Rates or revenues?
On the relation between tax structures and growth

Master's Thesis

Henrik Andersson
Supervisor: Åsa Hansson

June 20, 2013

School of Economics and Management
Lund University

Abstract

This paper uses panel data from 45 OECD and Latin American countries over 21 years to estimate the effect of different tax structures on GDP growth. A key aim is to compare the results from using two common measurement techniques, statutory tax rates and tax revenues as share of total tax income. The results from GMM estimations indicate that the choice of measure not only affects the statistical results, but is of critical importance regarding economic interpretations. While the use of tax rates show a small significant negative connection between corporate income taxes and growth, tax revenues demonstrate a positive effect. The results call for more caution and better theoretical understanding regarding the effect of tax structures on growth given the choice of measure.

Keywords: Tax structures, tax rates, tax revenues, growth, panel data

Contents

Chapter 1

Introduction

One of the more, if not the most, studied economic concepts is GDP growth. Because of its close connection to economic prosperity, how to create long run economic growth has been an essential question for academics and politicians for long.

For many years growth modeling relied on exogenous models. This implies that the technological progress was given, and output per worker was constant. Assuming this, the effect of government policy is very limited, if not non-existent. With the development of endogenous growth models, where technological progress is an internal feature of the model, the effects of policy became increasingly relevant. Naturally, this also opens for a possible link between *taxes* and growth (Lee and Gordon 2005: 1028).

Looking at growth and taxes in a very simplified fashion, higher taxes imply behavioral changes. For example, higher personal income taxes imply lower net wages, which decreases the price of leisure. Assuming this causes less work and more leisure, higher taxes could affect total economic output in a negative sense. On the other end, revenues from higher taxes raise the possibility to invest in human and physical capital (for example schools and roads) thereby possibly increasing growth.

This very simplified version does, however, not help much to sort out the differences between tax structures. Today most countries have rather complex tax systems spanning from simple income taxes on wages to excise taxes on fuel. It goes without saying that the effects of these taxes differ a great deal. To contribute to the understanding of the connection between tax-structures and growth, is the topic of this essay.

Previous research within the field has failed to offer consistent conclusions. Corporate income taxes has turned out both positive and negative, and results for consumption taxes and personal income taxes are not consistently significant. Furthermore, most research focus on OECD-countries.

More importantly, even if research has evolved in dealing with relevant empirical problems such as different covariates, endogeneity and unit roots, there is still no consensus on how to measure tax structures. The two most common approaches are the theoretically appealing *statutory tax rates*, and the measure with the highest data availability: *tax revenue as share of total tax revenues.* Using the value added tax (*vat*) as an example, the former uses the standard rate of, say 20 %, while the latter uses the percentage of tax revenues which were raised from the chosen tax.

Awareness of the problems of using the measures interchangeably are growing, and some recent papers have addressed and discussed the specific problem of using tax revenues as a measure of tax structures (Myles 2007; Gemmel et al 2011). As of today no paper have, however, compared the results of using the different measures in a similar estimation