error model

These test results suggest that a spatial lag model and a spatial error model are appropriate for the estimation. Next section discusses the specifications of these two models.

2. Specifications of spatial lag and spatial error model

Spatial lag model

This model has been discussed in chapter 4, section III. The specification of the model is

$$t_{i,t} = \alpha + \gamma \sum_{j \neq i} s_{ij} t_{j,t-1} + \sum X_{i,t-1}\beta + \varepsilon_{it}.$$

or the matrix format:

$$t = \alpha + \gamma \cdot W \cdot t + X \cdot \beta + \varepsilon$$

where W is a spatial weight matrix. S_{ij}, an element of the spatial weight matrix. It is a spatial weight that is assigned to country j with respect to country i. The estimated parameter γ is the main focus of this model. It provides insight into developing countries' tax response function. For example, a positive and significant γ indicates that country i lowers its corporate tax rate if other countries lower their rates (tax competition among countries). Countries compete with each other in lowering their corporate tax rates. The larger the value of γ, the more aggressive the competition is among developing countries.

Spatial error model

The specification of this model is

$$t = \alpha + X \cdot \beta + \varepsilon$$

$$\varepsilon = \lambda \cdot W \cdot \varepsilon + \vartheta$$

where t is a corporate tax rates matrix (n × 1). W is a spatial weight matrix (n×n). X are other independent variables (n × k). β regression coefficient matrix (k × 1). ε and ϑ are vectors of error terms. In the spatial error model, λ is a nuisance parameter which is not of our interest.

3. Estimation results

Table 5.7 and 5.8 present estimation results from spatial lag and spatial error models for all 63 developing countries in the dataset. While spatial error model does not produce a parameter estimate for the tax response function, it does provide estimates of the coefficients on all other explanatory variables. The two results are shown side by side for a comparison and robustness check. The last row presents the results of spatial dependence tests. They are tests of the spatial parameters $\gamma = 0$ for the spatial lag model, and λ=0 for the spatial error model. The test results show that both γ and λ are significantly different from zero in all four models.

Appendix E presents estimation results from spatial lag and spatial error models for 55 developing countries (eight countries that received no foreign aid are excluded). These countries are Bulgaria, Hungary, Kuwait, Poland, Qatar, Romania, Russia and UAE). The regression results are similar as the regression results for all 63 developing countries in table 5.5, 5.6, 5.7 and 5.8. The tax response functions are all positive in all estimations. The impact of ODA on tax competition is also unchanged.

Appendix F presents estimation results from spatial lag and spatial error models for 62 developing countries excluding China. The regression results are similar to the regression results for all 63 developing countries in table 5.5, 5.6, 5.7 and 5.8. The tax response functions are all positive. A minor change is that the estimation results with China have slightly larger tax response

parameters than the results without China. The results imply that China had a relatively strong tax competition policy.

Table 5.7 Spatial estimation (using statutory corporate tax rates)

Estimation method		**(1) Spatial lag model (spatial autoregressive model)**		**(2) Spatial error model**	
Independent variable	Meas. Unit	Coef.	Std. err.	Coef.	Std. err.
γ(tax response function)		.747844***	.0982554		
λ (nuisance parameter)				.839798***	.1010535
Population (pop)	Million	.004387***	.0013019	.004728***	.001322
Employment rate (empl)	Percent	.108307***	.0251219	.083286***	.0300528
Productivity (gdpc)	Dollar	.000087***	.0000254	.0001007***	.0000302
ODA (oda)	Million	.001096***	.0002921	.001146***	.0003017
Investment in public inputs (fcap)	Percent of GDP	-.0594984	.0442419	-.0574111	.0433159
Openness (openness)	100 percent	-2.27786***	.7947425	-1.69155**	.823855
Constant		2.255559	2.416618	24.75714	4.001502
Tests of spatial parameters (Ho: $\gamma = 0$ for spatial lag model, and Ho: λ=0 for spatial error model		Wald test: χ^2 = 57.9 (p=0.000) Likelihood ratio test: χ^2= 50.4 (p=0.000) Lagrange multiplier test: χ^2= 220 (p=0.000)		Wald test: χ^2 = 69.1 (p=0.000) Likelihood ratio test: χ^2= 30.6 (p=0.000) Lagrange multiplier test: χ^2= 123.7 (p=0.000)	

, ** and * next to estimated coefficients indicate statistical significance level of 10 percent, 5 percent and 1 percent respectively.*

Table 5.8 Spatial estimation (using effective corporate tax rates)

Estimation method		(3) Spatial lag model (spatial autoregressive model)		(4) spatial error model	
Independent variable	Meas. Unit	Coef.	Std. err.	Coef.	Std. err.
γ(tax response function)		.6927811 ***	.1186322		
λ (nuisance parameter)				.667882 ***	.1487389
Population (pop)	Million	-.0000905	.0013562	-.0001146	.0013814
Employment rate (empl)	Percent	.0874518 ***	.02496	.0829901 ***	.0309751
Productivity (gdpc)	Dollar	-.0001925 ***	.0000293	-.000206 ***	.0000334
ODA (oda)	Million	.0009664 ***	.0002953	.000974 ***	.0003042
Investment in public inputs (fcap)	Percent of GDP	.0521476	.0459288	.0499438	.0452331
Openness (openness)	100 percent	.1130781	.8081356	.223381	.8395489
Constant		-.0297527	2.143118	11.74588	2.494018
Tests of spatial parameters (Ho: $\gamma = 0$ for spatial lag model, and Ho: λ=0 for spatial error model		Wald test: χ^2= 34.1 (p=0.000) Likelihood ratio test: χ^2= 30.2 (p=0.000) Lagrange multiplier test: χ^2= 144 (p=0.000)		Wald test: χ^2= 20.2 (p=0.000) Likelihood ratio test: χ^2= 14.4 (p=0.000) Lagrange multiplier test: χ^2= 65.1 (p=0.000)	

, ** and * next to estimated coefficients indicate statistical significance level of 10 percent, 5 percent and 1 percent respectively.*

The next section analyzes the regression results.

4. Tax competition among developing countries

The estimated parameter γ for models (1) and (3), in tables 5.7 and 5.8 presents the tax response function of the developing countries analyzed. The estimated coefficients γ are statistically significant at a one-percent level for both models. The test results of spatial dependence model (shown in the last rows in the tables) further confirm that the spatial parameter γ is statistically significant. The sign of the estimated coefficients γ are positive in both regression models. The positive sign indicates the presence of tax competition among developing countries. Countries monitor each other's corporate tax rate changes and set their corporate tax rates in the same direction. The coefficients γ are positive for both statutory and effective rates which means that countries compete in both types of rates. The γ estimates are .75 and .69 for statutory and effective rates respectively. The magnitude of competition is stronger for the statutory rates. When there is one percentage reduction in the weighted average statutory rates in other developing countries, the home country will lower its rate by 0.75 percentage points. If the weighted average effective rates in other developing countries decreases by one percentage point, the home country will lower its effective corporate tax rate by 0.69 percentage points.

This result of tax competition among developing countries together with the previous result in section I regarding the existence of tax competition help us to characterize tax competition in developing countries. Figure 5.1 summarizes these results.

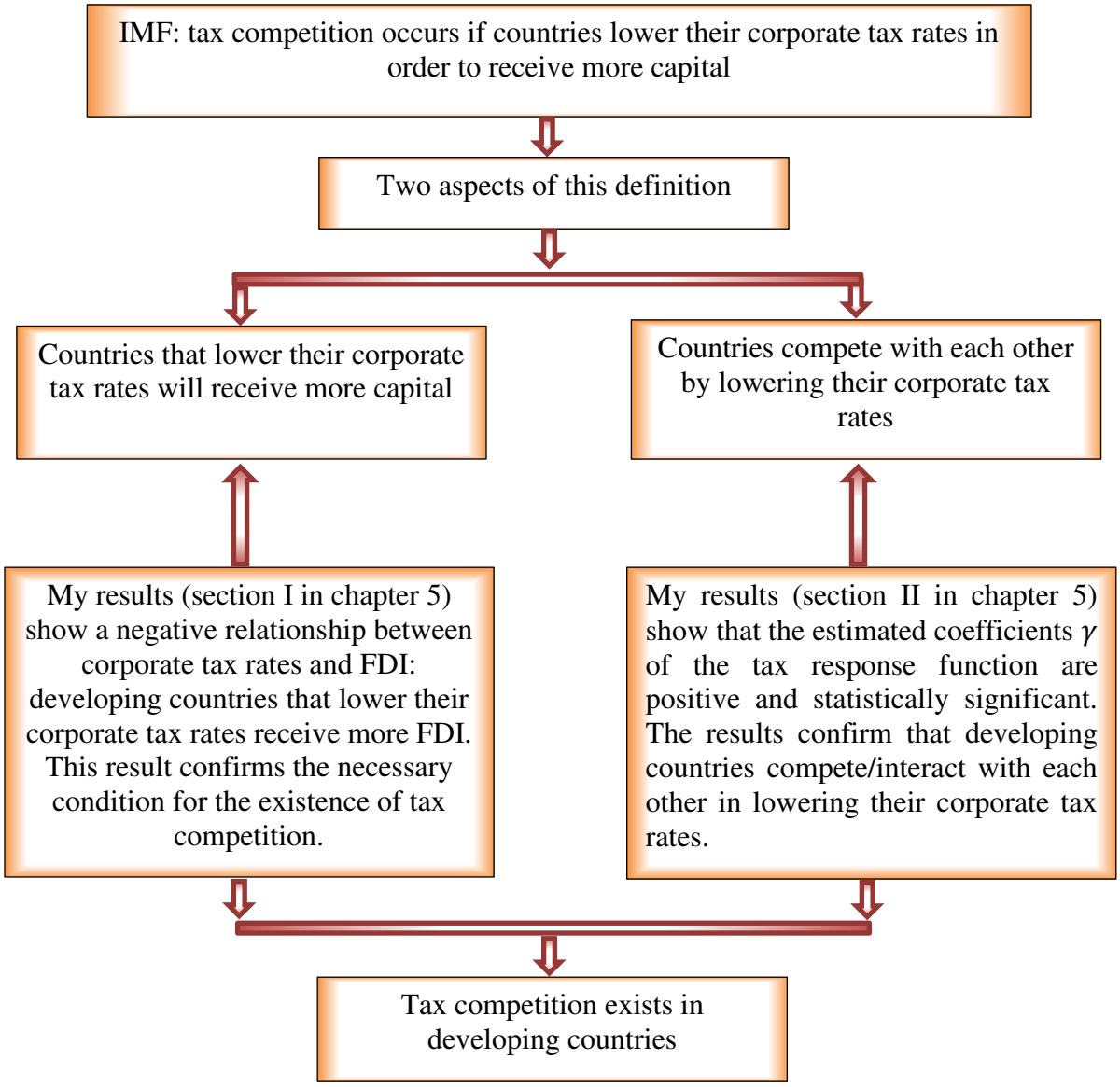


Figure 5.1 The existence of tax competition in developing countries

Tax competition and the "race-to-the-bottom" in my theoretical and empirical results

My theoretical results suggest that when a country lowers its capital tax rate, the country will receive more capital. $\frac{\partial K_i^*}{\partial t_i} = \left[\frac{-1}{(1-\alpha)}\right]\left[\frac{K_i^*}{(r+t_i)}\right] < 0$ and $\frac{\partial K_i^*}{\partial t_i} = -\frac{1}{1-\alpha}\left[A_i\alpha(1-\mu_i)^{\beta} I_i^{\rho}\right]^{\frac{1}{1-\alpha}} \frac{1}{(r+t_i)^{\frac{2-\alpha}{1-\alpha}}} < 0$. This is the only result which implies a "race-to-the-bottom".

The theoretical result in equation (24) may also imply a "race-to-the-bottom". With this equation, the "race-to-the-bottom" only occurs when $r = \frac{\alpha\Omega}{1-\alpha}$ which is unlikely to happen. The only firm conclusion that I can make from equation [24] is that a country which receives more foreign aid or has a higher output share of capital will have a lower optimal corporate tax rate.

So, do my theoretical results imply that a country will set its capital tax rate equal to zero (the "race-to-the-bottom") to receive more capital? The answer is yes, if we only look at getting more capital. My two above–referenced theoretical results simply confirm the existence of tax competition. As always, a country will receive more capital if the country lowers its capital tax rates. If we look at the maximization of total social welfare, my results cannot confirm the "race-to-the-bottom". In my model, the capital tax revenue enters the optimization problem and increases total social welfare via increasing public goods and public inputs. On one hand, capital tax lowers capital invested in a country. On the other hand, capital tax increases public goods and public inputs that also increase total social welfare.

My empirical results support my theoretical results. The results show that countries which lower capital tax rates will receive more capital. How much will countries lower their capital tax rates to attract capital? Again, if we only look at getting more capital, we can indirectly infer the "race-to-the-bottom" – countries lower capital tax rates to receive more capital – it is the nature of

tax competition. However, countries may look at several other aspects of lowering capital taxes and receiving more investments. My other empirical results do not indicate that countries set capital tax rates equal to zero. The estimated parameters of tax response functions are all less than one and greater than zero.

5. Effects of other explanatory variables

This section analyzes the impact of other independent variables on corporate tax rates. The regression results in table 5.7 (model 1) and Table 5.8 (model 3) are discussed in detail because these two models provide estimated coefficients γ of tax response functions.

Population

Regression results in table 5.7 model (1) and (2) show that population variable is statistically significant at a one-percent level and positive. The positive estimate means that a country with a larger population size has a higher statutory corporate tax rate. A larger population provides some extra advantage for investors; for example, a larger market for products and services, a larger pool of labor, and higher agglomeration effects. The extra advantage allows the country with larger populations to collect additional rents through higher taxes. The estimated coefficient of 0.0044 means that a country with one million more people sets a 0.44 percentage point higher statutory corporate tax rate. On average, if population increases by one percent, the statutory corporate tax rate increases by 0.35 percentage point.

Employment rate

In table 5.7 and 5.8, the employment rate is statistically significant at a one-percent level in both models, using statutory and effective corporate tax rates. The positive coefficients show

that the employment rate has a positive impact on the corporate tax rate. Since unemployment and employment rates usually have an inverse relationship. We can infer that the unemployment rate has a negative impact on corporate tax rates. Countries with a higher unemployment rate set a lower corporate tax rate. It indicates that the pressure from high unemployment rates may push the government to be more aggressive in tax competition in order to attract capital to solve unemployment issues. This result supports my proposal about the link between tax competition and unemployment as illustrated in Figure 1.2, chapter 1.

Productivity

Productivity is statistically significant at a one-percent level in all models. However, the magnitude of the impact is very small. For the model with statutory corporate tax rates, the estimated coefficient is positive. A country with higher productivity sets a higher statutory corporate tax rate. Higher productivity increases output for investors, thereby attracting capital even with higher tax rates. The estimated coefficient 0.000087 means that if a developing country has a higher productivity of 1,000 dollars, their statutory corporate tax rate is 0.087 percentage point higher. On average, if the productivity increases by one percent, the statutory corporate tax rate increases by 0.0073 percentage point. For the model with effective corporate tax rates, the estimated coefficient is negative. It means that a developing country with higher productivity has a lower effective corporate tax rate. A higher productivity country offers more tax incentives and deductions for FDI than a lower productivity country.

Foreign aid (ODA)

Foreign aid is statistically significant at a one-percent level of significance for all models. However, the magnitude of the impact is negligible. The estimated coefficient on the ODA variable

is 0.001 and 0.00097 for models with statutory and effective corporate tax rates, respectively. If a developing receives one more million dollars in ODA, statutory and effectively corporate tax rates almost stay the same (increase by only 0.001 percentage points). On average, if ODA to developing countries increases by one percent, statutory and effective corporate tax rate increases by 0.006 percent. The two opposite impacts of ODA on corporate tax rates may offset each other, keeping the corporate tax rates unchanged. On one hand, ODA is mainly targeted to public projects which can help the government to reduce their expenditure in those public projects which may result in lower corporate tax rates[43]. On the other hand, ODA can help a developing country improve its business environment, raising the country's productivity and hence attracting capital without needing to lower its corporate tax rates. Another explanation for the negligible impact of ODA to tax competition is that a larger amount of ODA is usually provided to least developed countries. As our earlier analysis suggests, an increase in foreign aid is not necessarily followed by a tax competition in these countries. For example, many African countries receiving a large amount of ODA are not involved in tax competition. Those countries may not be able attract foreign investment even if they lower their capital tax rates. They simply give up tax competition. Foreign aid simply serves domestic consumption, with tax competition being unaffected.

Investment in public inputs

Investment in public inputs variable is not a statistically significant in the model. There is no clear relationship between investment in public inputs and developing countries' corporate tax rates. From a balance budge equation, one may expect a positive relationship between investment in public inputs and corporate tax rates. An increase in investments in public inputs (the

[43] Discussed in Figure 1.1, page 15.

government expenditure) may results in an increase in corporate tax rates (the government revenue). In other words, investment in public inputs may restrict tax competition. However, my regression results do not confirm this relationship. The results suggest that developing countries may implement both tax competition (lower corporate taxes) and fiscal competition (increase investment in public inputs). The increase in investment in public inputs may be financed from different sources of government revenue such as an increase in property taxes, sale taxes, personal income taxes or foreign aid.

Trade openness

Trade openness is statistically significant at a five-percent level and has a negative impact on statutory corporate tax rates. A developing country that is more open to international trade is involved in more tax competition. Specifically, if trade openness increases by one unit (one hundred percent), the statutory corporate tax rate decreases by 2.27 percentage points. Trade integration increases tax competition.

CHAPTER 6: POLICY IMPLICATIONS

In this chapter, I analyze the policy implications from my theoretical and empirical results. I intend to provide the recommendations to policy makers regarding corporate tax policies and FDI flows in developing countries.

1. Tax competition for developing countries

My theoretical and empirical results suggest that tax competition exists among developing countries and that tax competition increases investments in those countries. These results imply that developing countries should engage in tax competition because it benefits them. I presented several arguments throughout the paper that tax competition must be a policy choice for developing countries to attract capital. Tax competition provides developing countries with opportunities to be attractive locations for investments.

2. Effective vs statutory corporate tax rates in attracting FDI

My empirical results suggest that developing countries can attract more FDI by lowering statutory corporate tax rates and/ or offering tax incentives and deductions. Offering tax incentives and deductions has a stronger impact on FDI than lowering statutory corporate tax rates. The results provide some insights into designing a tax competition policy for developing countries. My results suggest that developing countries should use more tax incentives and deductions to attract FDI. Tax incentives and deductions are also more flexible than statutory corporate tax rates. A country may apply different tax incentives and deductions to different FDI projects. For example, a country may offer extra incentives for FDI projects that have advanced technologies, have strong positive externalities and knowledge spillovers, use more domestic inputs from domestic

supporting companies, and export the majority of their output. A developing country with a high unemployment rate may offer extra tax incentives and deductions for FDI projects that employ a large number of workers. A country with uneven areas of development may also offer special incentives for investments in less developed or rural areas. Tax incentives and deductions may be used as special investment invitations to target specific large MNCs. These large technology companies may bring in several extra benefits for recipient countries such as an access to world-wide distribution network and expansion of domestic supporting industries providing inputs for these MNCs. Overall, tax incentives and deductions can be adapted to target investments that fit any needs of a developing country.

3. Tax competition, understanding responses of other countries

My empirical results suggest that if countries lower their statutory corporate tax rates, other countries will also lower their statutory rates. If countries offer corporate tax incentives and deductions, other countries will do the same. Developing countries that are not actively involved in tax competition may lose a chance to attract capital. Statistics indicates that African countries have highest corporate tax rates and receive least amount of FDI. Countries that actively search and compete for capital receive larger portion of FDI (such as Taiwan, Singapore and Hongkong).

My results also suggest that the response function for statutory rates is stronger than the response function for effective rates. The findings have important policy implications for developing countries. First, the estimated tax response function helps developing countries predict the reactions of other countries regarding corporate tax policies. Second, the reaction is stronger via statutory corporate tax rates which means that a statutory corporate tax cut triggers a stronger tax competition than an effective corporate tax reduction via tax incentives and deductions.

4. Unemployment rate, tax competition and FDI to developing countries

My theoretical and empirical results imply that FDI to developing countries lowers their unemployment rates. Thus, a country with a higher unemployment rate should be more active in searching for capital and more involved in tax competition. In the early stages of development, developing countries usually face high unemployment rates and a majority of their labor force is in the agricultural sector. In order to solve the unemployment issue and move the labor force from agriculture to manufacturing, the government should implement a competitive corporate tax policy. They should also offer special tax incentives for investments that employ a large number of workers.

A common concern from tax competition policy in developing countries is the corporate tax revenue loss from corporate tax cuts. My results show that tax competition attracts more investments which should generate a larger corporate tax base. Thus, tax competition may not necessarily reduce corporate tax revenues.

5. Investment in public inputs in developing countries

My theoretical and empirical findings imply that developing countries have two ways to compete for capital: fiscal competition or tax competition. In fiscal competition, government expenditures can be directed toward investment in public inputs such as infrastructure, thereby improving the business environment and productivities[44], attracting more investments, and lowering unemployment rates[45]. Investment in public inputs builds a strong foundation for a long-term and sustainable growth in developing countries.

[44] My results show that investment in public inputs increases the total factor productivity.
[45] My results indicate that investment in public inputs decreases the unemployment rate.

6. Productivity and FDI to developing countries

My empirical and theoretical results find a positive relationship between productivity and FDI in developing countries. The findings suggest that developing countries can attract FDI by increasing their productivity. As we have discussed earlier, investment in public inputs that improves the business environment can increase productivity. There are other common ways that developing countries can use to increase their productivity, such as improving education, reducing corruption, increasing transparency and market access for all businesses, and avoiding government activities that distort business operations and create unfair business practices.

7. Productivity and tax competition

My empirical results suggest that productivity has a positive relationship with statutory corporate tax rates and a negative relationship with effective corporate tax rates. The results suggest using adaptive corporate tax policies for developing countries depending on their productivity levels. A low productivity country will set lower statutory tax rates to compete for capital. High productivity countries can charge higher statutory corporate tax rates and still be attractive to FDI. High productivity countries compete less over statutory corporate tax rates but compete more over tax incentives and deductions. As my previous discussion indicated, tax competition via tax incentives and deduction is more flexible and more targeted to certain types of FDI. It means that high productivity countries are more selective in attracting FDI by setting higher statutory corporate tax rates while offering more tax incentives and deductions for selective types of FDI. On the other hand, low productivity countries attract a wide range of FDI by setting lower statutory corporate tax rates.

CHAPTER 7: CONCLUSION

The tax competition literature has generally studied tax competition in the context of developed countries. Research for developing countries is very limited. These two groups of countries are very different, even opposite in many aspects of tax competition. Hence, one cannot necessarily apply tax competition results for developed countries to developing countries. I summarize my main arguments to justify the importance of studying tax competition and potential benefits of using tax competition in developing countries. First, all countries need capital for their development. Developing countries usually have a shortage of capital. Thus, tax competition policy to attract capital must be studied more thoroughly in developing countries. Second, in the previous literature, studies on tax competition in developed countries often call for a tax harmonization or a restriction in tax competition. Developed countries are at a disadvantage in using tax competition to attract capital from the developing world. It does not make sense for the developed world to promote tax competition (and to lose tax revenues) while trying to attract capital from the developing world (where they do not have or have little of capital). Capital from the developing world, if any, is less attractive to them due to a lower technology content. Tax competition results in the loss of tax revenue, a reduction in the government expenditure and under-provision of public goods. It is no surprise that policy recommendations by developed countries is to limit tax competition to retain capital pool to their countries. On the other hand, tax competition in developing countries can attract a large amount of capital from developed countries. Tax revenue loss may not be an issue in developing countries because an increase in investments will result in an increase in the tax base. Third, unlike most other measures to attract investment, tax competition can be implemented easily and quickly with instant effects. Developing countries only

need to keep their corporate tax policy competitive. Lower corporate tax rates are also transparent to investors.

To study tax competition in developing countries, I used the tax competition framework laid out by Zodrow and Mieszkowski (1986), Cai and Treisman (2005) and Ogawa, Sato and Tamai (2006). However, my model goes beyond these models in several aspects. First my model allows unemployment rates to vary across countries. Unemployment is an important characteristic of most developing countries and it is also one of the most important reasons forcing developing countries to attract capital. Second, my model accounts for foreign aid, another typical characteristic of developing countries. My model evaluates the impact of foreign aid on tax competition in developing countries. Third, these above earlier papers are theoretical models without empirical testing. My paper presents both a theoretical model and an empirical model to test my theoretical results. My two empirical models investigate several aspects of tax competition. The first model tests the necessary condition of tax competition in developing countries. The model also estimates several other determinants of FDI to developing countries. I found the existence of cross-sectional dependence and serial correlation in both models. I presented appropriate estimation methods to correct these issues. The second model estimates tax response functions and effects of other variables on tax competition among developing countries. To estimate this model, I employed a spatial model that is commonly used to estimate interactions among countries.

I found that tax competition exists in developing countries in both theoretical and empirical models. The necessary condition for tax competition is confirmed. Countries that lower their capital tax rates receive more investments. I also found that tax competition exists in both effective and statutory corporate tax rates. The tax response functions for both rates are positive; countries lower their statutory corporate tax rates for more FDI. Countries also compete for capital by

offering tax incentives and deductions to investors. In addition, I found that countries compete more over statutory tax rates than effective tax rates. Furthermore, I found that a country with higher trade openness index set lower statutory corporate tax rate.

I found several other results related to tax competition in developing countries. *Productivity* has different impacts on tax competition and FDI. First, productivity is an important determinant of FDI. A country with a high productivity is more attractive to FDI and receives more FDI than a country with a low productivity. Second, productivity affects tax competition behavior across countries. Low productivity countries have strong tax competition in statutory corporate tax rates. They set lower statutory corporate tax rates than high productivity countries. On the other hand, high productivity countries have strong tax competition in effective tax rates. They offer more tax incentives and deductions. *Investment in public inputs* has indirect impacts on tax competition in developing countries. First, investment in public inputs offers developing countries another channel to compete for capital – fiscal competition. A country can attract capital by investing in public inputs. Second, investment in public inputs increases productivity. Productivity, in turn, affects tax competition behavior across countries.

I also found several results related to foreign aid and unemployment rates in developing countries. Foreign aid can create both tax competition and fiscal competition in developing countries. Specifically, foreign aid helps developing countries to invest in public inputs and lower corporate tax rates which attract more investments. Regarding unemployment rates, tax competition is stronger in high unemployment rate countries. In addition, investment in public inputs can help developing countries lower their unemployment rates. Attracting more investment is another way for developing countries to lower their unemployment rates.

This study has some potential limitations. In my theoretical models, I found that the impact of foreign aid on tax competition depends on the output share of capital. In my empirical models, I could not get enough data for most developing countries to group countries depending on their output share of capital. My estimation results regarding the impact of foreign aid on tax competition could be improved if my empirical models were estimated separately for two groups of developing countries as suggested in my theoretical findings.

I also face another limitation in my empirical model. To estimate tax competition among developing countries, I use a spatial model based on geographical dependence among countries. I have discussed several reasons to justify the use of geographical dependence in the model. However, there are some possible expansions to use different types of dependence such as economic dependence, trade dependence and natural resource dependence. However, currently there is a lack of theoretical framework to calculate a spatial weight matrix for those dependencies. For example, natural resource, labor intensity and foreign trade are time variant variables while the standard method of geographical dependence bases on time invariant distance. Estimating the models with the above alternative dependences will fill the gaps in the prior literature.

Another deficiency in my model is that I developed the model using an aggregate production function with a representative capital K and labor L. My model can only investigate tax competition across countries and the impacts of tax competition on the aggregate capital and labor. A possible expansion is to develop a model with different types of capital and different types of labor. The new model will be useful to analyze the impacts of tax competition on different sectors and different groups of labor. The results of the new model may also allow us to conclude whether or not developing counties should use different types of tax competition policy toward different types of capital and labor.

REFERENCES

1. Abdul, Aziz, and Bilal Makkawi. 2012. "Relationship between foreign direct investment and country population." *International Journal of Business and Management*, vol. 7, no. 8, pp. 63-70.

2. Alesina, Alberto, and David Dollar. 2000. "Who gives foreign aid to whom and why?." *Journal of Economic Growth,* vol. 5, no. 1, pp. 33-63.

3. Alfaro, Laura, Areendam Chanda, Sebnem Kalemli-Ozcan, and Selin Sayek. 2006. "How does foreign direct investment promote economic growth? Exploring the effects of financial markets on linkages." *National Bureau of Economic Research*, no. 12522, working paper series.

4. Altshuler, Rosanne, Harry Grubert, and Scott Newlon. 2000. "Has U.S. Investment Abroad Become More Sensitive to Tax Rates?." *NBER International Taxation and Multinational Activity*, pp. 9-38.

5. An, Zhiyong. 2012. "Taxation and foreign direct investment (FDI): empirical evidence from a quasi-experiment in China." *International Tax and Public Finance,* vol. 19, no. 5, pp. 660-676.

6. Anyanwu, Chukwudi. 2011. "Determinants of foreign direct investment inflows to Africa, 1980-2007." *African Development Bank Group*, working paper series.

7. Arazmuradov, Annageldy. 2012. "Foreign Aid, Foreign Direct Investment, and Domestic Investment Nexus in Landlocked Economies of Central Asia." *Economic Research Guardian*, Weissberg Publishing, vol. 2, no. 1, pp. 129-151.

8. Azémara, Céline and Andrew Delios. 2008. “Tax competition and FDI: The special case of developing countries.” *Journal of the Japanese and International Economies*, vol. 22, pp. 85–108.

9. Baldwin, Richard, and Paul Krugman. 2004. "Agglomeration, integration and tax harmonisation." *European Economic Review*, vol. 48, no. 1, pp. 1-23.

10. Baldwin, Richard, and Toshihiro Okubo. 2014. “Tax Competition with Heterogeneous Firms.” *Spatial Economic Analysis*, vol. 9, no. 3, pp. 309-326

11. Beck, Nathaniel, and Jonathan Katz. 1995. "What to do (and not to do) with time-series cross-section data." *American Political Science Review*, vol. 89, no. 3, pp. 634-647.

12. Becker, Gary. 1998. "‘What’s Wrong with a Centralized Europe." *Business Week* (Industrial/technology edition), no. 3584.

13. Bénassy, Agnès, Lionel Fontagné and Amina Lahrèche-Révil. 2001. "Foreign Direct Investment and Company Taxation in Europe." *European Network of Economic Policy Research Institutes (ENEPRI)*, Working Paper.

14. Bénassy, Agnès, Nicolas Gobalraja, and Alain Trannoy. 2007. “Tax and public input competition.” *Economic Policy*, vol. 22, no. 50, pp. 385-430.

15. Benedek, Dora, Ernesto Crivelli, Sanjeev Gupta and Priscilla Muthoora. 2014. "Foreign Aid and Revenue: Still a Crowding-Out Effect?." *FinanzArchiv: Public Finance Analysis*, vol. 70, no. 1, pp. 67-96.

16. Bhavan, Thangamani, Changsheng Xu, and Chunping Zhong. 2011. "The relationship between foreign aid and FDI in South Asian economies." *International Journal of Economics and Finance*, vol. 3, no. 2, pp. 143-149.

17. Blomstrom, Magnus. 1991. "Host country benefits of foreign investment." *National Bureau of Economic Research* – NBER Working Paper Series w3615.

18. Braid, Ralph. 2000. "A spatial model of tax competition with multiple tax instruments." *Journal of Urban Economics*, vol. 47, no. 1, pp. 88-114.

19. Brennan, Geoffrey, and James Buchanan. 1980. *The power to tax: Analytic foundations of a fiscal constitution*. Cambridge University Press, NY 10022, USA.

20. Bucovetsky, Sam. 1991. "Asymmetric tax competition." *Journal of Urban Economics*, vol. 30, no. 2, pp. 167-181.

21. Cai, Hongbin, and Daniel Treisman. 2005. "Does competition for capital discipline governments? Decentralization, globalization, and public policy." *American Economic Review*, vol. 95, no. 3, pp. 817-830.

22. Carro, Martha, and José Larrú. 2010. "Flowing together or flowing apart: An analysis of the relation between FDI and ODA flows to Argentina and Brazil." *MPRA Paper 25064*, University Library of Munich, Germany.

23. Carter, Patrick. 2013. "Does foreign aid displace domestic taxation?." *Journal of Globalization and Development*, vol. 4, no. 1, pp. 1-47.

24. Caselli, Francesco, and James Feyrer. 2007. "The marginal product of capital." *The Quarterly Journal of Economics*, vol. 122, no. 2, pp. 535-568.

25. Chatelais, Nicolas, and Mathilde Peyrat. 2008. "Are Small countries leaders of the European tax competition?." *Working paper, Université Paris 1 Panthéon-Sorbonne*.

26. Clist, Paul, and Oliver Morrissey. 2011. "Aid and tax revenue: signs of a positive effect since the 1980s." *Journal of International Development*, vol. 23, no. 2, pp. 165-180.

27. Coulibaly, Souleymane. 2008. "Empirical Assessment of the Existence of Taxable Agglomeration Rents." *University of Lausanne*, Cahiers de Recherches Economiques du Département d'Econométrie et d'Economie politique, No. 08-01.

28. Craigwell, Roland. 2006. "Foreign direct investment and employment in the English and Dutch-speaking Caribbean." *ILO Subregional Office for the Caribbean.* *https://www.ilo.org/caribbean/events-and-meetings/WCMS_306245/lang--en/index.htm*.

29. Dao, Mai Chi, Mitali Das, Zsoka Koczan and Weicheng Lian. 2017. "Why Is Labor Receiving a Smaller Share of Global Income? Theory and Empirical Evidence." *International Monetary Fund,* working paper series.

30. Darby, Julia, Ben Ferrett and Ian Wooton. 2014. "Regional Centrality and Tax Competition for FDI." *Regional Science and Urban Economics*, vol.49, pp. 84-92.

31. Decreuse, Bruno, and Paul Maarek. 2007. "Foreign Direct Investment and the labor share in developing countries." *University of Aix-Marseilles II,* Working Paper.

32. Demirhan, Banu, and Cengiz Yilmaz. 2015. "A Panel Data Investigation of the Foreign Direct Investment Determinants: Evidence from Balkan Countries." *The Empirical Economics Letters*, vol. 14, no. 11, pp. 1067-1075.

33. Devereux, Michael, Ben Lockwood, and Michela Redoano. 2008. "Do countries compete over corporate tax rates?." *Journal of Public Economics*, vol. 92(5-6), pages 1210-1235.

34. Dhillon, Amrita, Myrna Wooders, and Ben Zissimos. 2007. "Tax Competition Reconsidered." *Journal of Public Economic Theory*, vol. 9, no. 3, pp. 391-423.

35. Dietsch, Peter. 2015. *Catching capital, the ethics of tax competition.* Oxford University Press, New York, USA.

36. Dodangi, Mohammad. 2016. "Factors affecting domestic and foreign investments in Iran." *Quarterly Journal of Economic Growth and Development Research*, vol. 6, no. 23, pp. 131-147.

37. Driscoll, John, and Aart Kraay. 1998. "Consistent covariance matrix estimation with spatially dependent panel data." *Review of Economics and Statistics*, vol. 80, no. 4, pp. 549-560.

38. Dudley, Leonard, and Claude Montmarquette. 1976. "A model of the supply of bilateral foreign aid." *The American Economic Review,* vol. 66, no. 1, pp.132-142.

39. Edwards, Jeremy, and Michael Keen. 1996. "Tax competition and Leviathan." *European Economic Review*, vol. 40, no. 1, pp. 113-134.

40. Egger, Peter, and Tobias Seidel. 2011. "Tax competition, trade liberalization, and imperfect labor markets." *Oxford Economic Papers*, Oxford University Press, vol. 63, no. 4, pp. 722-739.

41. Eichner, Thomas, and Thorsten Upmann. 2010. "Tax-Competition with Involuntary Unemployment." *CESifo Working Paper Series 3048*, CESifo.

42. Genschel, Philipp, Hanna Lierse, Henning Schmidtke, Laura Seelkopf, Stefan Traub, and Hongyan Yang. 2015. "Tax competition and inequality." *14th Biennial Conference of the European Union Studies Association.*

43. Görg, Holger, and David Greenaway. 2001. “Foreign Direct Investment and Intra-Industry spillovers: A review of the literature.” *Research paper series: Globalisation and Labour Markets Programme,* Nottingham, Leverhulme Centre for Research on Globalisation and Economic Policy, no. 37.

44. Hale, Galina and Cheryl Long. 2011. "Did Foreign Direct Investment Put an Upward Pressure on Wages in China?." *IMF International Monetary Fund Economic Review*, Palgrave Macmillan, vol. 59, no. 3, pp. 404-430.

45. Hale, Galina and Mingzhi Xu. 2016. "FDI effects on the labor market of host countries." *Working Paper Series 2016-25*, Federal Reserve Bank of San Francisco. https://www.frbsf.org/economic-research/files/wp2016-25.pdf

46. Harms, Philipp, and Matthias Lutz. 2006. "Aid, governance and private foreign investment: Some puzzling findings for the 1990s." *The Economic Journal*, vol. 116, no. 513, pp. 773-790.

47. Haufler, Andreas, and Ian Wooton. 1999. “Country size and tax competition for foreign direct investment.” *Journal of Public Economics*, Vol. 71, no. 1, 121-139.

48. Haughwout, Andrew. 2001. "Infrastructure and social welfare in metropolitan America." *Economic Policy Review*, vol. 7, no. 3.

49. Hindriks, Jean, Susana Peralta, and Shlomo Weber. 2008. “Competing in Taxes and Investment under Fiscal Equalisation.” *Journal of Public Economics*, vol. 92, pp. 2392 – 2402.

50. Hines, James. 1999. "Lessons from Behavioral Responses to International Taxation." *National Tax Journal*, vol. 52, 305-222.

51. Huttunen, Kristiina. 2007. “The Effect of Foreign Acquisition on Employment and Wages: Evidence from Finnish Establishments.” *The Review of Economics and Statistics*, vol. 89, no. 3, pp. 497-509.

52. ILO – International Labour Organization. 2018. “World Employment and Social Outlook – Trends 2018.” *Labour Market Trends and Policy Evaluation Unit of the ILO Research Department.*

53. ILO - International Labour Organization. 2019. “Quick guide on interpreting the unemployment rate.” *International Labour Office – Geneva: ILO publication.*

54. IMF - International Monetary Fund. 2001. “World Economic Outlook.” October 2001 report.

55. IMF - International Monetary Fund. 2019. “World Economic Outlook.” October 2019 report

56. Johansson, Åsa, Chistopher Heady, Jens Arnold, Bert Brys, and Laura Vartia. 2008. "Taxation and economic growth." *OECD Economics Department*, Working Papers no. 620.

57. Kanbur, Ravi, and Michael Keen. 1993. “Tax Competition and Tax Coordination When Countries Differ in Size.” *American Economic Review*, vol. 83, pp. 877-892.

58. Karkalakos, Sotiris, and Christos Kotsogiannis. 2007. "A spatial analysis of provincial corporate income tax responses: evidence from Canada." *Canadian Journal of Economics/* Revue canadienne d'économique, vol. 40, no. 3, pp. 782-811.

59. Karlsson, Sune, Nannan Lundin, Fredrik Sjöholm, and Ping He. 2009. "Foreign firms and Chinese employment." *World Economy,* vol. 32, no. 1, pp. 178-201.

60. Karpaty, Patrik, and Lars Lundberg. 2004. "Foreign Direct Investment and Productivity Spillovers in Swedish Manufacturing." *Trade Union Institute for Economic Research*, Working Paper Series no. 194.

61. Kato, Hayato. 2015. "The Importance of Government Commitment in Attracting Firms: A Dynamic Analysis of Tax Competition in an Agglomeration Economy." *European Economic Review*, vol. 74, pp. 57-78.

62. Keen, Michael and James Brumby. 2017. "Peer Pressure: Tax competition and developing economies." World Bank publication, available at https://blogs.worldbank.org/governance/peer-pressure-tax-competition-and-developing-economies .

63. Keen, Michael, and Kai Konrad. 2013. "The theory of international tax competition and coordination." *Handbook of Public Economics*, vol. 5, pp. 257-328.

64. Kind, Hans, Helene Knarvik, and Guttorm Schjelderup. 2000. "Competing for capital in a 'lumpy' world." *Journal of Public Economics*, vol. 78, no. 3, pp. 253-274.

65. Klein, Michael, and Eric Rosengren. 1994. "The real exchange rate and foreign direct investment in the United States: relative wealth vs. relative wage effects." *Journal of International Economics*, vol. 36, no. 3-4, pp. 373-389.

66. Knight, Brian. 2002. "State capital taxes and the location of investment: Empirical lessons from theoretical models of tax competition." *Finance and Economics Discussion Series 2002*, Board of Governors of the Federal Reserve System (U.S.).

67. Kosack, Stephen, and Jennifer Tobin. 2006. "Funding self-sustaining development: The role of aid, FDI and government in economic success." *International Organization*, vol. 60, no. 1, pp. 205-243.

68. Laussel, Didier, and Michel Le Breton. 1998. "Existence of Nash equilibria in fiscal competition models." *Regional Science and Urban Economics*, vol. 28, no. 3, pp. 283-296.

69. Ludema, Rodney, and Ian Wooton. 2000. "Economic geography and the fiscal effects of regional integration." *Journal of International Economics*, vol. 52, no. 2, pp. 331-357.

70. Mansfield, Edwin and Anthony Romeo. 1980. “Technology transfer to overseas subsidiaries by U.S.-based firms.” *The Quarterly Journal of Economics*, vol. 95, no. 4, pp. 737-750.

71. Mansfield, Edwin. 1982. *Technology Transfer, Productivity, and Economic Policy.* Norton publisher.

72. Margalioth, Yoram. 2003. “Tax Competition, Foreign Direct Investments and Growth: Using The Tax System To Promote Developing Countries.” *Virginia Tax Review*, vol. 23.

73. Meernik, James, Eric Krueger, and Steven Poe. 1998. "Testing models of US foreign policy: Foreign aid during and after the Cold War." *The Journal of Politics,* vol. 60, no. 1, pp. 63-85.

74. Mooij, Ruud, and Sjef Ederveen. 2003. "Taxation and foreign direct investment: a synthesis of empirical research." *International Tax and Public Finance,* vol. 10, no. 6, pp. 673-693.

75. Morrison, Catherine, and Amy Schwartz. 1996. "Public infrastructure, private input demand, and economic performance in New England manufacturing." *Journal of Business & Economic Statistics,* vol. 14, no. 1, pp. 91-101.

76. Mustafa, Seref, and Valerica Vlad. 2011. "The relationship between education and foreign direct investment: testing the inverse U shape." *European Journal of Economic and Political Studies*, vol. 4, no. 1, pp. 27-46.

77. Mutti, John, and Harry Grubert. 2004. "Empirical asymmetries in foreign direct investment and taxation." *Journal of International Economics*, vol. 62, no. 2, pp. 337-358.

78. Nadiri, Ishaq, and Theofanis Mamuneas. 1994. "Infrastructure and public R&D investments, and the growth of factor productivity in US manufacturing industries." *NBER - National Bureau of Economic Research*, no. w4845.

79. Oates, Wallace. 1972. *Fiscal Federalism*. New York: Harcourt Brace Jovanovich.

80. OECD - Organization for Economic Cooperation and Development. 1998. "Harmful tax competition: An emerging global issue." OECD publication, vol. 235.

81. Ogawa, Hikaru, Yasuhiro Sato, and Toshiki Tamai. 2006. "A note on unemployment and capital tax competition." *Journal of Urban Economics*, vol. 60, no. 2, pp. 350-356.

82. Ouattara, Bazoumana. 2006. "Foreign aid and government fiscal behavior in developing countries: Panel data evidence." *Economic Modelling*, vol. 23, no. 3, pp. 506-514.

83. Overesch, Michael, and Johannes Rincke. 2011. "What Drives Corporate Tax Rates Down? A Reassessment of Globalization, Tax Competition and Dynamic Adjustment to Shocks." *Scandinavian Journal of Economics*, vol. 113, no. 3, pp. 579–602.

84. Peralta, Susana, and Tanguy Ypersele. 2005. "Factor endowments and welfare levels in an asymmetric tax competition game." *Journal of Urban Economics*, vol. 57, no. 2, pp. 258-274.

85. Rashid, Mamunur, Xuan Looi, and Shao Wong. 2017. "Political stability and FDI in the most competitive Asia Pacific countries." *Journal of Financial Economic Policy*, vol. 9, no. 2, pp. 140-155.

86. Redoano, Michela. 2014. "Tax Competition among European Countries: Does the EU Matter?." *European Journal of Political Economy*, vol. 34, pp. 353-371.

87. Reichl, Bettina. 1998. *Tax competition for international portfolio capital among emerging markets: An approach considering the substitutability of risky assets*. Discussion Paper Series 26312, Hamburg Institute of International Economics.

88. Sjöholm, Fredrik and Robert Lipsey. 2006. "Foreign Firms and Indonesian Manufacturing Wages: An Analysis with Panel Data." *Economic Development and Cultural Change*, vol. 55, no. 1, pp. 201-221.

89. Slemrod, Joel. 2004. "Are corporate tax rates, or countries, converging?." *Journal of Public Economics*, vol. 88, no. 6, pp. 1169-1186.

90. Sorens, Jason. 2014. “Fiscal Federalism, Jurisdictional Competition, and the Size of Government.” *Constitutional Political Economy*, vol. 25, iss. 4, pp. 354-75

91. Tiebout, Charles. 1956. “A Pure Theory of Local Expenditures.” *The Journal of Political Economy*, vol. 64, no. 5, pp. 416-424.

92. UNCTAD - United Nations Conference on Trade and Development. 2007. *World Investment Report*. UNCTAD publication.

93. UNCTAD - United Nations Conference on Trade and Development. 2015. *World Investment Report.* UNCTAD publication.

94. UNCTAD - United Nations Conference on Trade and Development. 2018. “Tax reform in the United States: implications for international investment.” Special Edition, Investment Trend Monitor.

95. UNCTAD - United Nations Conference on Trade and Development. 2018. *World Investment Report.* UNCTAD publication.

96. Waldkirch, Andreas, Peter Nunnenkamp and Jose Bremont. 2009. “Employment Effects of FDI in Mexico's Non-Maquiladora Manufacturing.” *The Journal of Development Studies*, vol. 45, no. 7, pp. 1165-1183.

97. Wilson, Douglas, and David Wildasin. 2004. “Capital tax competition: bane or boon.” *Journal of Public Economics*, vol. 88, no. 6, pp. 1065-1091.

98. Wilson, Douglas. 1991. “Tax Competition with Interregional Differences in Factor Endowments.” *Regional Science and Urban Economics*, vol. 21, pp. 423 – 451.

99. Wilson, Douglas. 1999. “Theories of tax competition.” *National Tax Journal*, vol. 52, no. 2, pp. 269-304.

100. Wooldridge, Jeffrey. 2002. *Econometric Analysis of Cross Section and Panel Data.* MIT press, Cambridge, MA.

101. Yakita, Akira. 2014. "Capital tax competition and cooperation with endogenous capital formation." *Review of International Economics*, vol. 22, no. 3, pp. 459-468.

102. Zissimos, Ben, and Myrna Wooders. 2008. "Public good differentiation and the intensity of tax competition." *Journal of Public Economics*, vol. 92, no. 5-6, pp. 1105-1121.

103. Zodrow, George and Peter Mieszkowski. 1986. “Pigou, Tiebout, Property Taxation and the Underprovision of Local Public Goods.” *Journal of Urban Economics*, Vol. 19, pp. 356-370.

APPENDIX A –DERIVATION OF MATHEMATICAL EQUATIONS IN CHAPTER 3

A.1. Derivation to the equation [13]

$$W_i = \mu_i b_i + \mu_i\gamma_i[t_iF_i + \Omega F_i - \mu_i b_i] + (1-\mu_i)w_i + (1-\mu_i)\gamma_i[t_iF_i + \Omega F_i - \mu_i b_i]$$

$$W_i = \mu_i b_i + \mu_i\gamma_i t_iF_i + \mu_i\gamma_i \Omega F_i - \mu_i\gamma_i\mu_i b_i + w_i - \mu_i w_i + (\gamma_i - \mu_i\gamma_i)[t_iF_i + \Omega F_i - \mu_i b_i]$$

$$W_i = \mu_i b_i + \mu_i\gamma_i t_iF_i + \mu_i\gamma_i \Omega F_i - \mu_i\gamma_i\mu_i b_i + w_i - \mu_i w_i + \gamma_i[t_iF_i + \Omega F_i - \mu_i b_i] - \mu_i\gamma_i[t_iF_i + \Omega F_i - \mu_i b_i]$$

$$W_i = \mu_i b_i + \mu_i\gamma_i t_iF_i + \mu_i\gamma_i \Omega F_i - \mu_i\gamma_i\mu_i b_i + w_i - \mu_i w_i + \gamma_i t_iF_i + \gamma_i \Omega F_i - \gamma_i\mu_i b_i - [\mu_i\gamma_i t_iF_i + \mu_i\gamma_i \Omega F_i - \mu_i\gamma_i\mu_i b_i]$$

$$W_i = \mu_i b_i + \mu_i\gamma_i t_iF_i + \mu_i\gamma_i \Omega F_i - \mu_i\gamma_i\mu_i b_i + w_i - \mu_i w_i + \gamma_i t_iF_i + \gamma_i \Omega F_i - \gamma_i\mu_i b_i - \mu_i\gamma_i t_iF_i - \mu_i\gamma_i \Omega F_i + \mu_i\gamma_i\mu_i b_i$$

$$W_i = \mu_i b_i + w_i - \mu_i w_i + \gamma_i t_iF_i + \gamma_i \Omega F_i - \gamma_i\mu_i b_i$$

$$W_i = \mu_i b_i + w_i - \mu_i w_i - \gamma_i\mu_i b_i + \gamma_i t_iF_i + \gamma_i \Omega F_i \qquad [13]$$

A.2. Mathematical results - Proposition 1

From equilibrium capital, equation [15]

$$K_i^* = \left[\frac{A_i\alpha(1-\mu_i)^\beta}{r + t_i}\right]^{\frac{1}{1-\alpha}} \qquad [15]$$

$$K_i^* = \left[A_i\alpha(1-\mu_i)^\beta\right]^{\frac{1}{1-\alpha}}[(r + t_i)]^{\frac{-1}{1-\alpha}}$$

$$\frac{\partial K_i^*}{\partial t_i} = \left[A_i\alpha(1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}} \frac{-1}{1-\alpha}[(r+\ t_i)]^{\frac{-1}{1-\alpha}-1}$$

$$\frac{\partial K_i^*}{\partial t_i} = \left[A_i\alpha(1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}} \frac{-1}{1-\alpha}[(r+\ t_i)]^{\frac{\alpha-2}{1-\alpha}}$$

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{1-\alpha}\left\{\left[A_i\alpha(1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}}[(r+\ t_i)]^{\frac{\alpha-2}{1-\alpha}}\right\}$$

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{1-\alpha}\left\{\left[A_i\alpha(1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}}[(r+\ t_i)]^{\frac{-1+\alpha-1}{1-\alpha}}\right\} \qquad [15.1]$$

Rewrite equation [15.1]

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{1-\alpha}\left\{\left[A_i\alpha(1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}}[(r+\ t_i)]^{\frac{-1}{1-\alpha}-1}\right\}$$

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{1-\alpha}\left\{\frac{\left[A_i\alpha(1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}}}{[(r+\ t_i)]^{\frac{1}{1-\alpha}}}[(r+\ t_i)]^{-1}\right\}$$

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{1-\alpha}[(r+\ t_i)]^{-1}\left\{\frac{\left[A_i\alpha(1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}}}{[(r+\ t_i)]^{\frac{1}{1-\alpha}}}\right\}$$

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{(1-\alpha)(r+\ t_i)}\left\{\frac{\left[A_i\alpha(1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}}}{[(r+\ t_i)]^{\frac{1}{1-\alpha}}}\right\}$$

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{(1-\alpha)(r+\ t_i)}\left\{\frac{\left[A_i\alpha(1-\mu_i)^{\beta}\right]}{[(r+\ t_i)]}\right\}^{\frac{1}{1-\alpha}}$$

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{(1-\alpha)(r+\ t_i)}K_i^*$$

$$\frac{\partial K_i^*}{\partial t_i} = \frac{-1}{(1-\alpha)} \frac{K_i^*}{(r + t_i)} \quad [16]$$

A.3. Mathematical result - Proposition 2

Differentiating equation [15] with respect to μ_i:

$$K_i^* = \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i}\right]^{\frac{1}{1-\alpha}} \quad [15]$$

$$K_i^* = \left[A_i \alpha (1-\mu_i)^{\beta}\right]^{\frac{1}{1-\alpha}} (r + t_i)^{\frac{-1}{1-\alpha}}$$

$$K_i^* = [(1-\mu_i)]^{\frac{\beta}{1-\alpha}} (A_i \alpha)^{\frac{1}{1-\alpha}} (r + t_i)^{\frac{-1}{1-\alpha}}$$

$$K_i^* = [(1-\mu_i)]^{\frac{\beta}{1-\alpha}} \left\{(A_i \alpha)^{\frac{1}{1-\alpha}} (r + t_i)^{\frac{-1}{1-\alpha}}\right\}$$

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha} [(1-\mu_i)]^{\frac{\beta}{1-\alpha}-1} \left\{(A_i \alpha)^{\frac{1}{1-\alpha}} (r + t_i)^{\frac{-1}{1-\alpha}}\right\}$$

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha} [(1-\mu_i)]^{\frac{\beta-1+\alpha}{1-\alpha}} \left\{(A_i \alpha)^{\frac{1}{1-\alpha}} (r + t_i)^{\frac{-1}{1-\alpha}}\right\}$$

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha} [(1-\mu_i)]^{\frac{\beta+\alpha-1}{1-\alpha}} \left\{(A_i \alpha)^{\frac{1}{1-\alpha}} (r + t_i)^{\frac{-1}{1-\alpha}}\right\}$$

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha} [(1-\mu_i)]^{\frac{\beta+\alpha-1}{1-\alpha}} \left\{\frac{(A_i \alpha)^{\frac{1}{1-\alpha}}}{(r + t_i)^{\frac{1}{1-\alpha}}}\right\}$$

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha} [(1-\mu_i)]^{\frac{\beta+\alpha-1}{1-\alpha}} \left\{\frac{(A_i \alpha)}{(r + t_i)}\right\}^{\frac{1}{1-\alpha}}$$

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha}[(1-\mu_i)]^{\frac{\beta+\alpha-1}{1-\alpha}}\left(\frac{A_i\alpha}{r+\ t_i}\right)^{\frac{1}{1-\alpha}}$$

$$\frac{\partial K_i^*}{\partial \mu_i} = -\frac{\beta}{1-\alpha}\left\{[(1-\mu_i)]^{\frac{\beta+\alpha-1}{1-\alpha}}\left(\frac{A_i\alpha}{r+\ t_i}\right)^{\frac{1}{1-\alpha}}\right\} \quad [17]$$

A.4. Mathematical result - Proposition 4

From equation [15] $K_i^* = \left[\frac{A_i\alpha(1-\mu_i)^{\beta}}{r+\ t_i}\right]^{\frac{1}{1-\alpha}}$

Rearrange equation [15]

$$K_i^* = \left[\frac{A_i\alpha}{r+\ t_i}\right]^{\frac{1}{1-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\alpha}}$$

$$K_i^* = \left[\frac{A_i\alpha}{r+\ t_i}\right]^{\frac{1}{1-\alpha}}\left[(1-\mu_i)^{\frac{1}{1-\alpha}}\right]^{\beta}$$

$$\frac{\partial K_i^*}{\partial \beta} = \left[\frac{A_i\alpha}{r+\ t_i}\right]^{\frac{1}{1-\alpha}}\left[(1-\mu_i)^{\frac{1}{1-\alpha}}\right]^{\beta} ln\left[(1-\mu_i)^{\frac{1}{1-\alpha}}\right]$$

$$\frac{\partial K_i^*}{\partial \beta} = \left[\frac{A_i\alpha}{r+\ t_i}\right]^{\frac{1}{1-\alpha}}\left[(1-\mu_i)^{\frac{1}{1-\alpha}}\right]^{\beta}\frac{1}{1-\alpha}ln(1-\mu_i)$$

$$\frac{\partial K_i^*}{\partial \beta} = \left\{\left[\frac{A_i\alpha}{r+\ t_i}\right]^{\frac{1}{1-\alpha}}\frac{1}{1-\alpha}(1-\mu_i)^{\frac{\beta}{1-\alpha}}\right\}\ln(1-\mu_i) \quad [19]$$

A.5. First order condition – Social welfare maximization (Model 1 – Government provides public good).

$$\frac{\partial W_i}{\partial t_i} = \gamma_i F_i + \gamma_i t_i \frac{\partial F_i}{\partial K_i}\frac{\partial K_i}{\partial t_i} + \gamma_i \Omega \frac{\partial F_i}{\partial K_i}\frac{\partial K_i}{\partial t_i} = 0 \quad [20]$$

Equilibrium K_i in equation [15]

$$K_i = \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i}\right]^{\frac{1}{1-\alpha}}$$

Production function in equation [2]

$$F_i = A_i K_i^{\alpha} (1-\mu_i)^{\beta} \quad [2]$$

First find $\frac{\partial K_i}{\partial t_i}$ using [15]

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha}\left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i}\right]^{\frac{1}{1-\alpha}-1} A_i \alpha (1-\mu_i)^{\beta} \frac{1}{(r + t_i)^2}$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha}\left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i}\right]^{\frac{\alpha}{1-\alpha}} A_i \alpha (1-\mu_i)^{\beta} \frac{1}{(r + t_i)^2}$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha}\left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i}\right]^{\frac{\alpha}{1-\alpha}+1} \frac{1}{(r + t_i)}$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha}\left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i}\right]^{\frac{1}{1-\alpha}} \frac{1}{(r + t_i)} \quad [21]$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha} K_i \frac{1}{(r + t_i)}$$

Condition for profit maximization:

$$\frac{\partial F_i}{\partial K_i} = r + t_i \qquad [22]$$

Substitute [21] and [22] and [2] into the first order condition [20]:

$\frac{\partial W_i}{\partial t_i} = \gamma_i F_i + \gamma_i t_i \frac{\partial F_i}{\partial K_i}\frac{\partial K_i}{\partial t_i} + \gamma_i \Omega \frac{\partial F_i}{\partial K_i}\frac{\partial K_i}{\partial t_i} = 0$

$$F_i = A_i K_i^{\alpha} L_i^{\beta} = A_i K_i^{\alpha}(1-\mu_i)^{\beta}$$

$$K_i = \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i}\right]^{\frac{1}{1-\alpha}}$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i A_i K_i^{\alpha}(1-\mu_i)^{\beta} + \gamma_i t_i (r+t_i)\left[-\frac{1}{1-\alpha}K_i \frac{1}{(r+t_i)}\right]$$

$$+ \gamma_i \Omega (r+t_i)\left[-\frac{1}{1-\alpha}K_i \frac{1}{(r+t_i)}\right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i A_i K_i^{\alpha}(1-\mu_i)^{\beta} + \gamma_i t_i \left[-\frac{1}{1-\alpha}K_i\right] + \gamma_i \Omega \left[-\frac{1}{1-\alpha}K_i\right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i A_i K_i^{\alpha}(1-\mu_i)^{\beta} - \gamma_i t_i \frac{1}{1-\alpha}K_i - \gamma_i \Omega \frac{1}{1-\alpha}K_i = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[A_i K_i^{\alpha-1}(1-\mu_i)^{\beta} - t_i \frac{1}{1-\alpha} - \Omega \frac{1}{1-\alpha}\right] = 0$$

Substitute the equilibrium capital K_i in equation [15] $K_i = \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r+t_i}\right]^{\frac{1}{1-\alpha}}$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[A_i \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r+t_i}\right]^{\frac{1}{1-\alpha}(\alpha-1)} (1-\mu_i)^{\beta} - t_i \frac{1}{1-\alpha} - \Omega \frac{1}{1-\alpha}\right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[A_i \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i} \right]^{\frac{1}{1-\alpha}(\alpha-1)} (1-\mu_i)^{\beta} - \mathrm{t}_i \frac{1}{1-\alpha} - \Omega \frac{1}{1-\alpha} \right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[A_i \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{r + t_i} \right]^{-1} (1-\mu_i)^{\beta} - \mathrm{t}_i \frac{1}{1-\alpha} - \Omega \frac{1}{1-\alpha} \right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[\left[\frac{\alpha}{r + t_i} \right]^{-1} - \mathrm{t}_i \frac{1}{1-\alpha} - \Omega \frac{1}{1-\alpha} \right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[\frac{r + t_i}{\alpha} - \mathrm{t}_i \frac{1}{1-\alpha} - \Omega \frac{1}{1-\alpha} \right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[\frac{(r + t_i)(1-\alpha)}{\alpha(1-\alpha)} - \frac{\mathrm{t}_i}{1-\alpha} - \frac{\Omega}{1-\alpha} \right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \left[\frac{(r + t_i)(1-\alpha)}{\alpha(1-\alpha)} - \frac{\alpha \mathrm{t}_i}{\alpha(1-\alpha)} - \frac{\alpha\Omega}{\alpha(1-\alpha)} \right] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \frac{1}{\alpha(1-\alpha)} [(r + t_i)(1-\alpha) - \alpha \mathrm{t}_i - \alpha\Omega] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \frac{1}{\alpha(1-\alpha)} [r - r\alpha + t_i - t_i\alpha - \alpha \mathrm{t}_i - \alpha\Omega] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \frac{1}{\alpha(1-\alpha)} [r - r\alpha - \alpha\Omega + t_i - 2\alpha \mathrm{t}_i] = 0$$

$$\frac{\partial W_i}{\partial t_i} = \gamma_i K_i \frac{1}{\alpha(1-\alpha)} [r - r\alpha - \alpha\Omega + t_i(1-2\alpha)] = 0 \qquad [23]$$

⇨ $r - r\alpha - \alpha\Omega + t_i(1-2\alpha) = 0$

⇨ $t_i(2\alpha - 1) = r - r\alpha - \alpha\Omega$

$$t_i^* = \frac{r - r\alpha - \alpha\Omega}{(2\alpha - 1)} \qquad [24]$$

A.6. Equilibrium K_i - model with both public input and public good

From the production function [25], $F_i = A_i K_i^{\alpha}(1-\mu_i)^{\beta} I_i^{\rho}$

Perfect competition and profit maximization implies:

$$\frac{\partial F_i}{\partial K_i} = A_i \alpha K_i^{\alpha-1}(1-\mu_i)^{\beta} I_i^{\rho} = r + t_i$$

$$\frac{\partial F_i}{\partial K_i} = A_i \alpha K_i^{\alpha-1}(1-\mu_i)^{\beta} I_i^{\rho} = r + t_i$$

$$K_i^{1-\alpha} = \frac{A_i \alpha (1-\mu_i)^{\beta} I_i^{\rho}}{r + t_i}$$

$$K^*_i = \left[\frac{A_i \alpha (1-\mu_i)^{\beta} I_i^{\rho}}{r + t_i}\right]^{\frac{1}{1-\alpha}} \quad [26]$$

A.7. Total welfare function -model with both public input and public good

$W_i = \mu_i u_i^u + (1-\mu_i) u_i^e$

$W_i = \mu_i[x_i^u + \gamma_i G_i] + (1-\mu_i)[x_i^e + \gamma_i G_i]$

Substitute [27], $G_i = t_i F_i + \Omega F_i - I_i - \mu_i b_i$ into the total welfare function:

$W_i = \mu_i\{x_i^u + \gamma_i[t_i F_i + \Omega F_i - I_i - \mu_i b_i]\} + (1-\mu_i)\{x_i^e + \gamma_i[t_i F_i + \Omega F_i - I_i - \mu_i b_i]\}$

$W_i = \mu_i\{b_i + \gamma_i[t_i F_i + \Omega F_i - I_i - \mu_i b_i]\} + (1-\mu_i)\{w_i + \gamma_i[t_i F_i + \Omega F_i - I_i - \mu_i b_i]\}$

$W_i = \mu_i b_i + \mu_i\gamma_i[t_i F_i + \Omega F_i - I_i - \mu_i b_i] + (1-\mu_i) w_i + (1-\mu_i)\gamma_i[t_i F_i + \Omega F_i - I_i - \mu_i b_i]$

$$W_i = \mu_i\, b_i + [\mu_i\gamma_i t_i F_i + \mu_i\gamma_i\, \Omega F_i - \mu_i\gamma_i\, I_i - \mu_i\gamma_i\mu_i b_i] + (w_i - \mu_i w_i) + (\gamma_i - \gamma_i\mu_i)\, [t_i F_i + \Omega F_i - I_i - \mu_i b_i]$$

$$W_i = \mu_i\, b_i + \mu_i\gamma_i t_i F_i + \mu_i\gamma_i\, \Omega F_i - \mu_i\gamma_i\, I_i - \mu_i\gamma_i\mu_i b_i + w_i - \mu_i w_i + \gamma_i[t_i F_i + \Omega F_i - I_i - \mu_i b_i] - \gamma_i\mu_i[t_i F_i + \Omega F_i - I_i - \mu_i b_i]$$

$$W_i = \mu_i\, b_i + \mu_i\gamma_i t_i F_i + \mu_i\gamma_i\, \Omega F_i - \mu_i\gamma_i\, I_i - \mu_i\gamma_i\mu_i b_i + w_i - \mu_i w_i + [\gamma_i t_i F_i + \gamma_i\Omega F_i - \gamma_i I_i - \gamma_i\mu_i b_i] - [\gamma_i\mu_i t_i F_i + \gamma_i\mu_i\, \Omega F_i - \gamma_i\mu_i\, I_i - \gamma_i\mu_i\mu_i b_i]$$

$$W_i = \mu_i\, b_i + \mu_i\gamma_i t_i F_i + \mu_i\gamma_i\, \Omega F_i - \mu_i\gamma_i\, I_i - \mu_i\gamma_i\mu_i b_i + w_i - \mu_i w_i + \gamma_i t_i F_i + \gamma_i\Omega F_i - \gamma_i I_i - \gamma_i\mu_i b_i - \gamma_i\mu_i t_i F_i - \gamma_i\mu_i\, \Omega F_i + \gamma_i\mu_i\, I_i + \gamma_i\mu_i\mu_i b_i$$

$$W_i = \mu_i\, b_i + \mu_i\gamma_i t_i F_i - \gamma_i\mu_i t_i F_i + \mu_i\gamma_i\, \Omega F_i - \gamma_i\mu_i\, \Omega F_i - \mu_i\gamma_i\, I_i + \gamma_i\mu_i\, I_i - \mu_i\gamma_i\mu_i b_i + \gamma_i\mu_i\mu_i b_i + w_i - \mu_i w_i + \gamma_i t_i F_i + \gamma_i\Omega F_i - \gamma_i I_i - \gamma_i\mu_i b_i$$

$$W_i = \mu_i\, b_i + w_i - \mu_i w_i + \gamma_i t_i F_i + \gamma_i\Omega F_i - \gamma_i I_i - \gamma_i\mu_i b_i$$

$$W_i = (\mu_i\, b_i + w_i - \mu_i w_i - \gamma_i\mu_i b_i) + \gamma_i t_i F_i + \gamma_i\Omega F_i - \gamma_i I_i \qquad [28]$$

A.8. First order condition with respect to t_i -model with both public input and public good

First order condition with respect to t_i and I_i:

$$\frac{\partial F_i}{\partial t_i} t_i + F_i + \Omega \frac{\partial F_i}{\partial t_i} = 0 \qquad [29]$$

$$-1 + t_i \frac{\partial F_i}{\partial I_i} + \Omega \frac{\partial F_i}{\partial I_i} = 0 \qquad [30]$$

$F_i = A_i K_i^{\alpha} (1 - \mu_i)^{\beta} I_i^{\rho}$

$$K^*_i = \left[\frac{A_i \alpha (1 - \mu_i)^{\beta} I_i^{\rho}}{r + t_i} \right]^{\frac{1}{1-\alpha}}$$

Using chain rule:

$$\frac{\partial F_i}{\partial t_i} = \frac{\partial F_i}{\partial K_i} \frac{\partial K_i}{\partial t_i}$$

Substitute the profit maximization condition $\frac{\partial F_i}{\partial K_i} = r + t_i$ to get:

$$\frac{\partial F_i}{\partial t_i} = (r + t_i) \frac{\partial K_i}{\partial t_i}$$

Using equilibrium capital [26]:

$$K^*_i = \left[\frac{A_i \alpha (1 - \mu_i)^{\beta} I_i^{\rho}}{r + t_i} \right]^{\frac{1}{1-\alpha}}$$

$$= \left[A_i \alpha (1 - \mu_i)^{\beta} I_i^{\rho} \right]^{\frac{1}{1-\alpha}} (r + t_i)^{-\frac{1}{1-\alpha}}$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha} \left[A_i \alpha (1 - \mu_i)^{\beta} I_i^{\rho} \right]^{\frac{1}{1-\alpha}} (r + t_i)^{-\frac{1}{1-\alpha} - 1}$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha} \left[\frac{A_i \alpha (1 - \mu_i)^{\beta} I_i^{\rho}}{r + t_i} \right]^{\frac{1}{1-\alpha}} \left[\frac{1}{(r + t_i)} \right]$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha} K_i \left[\frac{1}{(r + t_i)} \right] \qquad [30.1]$$

Using equation [30.1], the equation $\frac{\partial F_i}{\partial t_i}$ becomes:

$$\frac{\partial F_i}{\partial t_i} = -\frac{1}{1-\alpha}\left[\frac{A_i\alpha(1-\mu_i)^{\beta}I_i^{\rho}}{r+\ t_i}\right]^{\frac{1}{1-\alpha}} = -\frac{1}{1-\alpha}K_i \qquad [30.2]$$

Substitute [30.2] and [25] $F_i = A_i K_i^{\alpha}(1-\mu_i)^{\beta} I_i^{\rho}$ into equation [29]

$$\frac{\partial F_i}{\partial t_i}t_i + F_i + \Omega\frac{\partial F_i}{\partial t_i} = 0$$

$$-\frac{1}{1-\alpha}K_i t_i + A_i K_i^{\alpha}(1-\mu_i)^{\beta} I_i^{\rho} - \Omega\frac{1}{1-\alpha}K_i = 0$$

$$\frac{1}{1-\alpha}K_i\left[-t_i + (1-\alpha)A_i K_i^{\alpha-1}(1-\mu_i)^{\beta} I_i^{\rho} - \Omega\right] = 0$$

$$-t_i + (1-\alpha)A_i K_i^{\alpha-1}(1-\mu_i)^{\beta} I_i^{\rho} - \Omega = 0 \qquad [30.3]$$

Substitute equilibrium capital [26] $K^*_i = \left[\frac{A_i\alpha(1-\mu_i)^{\beta}I_i^{\rho}}{r+t_i}\right]^{\frac{1}{1-\alpha}}$ into equation [30.3]

$$-t_i + (1-\alpha)A_i\left[\frac{A_i\alpha(1-\mu_i)^{\beta}I_i^{\rho}}{r+\ t_i}\right]^{\frac{1}{1-\alpha}(\alpha-1)}(1-\mu_i)^{\beta} I_i^{\rho} - \Omega = 0$$

Rearrange the equation to get:

$$-t_i + (1-\alpha)A_i\left[\frac{A_i\alpha(1-\mu_i)^{\beta}I_i^{\rho}}{r+\ t_i}\right]^{-1}(1-\mu_i)^{\beta} I_i^{\rho} - \Omega = 0$$

$$-t_i + (1-\alpha)\left[\frac{\alpha}{r+\ t_i}\right]^{-1} - \Omega = 0$$

$$-t_i + (1-\alpha)\frac{r+\ t_i}{\alpha} - \Omega = 0$$

$$-\alpha t_i + (1-\alpha)(r+\ t_i) - \alpha\Omega = 0$$

$$-\alpha t_i + (1-\alpha)t_i + (1-\alpha)r - \alpha\Omega = 0$$

$$[-\alpha + (1-\alpha)]t_i + (1-\alpha)r - \alpha\Omega = 0$$

$$(1-\alpha)r - \alpha\Omega = [2\alpha - 1]t_i$$

$$t_i^* = \frac{(1-\alpha)r - \alpha\Omega}{2\alpha - 1} \quad [31]$$

A.9. First order condition with respect to I_i -model with both public input and public good

We use the result in equation [31] and the first order condition with respect to I_i in equation [30]to solve for equilibrium I_i:

$$-1 + \text{ ti}\ \frac{\partial F_i}{\partial I_i} + \Omega\frac{\partial F_i}{\partial I_i} = 0 \quad [30]$$

From production function in equation [25]:

$$\frac{\partial F_i}{\partial I_i} = A_i\rho K_i^{\alpha}(1-\mu_i)^{\beta} I_i^{\rho-1}$$

Substitute this result into equation [30]

$$-1 + \mathrm{t}_i A_i\rho K_i^{\alpha}(1-\mu_i)^{\beta} I_i^{\rho-1} + \Omega A_i\rho K_i^{\alpha}(1-\mu_i)^{\beta} I_i^{\rho-1} = 0$$

Substitute equilibrium capital equation [26] $K^*_i = \left[\frac{A_i\alpha(1-\mu_i)^{\beta} I_i^{\rho}}{r+ t_i}\right]^{\frac{1}{1-\alpha}}$ into the above equation to get:

$$-1 + \text{ ti}\ A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^{\beta} I_i^{\rho}}{r + t_i}\right]^{\frac{\alpha}{1-\alpha}}(1-\mu_i)^{\beta} I_i^{\rho-1} + \Omega A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^{\beta} I_i^{\rho}}{r + t_i}\right]^{\frac{\alpha}{1-\alpha}}(1-\mu_i)^{\beta} I_i^{\rho-1}$$

$$= 0$$

$$-1 + \text{ti}\, A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} I_i^{\frac{\rho\alpha}{1-\alpha}}(1-\mu_i)^\beta I_i^{\rho-1}$$

$$+ \Omega A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} I_i^{\frac{\rho\alpha}{1-\alpha}}(1-\mu_i)^\beta I_i^{\rho-1} = 0$$

$$-1 + \text{ti}\, A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta I_i^{\rho-1+\frac{\rho\alpha}{1-\alpha}}$$

$$+ \Omega A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta I_i^{\rho-1+\frac{\rho\alpha}{1-\alpha}} = 0$$

$$-1 + \text{ti}\, A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta I_i^{\frac{\rho-\rho\alpha-1+\alpha+\rho\alpha}{1-\alpha}}$$

$$+ \Omega A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta I_i^{\frac{\rho-\rho\alpha-1+\alpha+\rho\alpha}{1-\alpha}} = 0$$

$$-1 + \text{ti}\, A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta I_i^{\frac{\rho-1+\alpha}{1-\alpha}} + \Omega A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta I_i^{\frac{\rho-1+\alpha}{1-\alpha}}$$

$$= 0$$

$$\text{ti}\, A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta I_i^{\frac{\rho-1+\alpha}{1-\alpha}} + \Omega A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta I_i^{\frac{\rho-1+\alpha}{1-\alpha}} = 1$$

$$I_i^{\frac{\rho+\alpha-1}{1-\alpha}}\left\{\text{ti}\, A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta + \Omega A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta\right\} = 1$$

$$I_i = \left\{\frac{1}{\text{ti}\, A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta + \Omega A_i\rho\left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta}\right\}^{\frac{1-\alpha}{\rho+\alpha-1}}$$

$$I_i = \left\{ \text{ti}\ A_i\rho \left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta \right.$$

$$\left. + \Omega A_i\rho \left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ t_i}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta \right\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

Substitute equation [34] $t_i = \frac{r-\alpha r-\Omega\alpha}{2\alpha-1}$ into equation [35]:

$$I_i = \left\{ \frac{r-\alpha r-\Omega\alpha}{2\alpha-1} A_i\rho \left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ \frac{r-\alpha r-\Omega\alpha}{2\alpha-1}}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta \right.$$

$$\left. + \Omega A_i\rho \left[\frac{A_i\alpha(1-\mu_i)^\beta}{r+\ \frac{r-\alpha r-\Omega\alpha}{2\alpha-1}}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta \right\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \left\{ \frac{r-\alpha r-\Omega\alpha}{2\alpha-1} A_i\rho \left[\frac{A_i\alpha(1-\mu_i)^\beta}{\frac{2\alpha r-r+r-\alpha r-\Omega\alpha}{2\alpha-1}}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta \right.$$

$$\left. + \Omega A_i\rho \left[\frac{A_i\alpha(1-\mu_i)^\beta}{\frac{2\alpha r-r+r-\alpha r-\Omega\alpha}{2\alpha-1}}\right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^\beta \right\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \left\{ \frac{r-\alpha r-\Omega\alpha}{2\alpha-1} A_i \rho \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{\frac{\alpha r-\Omega\alpha}{2\alpha-1}} \right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta} \right.$$

$$\left. + \Omega A_i \rho \left[\frac{A_i \alpha (1-\mu_i)^{\beta}}{\frac{\alpha r-\Omega\alpha}{2\alpha-1}} \right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta} \right\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \left\{ \frac{r-\alpha r-\Omega\alpha}{2\alpha-1} A_i \rho \left[\frac{(2\alpha-1) A_i \alpha (1-\mu_i)^{\beta}}{\alpha r-\Omega\alpha} \right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta} \right.$$

$$\left. + \Omega A_i \rho \left[\frac{(2\alpha-1) A_i \alpha (1-\mu_i)^{\beta}}{\alpha r-\Omega\alpha} \right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta} \right\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \left\{ \frac{r-\alpha r-\Omega\alpha}{2\alpha-1} A_i \rho (2\alpha-1)^{\frac{\alpha}{1-\alpha}} A_i^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta\frac{\alpha}{1-\alpha}} \left[\frac{\alpha}{\alpha r-\Omega\alpha} \right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta} \right.$$

$$\left. + \Omega A_i \rho (2\alpha-1)^{\frac{\alpha}{1-\alpha}} A_i^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta\frac{\alpha}{1-\alpha}} \left[\frac{\alpha}{\alpha r-\Omega\alpha} \right]^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta} \right\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \left\{ \frac{r-\alpha r-\Omega\alpha}{2\alpha-1} (2\alpha-1)^{\frac{\alpha}{1-\alpha}} A_i A_i^{\frac{\alpha}{1-\alpha}} \rho (1-\mu_i)^{\beta\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta} \left[\frac{1}{r-\Omega} \right]^{\frac{\alpha}{1-\alpha}} \right.$$

$$\left. + \Omega A_i A_i^{\frac{\alpha}{1-\alpha}} \rho (2\alpha-1)^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta} \left[\frac{1}{r-\Omega} \right]^{\frac{\alpha}{1-\alpha}} \right\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \left\{ (r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{\alpha}{1-\alpha}-1} A_i^{\frac{\alpha}{1-\alpha}+1} \rho (1-\mu_i)^{\beta\frac{\alpha}{1-\alpha}+\beta} \left[\frac{1}{r-\Omega} \right]^{\frac{\alpha}{1-\alpha}} \right.$$

$$\left. + \Omega A_i^{\frac{\alpha}{1-\alpha}+1} \rho (2\alpha-1)^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\beta\frac{\alpha}{1-\alpha}+\beta} \left[\frac{1}{r-\Omega} \right]^{\frac{\alpha}{1-\alpha}} \right\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \Bigg\{(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} A_i^{\frac{1}{1-\alpha}} \rho(1-\mu_i)^{\frac{\beta}{1-\alpha}} \left[\frac{1}{r-\Omega}\right]^{\frac{\alpha}{1-\alpha}}$$

$$+ \Omega A_i^{\frac{1}{1-\alpha}} \rho(2\alpha-1)^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}} \left[\frac{1}{r-\Omega}\right]^{\frac{\alpha}{1-\alpha}} \Bigg\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \Bigg\{\rho(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} A_i^{\frac{1}{1-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}} \left[\frac{1}{r-\Omega}\right]^{\frac{\alpha}{1-\alpha}}$$

$$+ \rho\Omega A_i^{\frac{1}{1-\alpha}} (2\alpha-1)^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}} \left[\frac{1}{r-\Omega}\right]^{\frac{\alpha}{1-\alpha}} \Bigg\}^{\frac{\alpha-1}{\rho+\alpha-1}}$$

$$I_i = \Bigg\{\rho(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} A_i^{\frac{1}{1-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}} \left[\frac{1}{r-\Omega}\right]^{\frac{\alpha}{1-\alpha}}$$

$$+ \rho\Omega A_i^{\frac{1}{1-\alpha}} (2\alpha-1)^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}} \left[\frac{1}{r-\Omega}\right]^{\frac{\alpha}{1-\alpha}} \Bigg\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = \Bigg\{\rho(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} A_i^{\frac{1}{1-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}}$$

$$+ \rho\Omega A_i^{\frac{1}{1-\alpha}} (2\alpha-1)^{\frac{\alpha}{1-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} \Bigg\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\alpha}*\frac{1-\alpha}{1-\rho-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\alpha}*\frac{1-\alpha}{1-\rho-\alpha}} \rho^{\frac{1-\alpha}{1-\rho-\alpha}} \Bigg\{(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}}$$

$$+ \Omega(2\alpha-1)^{\frac{\alpha}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} \Bigg\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i^* = A_i^{\frac{1}{1-\rho-\alpha}} (1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}} \rho^{\frac{1-\alpha}{1-\rho-\alpha}} \Big\{(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} + \Omega(2\alpha-$$

$$1)^{\frac{\alpha}{1-\alpha}} (r-\Omega)^{\frac{-\alpha}{1-\alpha}} \Big\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

A.10. Rearrange the equation for equilibrium investment in public inputs I_i^* -model with both public input and public good

From equilibrium investment in public inputs equation [32]

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}\Big\{(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}}(r-\Omega)^{\frac{-\alpha}{1-\alpha}} + \Omega(2\alpha-1)^{\frac{\alpha}{1-\alpha}}(r-\Omega)^{\frac{-\alpha}{1-\alpha}}\Big\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

Rearrange the equation:

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}\Big[(r-\Omega)^{\frac{-\alpha}{1-\alpha}}\Big]^{\frac{1-\alpha}{1-\rho-\alpha}}\Big\{(r-\alpha r-\Omega\alpha)(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}} + \Omega(2\alpha-1)^{\frac{\alpha}{1-\alpha}}\Big\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}\Big[(r-\Omega)^{\frac{-\alpha}{1-\alpha}}\Big]^{\frac{1-\alpha}{1-\rho-\alpha}}\Big[(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}}\Big]^{\frac{1-\alpha}{1-\rho-\alpha}}\{(r-\alpha r-\Omega\alpha) + \Omega(2\alpha-1)\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}\Big[(r-\Omega)^{\frac{-\alpha}{1-\alpha}}\Big]^{\frac{1-\alpha}{1-\rho-\alpha}}\Big[(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}}\Big]^{\frac{1-\alpha}{1-\rho-\alpha}}\{r-\alpha r-\Omega\alpha + 2\Omega\alpha-\Omega\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}\Big[(r-\Omega)^{\frac{-\alpha}{1-\alpha}}\Big]^{\frac{1-\alpha}{1-\rho-\alpha}}\Big[(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}}\Big]^{\frac{1-\alpha}{1-\rho-\alpha}}\{r-\alpha r+\Omega\alpha - \Omega\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}\left[(r-\Omega)^{\frac{-\alpha}{1-\alpha}}\right]^{\frac{1-\alpha}{1-\rho-\alpha}}\left[(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}}\right]^{\frac{1-\alpha}{1-\rho-\alpha}}\{r(1-\alpha)-\Omega(1-\alpha)\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}\left[(r-\Omega)^{\frac{-\alpha}{1-\alpha}}\right]^{\frac{1-\alpha}{1-\rho-\alpha}}\left[(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}}\right]^{\frac{1-\alpha}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}\{r-\Omega\}^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(r-\Omega)^{\frac{-\alpha}{1-\rho-\alpha}}\left[(2\alpha-1)^{\frac{2\alpha-1}{1-\alpha}}\right]^{\frac{1-\alpha}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}(r-\Omega)^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(r-\Omega)^{\frac{-\alpha}{1-\rho-\alpha}}(2\alpha-1)^{\frac{2\alpha-1}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}(r-\Omega)^{\frac{1-\alpha}{1-\rho-\alpha}}$$

$$I_i = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(r-\Omega)^{\frac{1-2\alpha}{1-\rho-\alpha}}(2\alpha-1)^{\frac{2\alpha-1}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}} \quad [35]$$

A.11. $\frac{\partial I_i}{\partial \Omega}$ using equation [34] -model with both public input and public good

$$\frac{\partial I_i}{\partial \Omega} = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(2\alpha-1)^{\frac{2\alpha-1}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}\frac{1-2\alpha}{1-\rho-\alpha}(r-\Omega)^{\frac{1-2\alpha}{1-\rho-\alpha}-1}(-1)$$

$$\frac{\partial I_i}{\partial \Omega} = A_i^{\frac{1}{1-\rho-\alpha}}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(2\alpha-1)^{\frac{2\alpha-1}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}\frac{2\alpha-1}{1-\rho-\alpha}(r-\Omega)^{\frac{\rho-\alpha}{1-\rho-\alpha}}$$

$$\frac{\partial I_i}{\partial \Omega} = A_i^{\frac{1}{1-\rho-\alpha}}\frac{1}{1-\rho-\alpha}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(2\alpha-1)^{\frac{2\alpha-1}{1-\rho-\alpha}+1}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}(r-\Omega)^{\frac{\rho-\alpha}{1-\rho-\alpha}}$$

$$\frac{\partial I_i}{\partial \Omega} = A_i^{\frac{1}{1-\rho-\alpha}}\frac{1}{1-\rho-\alpha}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}}\rho^{\frac{1-\alpha}{1-\rho-\alpha}}(2\alpha-1)^{\frac{3\alpha+\rho}{1-\rho-\alpha}}(1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}(r-\Omega)^{\frac{\rho-\alpha}{1-\rho-\alpha}}$$

$$\frac{\partial I_i}{\partial \Omega} = \left[A_i^{\frac{1}{1-\rho-\alpha}} \frac{1}{1-\rho-\alpha}(1-\mu_i)^{\frac{\beta}{1-\rho-\alpha}} \rho^{\frac{1-\alpha}{1-\rho-\alpha}} (1-\alpha)^{\frac{1-\alpha}{1-\rho-\alpha}}\right]\left[(2\alpha-1)^{\frac{3\alpha+\rho}{1-\rho-\alpha}}\right]\left[(r-\Omega)^{\frac{\rho-\alpha}{1-\rho-\alpha}}\right]$$

[36]

A.12. $\frac{\partial K_i}{\partial t_i}$ -model with both public input and public good

Equation [26]:

$$K^*_i = \left[\frac{A_i \alpha (1-\mu_i)^{\beta} I_i^{\rho}}{r + t_i}\right]^{\frac{1}{1-\alpha}} \quad [26]$$

$$K^*_i = \left[A_i \alpha (1-\mu_i)^{\beta} I_i^{\rho}\right]^{\frac{1}{1-\alpha}} (r + t_i)^{-\frac{1}{1-\alpha}}$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha}\left[A_i \alpha (1-\mu_i)^{\beta} I_i^{\rho}\right]^{\frac{1}{1-\alpha}} \frac{1}{(r + t_i)^{\frac{1}{1-\alpha}+1}} < 0$$

$$\frac{\partial K_i}{\partial t_i} = -\frac{1}{1-\alpha}\left[A_i \alpha (1-\mu_i)^{\beta} I_i^{\rho}\right]^{\frac{1}{1-\alpha}} \frac{1}{(r+ t_i)^{\frac{2-\alpha}{1-\alpha}}} < 0 \quad [37]$$

APPENDIX B - LIST OF ALL EMERGING MARKET AND DEVELOPING ECONOMIES

Table B1 List of 155 emerging market and developing economies[46]

Afghanistan, **Albania,** **Algeria,** **Angola,** Antigua and Barbuda, **Argentina,** **Armenia,** Azerbaijan, Bahamas, Bahrain, **Bangladesh,** **Barbados,** **Belarus,** Belize, Benin, Bhutan, **Bolivia,** **Bosnia and Herzegovina,** **Botswana,** **Brazil,** Brunei Darussalam, **Bulgaria,** Burkina Faso, Burundi, Cabo Verde, **Cambodia,** Cameroon, Central African Republic, Chad,	Georgia, Ghana, Grenada, **Guatemala,** Guinea, Guinea-Bissau, Guyana, Haiti, **Honduras,** **Hungary,** **India,** **Indonesia,** Iran, Iraq, **Jamaica,** **Jordan,** **Kazakhstan,** Kenya, Kiribati, Kosovo, **Kuwait,** Kyrgyz Republic, Lao P.D.R., Lebanon, Lesotho, Liberia, **Libya,** Madagascar, Malawi, **Malaysia,** Maldives, Mali, Marshall Islands,	**Pakistan,** Palau, **Panama,** Papua New Guinea, **Paraguay,** **Peru,** **Philippines,** **Poland,** **Qatar,** **Romania,** **Russian Federation,** Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, **Saudi Arabia,** Senegal, **Serbia,** Seychelles, Sierra Leone, Sint Maarten, Solomon Islands, **South Africa,** South Sudan **Sri Lanka,** Sudan, Suriname, Syria, São Tomé and Príncipe, Tajikistan, **Tanzania,** **Thailand,** Timor-Leste, Togo, Tonga, Trinidad and Tobago, **Tunisia,** **Turkey,** Turkmenistan, Tuvalu, **Uganda,** **Ukraine,** **United Arab Emirates,** **Uruguay,** Uzbekistan, Vanuatu, Venezuela, **Vietnam,** Yemen, **Zambia,** **Zimbabwe**
Chile, **China** **Colombia,** Comoros, Dem. Rep. of the Congo, Republic of Congo, **Costa Rica,** **Croatia,** Curacao, Côte d'Ivoire, Djibouti, Dominica, **Dominican Republic,** **Ecuador,** **Egypt,** El Salvador, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Fiji, Gabon, Gambia,	Mauritania, **Mauritius,** **Mexico,** Fed. States of Micronesia, Moldova, Mongolia, **Montenegro,** Morocco, **Mozambique,** Myanmar, Namibia, Nauru, Nepal, Nicaragua, Niger, **Nigeria,** North Macedonia, **Oman,**	

Source: IMF, 2019 - World Economic Outlook, 2019

[46] The countries in my dataset are ***underlined.***

APPENDIX C – REGRESSION RESULTS OF ECONOMETRIC MODEL 1 – DEPENDENT VARIABLE FDI PER CAPITA

Table C1 Estimation outputs – Prais-Winsten panel specific AR(1) regression, panels corrected standard errors (PCSEs) correction of first order autocorrelation and cross sectional-dependence

Estimation method		(1) Statutory tax rate – panel specific AR1 model with panels corrected standard errors (PCSEs)			(2) Effective tax rate - panel specific AR1 model with panels corrected standard errors (PCSEs)			(3) Statutory tax rate - panel specific AR1 model with panels corrected standard errors (PCSEs) and year dummy variables.			(4) Effective tax rate - panel specific AR1 model with panels corrected standard errors (PCSEs) and year dummy variables		
Independent variable	Meas. Unit	Coef.	Std. err.	z-stat	Coef.	Std. err.	z-stat	Coef.	Std. err.	t-stat	Coef.	Std. err.	t-stat
Statutory corporate tax rate (tax)	Percent	-1.508	2.7478	-0.55				-1.51	2.7	-0.56			
Effective tax	Percent				-1.231	1.570	-0.78				-1.142	1.686	-0.68
Employment rate (empl)	Percent	.00757	1.471	0.01	-1.795*	.9511	-1.89	-.2458	.9733	-0.25	-1.0036	.9879	-1.02
Inflation rate (infl)	Percent	.24	.7592	0.32	.0993	.7997	0.12	.3562	.6999	0.51	.1548	.87675	0.18
Productivity (gdpc)	Dollar	.0234***	.00628	3.74	.0257***	.0029	8.84	.0233***	.00608	3.83	.0257***	.00299	8.59
Investment in public inputs (fcap)	Percent of GDP	6.574***	1.59	4.13	6.624***	.9659	6.86	4.587***	1.228	3.73	5.22***	1.0294	5.07
Population (pop)	Million	-.124***	.03082	-4.04	-.175***	.027	-6.44	-.115***	.0233	-4.94	-.128***	.0206	-6.21
Exchange rate (exch)	Foreign currency per US dollar	5.08e-09	4.29e-09	1.19	7.5e-09***	2.8e-09	2.66	4.65e-09	6.81e-09	0.68	1e-08**	4.86e-09	2.06
Education (edu)	Percent	2.3378*	.999	2.34	1.93**	.945	2.04	3.158***	1.16	2.72	3.12***	1.079	2.89
Constant	-	-122	125	-0.98	-8.61	82.94	-0.1	-88.6	85.67	-1.03	-15.39	75	-0.21
Test of the overall significance		Wald chi(2)= 47.93/ Prob>chi2=0.000			Wald chi(2)=223/ Prob>chi2=0.000			Wald chi(2)=2406/ Prob>chi2=0.000			Wald chi(2)=4378/ Prob>chi2=0.000		

, ** and * next to estimated coefficients indicate statistical significance level of 10 percent, 5 percent and 1 percent respectively.*

APPENDIX D - A MODEL WITH TWO TYPES OF CAPITAL IN THE PRODUCTION FUNCTION

Assume F_i is a production function with two types of capital.

$$F_i = A_i(K_i^1)^{\alpha_1}(K_i^2)^{\alpha_2}L_i^{\beta} \quad [D1]$$

I assume that the production function has decreasing returns to scale ($\alpha_1 + \alpha_2 + \beta<1$, $F_K{}^1>0$, $F_L > 0$ and $F_K{}^1{}_K{}^1 < 0$, $F_K{}^2{}_K{}^2 <0$, $F_{LL}<0$).

In equilibrium, firms invest capital when the marginal product of capital equals capital cost:

$$\frac{\partial F_i}{\partial K_i^1} = r_1 + t_i \text{ and } \frac{\partial F_i}{\partial K_i^2} = r_2 + t_i$$

where r_1 and r_2 are cost of capital K^1 and K^2, respectively.

For the assumed production function, the marginal product of capital equals:

$$\frac{\partial F_i}{\partial K_i^1} = A_i\alpha_1(K_i^1)^{\alpha_1-1}(K_i^2)^{\alpha_2}(1-\mu_i)^{\beta} = r_1 + t_i \quad [D2]$$

$$\frac{\partial F_i}{\partial K_i^2} = A_i\alpha_2(K_i^1)^{\alpha_1}(K_i^2)^{\alpha_2-1}(1-\mu_i)^{\beta} = r_2 + t_i \quad [D3]$$

Divide each side of equation [D2] to each side of equation [D3]:

$$\frac{K_i^2}{K_i^1} = \frac{r_1 + t_i}{r_2 + t_i} \quad [D4]$$

If the cost of capital in K^1 and K^2 are the same $r_1 = r_2$, K^1 will equal K^2. The production function in [C1] becomes with same production function in [1] in chapter III, section II. The results

of this model with two different types of capital in the production function will be the same as the results for one type of capital in the production function.

If costs of capital are different $r_1 \neq r_2$, equation [D4] implies:

$$K_i^2 = \left[\frac{r_1 + t_i}{r_2 + t_i}\right] K_i^1 \qquad [D5]$$

$$K_i^1 = \left[\frac{r_2 + t_i}{r_1 + t_i}\right] K_i^2 \qquad [D6]$$

Substitute equation [D5] into equation [D2] to solve for equilibrium capital K^{1*}:

$$A_i \alpha_1 (K_i^1)^{\alpha_1 - 1} \left(\left[\frac{r_1 + t_i}{r_2 + t_i}\right] K_i^1\right)^{\alpha_2} (1 - \mu_i)^{\beta} = r_1 + t_i$$

$$A_i \alpha_1 (K_i^1)^{(\alpha_1 + \alpha_2) - 1} \left[\frac{r_1 + t_i}{r_2 + t_i}\right]^{\alpha_2} (1 - \mu_i)^{\beta} = r_1 + t_i$$

$$(K_i^1)^{(\alpha_1 + \alpha_2) - 1} = \frac{(r_1 + t_i)(r_2 + t_i)^{\alpha_2}}{A_i \alpha_1 (1 - \mu_i)^{\beta} (r_1 + t_i)^{\alpha_2}}$$

$$K_i^1 = \left\{\frac{(r_1 + t_i)(r_2 + t_i)^{\alpha_2}}{A_i \alpha_1 (1 - \mu_i)^{\beta} (r_1 + t_i)^{\alpha_2}}\right\}^{\frac{1}{(\alpha_1 + \alpha_2) - 1}}$$

$$K_i^1 = \left\{\frac{(r_1 + t_i)^{1 - \alpha_2} (r_2 + t_i)^{\alpha_2}}{A_i \alpha_1 (1 - \mu_i)^{\beta}}\right\}^{\frac{1}{(\alpha_1 + \alpha_2) - 1}}$$

$$K_i^{1*} = \left[\frac{1}{A_i \alpha_1 (1 - \mu_i)^{\beta}}\right]^{\frac{1}{(\alpha_1 + \alpha_2) - 1}} [(r_1 + t_i)^{1 - \alpha_2} (r_2 + t_i)^{\alpha_2}]^{\frac{1}{(\alpha_1 + \alpha_2) - 1}} \qquad [D7]$$

Substitute equation [D6] into equation [D3], to solve for equilibrium capital K^{2*}:

$$A_i \alpha_2 \left(\left[\frac{r_2 + t_i}{r_1 + t_i}\right] K_i^2\right)^{\alpha_1} (K_i^2)^{\alpha_2 - 1} (1 - \mu_i)^{\beta} = r_2 + t_i$$

$$A_i\alpha_2\left[\frac{r_2 + t_i}{r_1 + t_i}\right]^{\alpha_1}(K_i^2)^{\alpha_1+\alpha_2-1}(1-\mu_i)^{\beta} = r_2 + t_i$$

$$(K_i^2)^{\alpha_1+\alpha_2-1} = \frac{(r_2 + t_i)^{1-\alpha_1}(r_1 + t_i)^{\alpha_1}}{A_i\alpha_2(1-\mu_i)^{\beta}}$$

$$K_i^2 = \left\{\frac{(r_2 + t_i)^{1-\alpha_1}(r_1 + t_i)^{\alpha_1}}{A_i\alpha_2(1-\mu_i)^{\beta}}\right\}^{\frac{1}{\alpha_1+\alpha_2-1}}$$

$$K_i^{2*} = \left\{\frac{1}{A_i\alpha_2(1-\mu_i)^{\beta}}\right\}^{\frac{1}{\alpha_1+\alpha_2-1}}[(r_2 + t_i)^{1-\alpha_1}(r_1 + t_i)^{\alpha_1}]^{\frac{1}{\alpha_1+\alpha_2-1}} \qquad [D8]$$

From equilibrium capital in equations [D7] and [D8], we can verify the existence of tax competition.

For capital K^1:

$$\frac{\partial K_i^1}{\partial t_i} = \left[\frac{1}{A_i\alpha_1(1-\mu_i)^{\beta}}\right]^{\frac{1}{(\alpha_1+\alpha_2)-1}}\frac{1}{(\alpha_1+\alpha_2)-1}\{(r_1 + t_i)^{1-\alpha_2}(r_2 + t_i)^{\alpha_2}\}^{\frac{1}{(\alpha_1+\alpha_2)-1}-1}\{(1$$

$$-\alpha_2)(r_1 + t_i)^{-\alpha_2}(r_2 + t_i)^{\alpha_2} + \alpha_2(r_1 + t_i)^{1-\alpha_2}(r_2 + t_i)^{\alpha_2-1}\}$$

$$\frac{\partial K_i^1}{\partial t_i} = \left[\frac{1}{A_i\alpha_1(1-\mu_i)^{\beta}}\right]^{\frac{1}{(\alpha_1+\alpha_2)-1}}\frac{1}{(\alpha_1+\alpha_2)-1}\{(r_1 + t_i)^{1-\alpha_2}(r_2 + t_i)^{\alpha_2}\}^{\frac{2-(\alpha_1+\alpha_2)}{(\alpha_1+\alpha_2)-1}}\{(1$$

$$-\alpha_2)(r_1 + t_i)^{-\alpha_2}(r_2 + t_i)^{\alpha_2} + \alpha_2(r_1 + t_i)^{1-\alpha_2}(r_2 + t_i)^{\alpha_2-1}\}$$

For capital K^2:

$$\frac{\partial K_i^2}{\partial t_i} = \left[\frac{1}{A_i\alpha_2(1-\mu_i)^{\beta}}\right]^{\frac{1}{(\alpha_1+\alpha_2)-1}}\frac{1}{(\alpha_1+\alpha_2)-1}\{(r_2 + t_i)^{1-\alpha_1}(r_1 + t_i)^{\alpha_1}\}^{\frac{1}{(\alpha_1+\alpha_2)-1}-1}\{(1$$

$$-\alpha_1)(r_2 + t_i)^{-\alpha_1}(r_1 + t_i)^{\alpha_1} + \alpha_1(r_2 + t_i)^{1-\alpha_1}(r_1 + t_i)^{\alpha_1-1}\}$$

$$\frac{\partial K_i^2}{\partial t_i} = \left[\frac{1}{A_i \alpha_2 (1-\mu_i)^{\beta}}\right]^{\frac{1}{(\alpha_1+\alpha_2)-1}} \frac{1}{(\alpha_1+\alpha_2)-1} \{(r_2 + t_i)^{1-\alpha_1}(r_1+t_i)^{\alpha_1}\}^{\frac{2-(\alpha_1+\alpha_2)}{(\alpha_1+\alpha_2)-1}} \{(1$$

$$-\alpha_1)(r_2 + t_i)^{-\alpha_1}(r_1+t_i)^{\alpha_1} + \alpha_1(r_2 + t_i)^{1-\alpha_1}(r_1+t_i)^{\alpha_1-1}\}$$

With $\alpha_1 + \alpha_2 + \beta < 1$, we can easily verify that both $\frac{\partial K_i^1}{\partial t_i}$ and $\frac{\partial K_i^2}{\partial t_i}$ are negative. The results confirm the existence of the necessary condition of tax competition for both types of capital.

Equation [D4] implies what types of capital is preferred. If cost of capital K^1 is higher than cost of capital K^2 ($r_1 > r_2$), capital K^2 is preferred. In equilibrium, country i will receive more capital K^2 than capital K^1 ($K^{2*} > K^{1*}$).

APPENDIX E – REGRESSION RESULTS FOR 55 COUNTRIES RECEIVED FOREIGN AID (EXCLUDE 8 COUNTRIES RECEIVED NO FOREIGN AID)

Table E1 Spatial dependence test (model using statutory tax rate)

	(i)	(ii)	(iii)
Test-statistics	48.623	819.765	1018.247
p-value	0.000	0.000	0.000
Null hypothesis	*No spatial dependence*	*No spatial lag dependence*	*No spatial error dependence*
Test result	Reject the Null	Reject the Null	Reject the Null
	There is spatial dependence	There is spatial lag dependence	There is spatial error dependence
Conclusion on an appropriate regression model	This is a general test; more specific tests should be implemented.	Spatial lag model.	Spatial error model

Table E2 Spatial dependence test (model using effective tax rate)

	(i)	(ii)	(iii)
Test-statistics	10.562	83.464	41.893
p-value	0.000	0.000	0.000
Null hypothesis	*No spatial dependence*	*No spatial lag dependence*	*No spatial error dependence*
Test result	Reject the Null	Reject the Null	Reject the Null
	There is spatial dependence	There is spatial lag dependence	There is spatial error dependence
Conclusion on an appropriate regression model	This is a general test; more specific tests should be implemented	Spatial lag model	Spatial error model

Table E3 Spatial estimation (using statutory corporate tax rates)

Estimation method		(1) Spatial lag model (spatial autoregressive model)		(2) Spatial error model	
Independent variable	Meas. Unit	Coef.	Std. err.	Coef.	Std. err.
γ(tax response function)		.977618***	.0218527		
λ (nuisance parameter)				.9836369***	.016161
Population (pop)	Million	.0025735***	.0010228	.0027158***	.0010374
Employment rate (empl)	Percent	.0236423	.0184048	.0236192	.0236192
Productivity (gdpc)	Dollar	-.0002397***	.0000512	-.0002154***	.0000516
ODA (oda)	Million	.0006109***	.0002338	.0007204***	.0002381
Investment in public inputs (fcap)	Percent of GDP	-.0045524	.0352685	.000647	.0341419
Openness (openness)	100 percent	-4.443495***	.6632517	-4.181657***	.6894295
Constant		4.160887***	1.509102	61.44108*	34.7483
Tests of spatial parameters (Ho: $\gamma = 0$ for spatial lag model, and Ho: λ=0 for spatial error model		Wald test: χ^2 = 2001.3 (p=0.000) Likelihood ratio test: χ^2= 156.4 (p=0.000) Lagrange multiplier test: χ^2= 819.7 (p=0.000)		Wald test: χ^2 = 3704.53 (p=0.000) Likelihood ratio test: χ^2= 144.070 (p=0.000) Lagrange multiplier test: χ^2= 1018.247 (p=0.000)	

, ** and * next to estimated coefficients indicate statistical significance level of 10 percent, 5 percent and 1 percent respectively.*

Table E4 Spatial estimation (using effective corporate tax rates)

Estimation method		**(3) Spatial lag model (spatial autoregressive model)**		**(4) spatial error model**	
Independent variable	Meas. Unit	Coef.	Std. err.	Coef.	Std. err.
γ(tax response function)		.5911911 ***	.1372715		
λ (nuisance parameter)				.5773004 ***	.1654069
Population (pop)	Million	-.0003924	.0014106	-.0005146	.0014392
Employment rate (empl)	Percent	.0910817***	.0274771	.0859335***	.0335242
Productivity (gdpc)	Dollar	-.000185***	.0000699	-.000174***	.0000707
ODA (oda)	Million	.000773**	.00032	.0008557***	.0003264
Investment in public inputs (fcap)	Percent of GDP	.0316606	.0483099	.0370249	.0477013
Openness (openness)	100 percent	-1.097405	.9055703	-1.157707	.9325014
Constant		2.509082	2.564593	12.69053***	2.521585
Tests of spatial parameters (Ho: $\gamma = 0$ for spatial lag model, and Ho: λ=0 for spatial error model		Wald test: χ^2= 18.5 (p=0.000) Likelihood ratio test: χ^2= 17.147 (p=0.000) Lagrange multiplier test: χ^2= 83.464 (p=0.000)		Wald test: χ^2= 12.181 (p=0.000) Likelihood ratio test: χ^2= 9.714 (p=0.002) Lagrange multiplier test: χ^2= 41.893 (p=0.000)	

, ** and * next to estimated coefficients indicate statistical significance level of 10 percent, 5 percent and 1 percent respectively.*

APPENDIX F – REGRESSION RESULTS FOR 62 COUNTRIES (EXCLUDE CHINA)

Table F1 Spatial dependence test (model using statutory tax rate)

	(i)	(ii)	(iii)
Test-statistics	12.869	153.160	59.516
p-value	0.000	0.000	0.000
Null hypothesis	*No spatial dependence*	*No spatial lag dependence*	*No spatial error dependence*
Test result	Reject the Null	Reject the Null	Reject the Null
	There is spatial dependence	There is spatial lag dependence	There is spatial error dependence
Conclusion on an appropriate regression model	This is a general test; more specific tests should be implemented	Spatial lag model	Spatial error model

Table F2 Spatial dependence test (model using effective tax rate)

	(i)	(ii)	(iii)
Test-statistics	10.839	125.511	40.889
p-value	0.000	0.000	0.000
Null hypothesis	*No spatial dependence*	*No spatial lag dependence*	*No spatial error dependence*
Test result	Reject the Null	Reject the Null	Reject the Null
	There is spatial dependence	There is spatial lag dependence	There is spatial error dependence
Conclusion on an appropriate regression model	This is a general test; more specific tests should be implemented	Spatial lag model	Spatial error model

Table F3 Spatial estimation (using statutory corporate tax rates)

Estimation method		(1) Spatial lag model (spatial autoregressive model)		(2) Spatial error model	
Independent variable	Meas. Unit	Coef.	Std. err.	Coef.	Std. err.
γ(tax response function)		.7009246***	.1059509		
λ (nuisance parameter)				.7805944***	.1233517
Population (pop)	Million	.0083053***	.0018601	.0085532***	.001878
Employment rate (empl)	Percent	.1331679***	.02757	.1131086***	.0342011
Productivity (gdpc)	Dollar	.0000534**	.0000275	.0000594*	.0000323
ODA (oda)	Million	.0008807***	.0003137	.0009615***	.0003226
Investment in public inputs (fcap)	Percent of GDP	.0018986	.0470259	-.0034551	.0460588
Openness (openness)	100 percent	-1.860029**	.8394098	-1.232608	.8898485
Constant		.3168218	2.54137	20.09982***	3.449941
Tests of spatial parameters (Ho: $\gamma = 0$ for spatial lag model, and Ho: λ=0 for spatial error model		Wald test: χ^2 = 43.766 (p=0.000) Likelihood ratio test: χ^2= 39.153 (p=0.000) Lagrange multiplier test: χ^2= 153.16 (p=0.000)		Wald test: χ^2 = 3704.53 (p=0.000) Likelihood ratio test: χ^2= 144.070 (p=0.000) Lagrange multiplier test: χ^2= 1018.247 (p=0.000)	

, ** and * next to estimated coefficients indicate statistical significance level of 10 percent, 5 percent and 1 percent respectively.*

Table F4 Spatial estimation (using effective corporate tax rates)

Estimation method		(1) Spatial lag model (spatial autoregressive model)		(2) Spatial error model	
Independent variable	Meas. Unit	Coef.	Std. err.	Coef.	Std. err.
γ(tax response function)		.6637162 ***	.1180674		
λ (nuisance parameter)				.5745628***	.1642076
Population (pop)	Million	.0070662***	.0018161	.0068883***	.0018554
Employment rate (empl)	Percent	.1056252 ***	.0249756	.1129577***	.0310581
Productivity (gdpc)	Dollar	-.0002001***	.0000291	-.0002185***	.0000333
ODA (oda)	Million	.0004613	.0003071	.0005029	.0003173
Investment in public inputs (fcap)	Percent of GDP	.0936624**	.0459087	.0853156*	.0453548
Openness (openness)	100 percent	.113235	.7971926	.1313506	.828107
Constant		-1.548926	2.131804	8.99429***	2.317288
Tests of spatial parameters (Ho: $\gamma = 0$ for spatial lag model, and Ho: λ=0 for spatial error model		Wald test: χ^2 = 31.601 (p=0.000) Likelihood ratio test: χ^2= 28.639 (p=0.000) Lagrange multiplier test: χ^2= 125.511 (p=0.000)		Wald test: χ^2 = 12.243 (p=0.000) Likelihood ratio test: χ^2= 9.538 (p=0.002) Lagrange multiplier test: χ^2= 40.889 (p=0.000)	

, ** and * next to estimated coefficients indicate statistical significance level of 10 percent, 5 percent and 1 percent respectively.*

APPENDIX G – COMPARING 63 DEVELOPING COUNTRIES IN THE DATASET AND OTHER DEVELOPING COUNTRIES IN TERMS OF GDP PER CAPITA AND MEDIAN AGE

Table G1 Comparing 63 developing countries in the dataset and other developing countries

	63 countries in the dataset	Other developing countries (not in the dataset)
	Countries are in the list of developing countries by IMF (Appendix B).	
Total population in 2017	5,316,651,993	692,213,748
Total GDP in 2017 (constant $ in 2010)	28,711,632,229,344	1,635,112,978,122 (GDP data available for 64 other developing countries)
GDP per capita in 2017 (constant $ in 2010)	5,400.3	2362.150
Average median age in 2015	29.86	23.26 (Median age data available for 82 other developing countries)

Source: Population and GDP data from the World Bank's Databank; Median age data from https://ourworldindata.org/ data from this website is from UN Population Division 2017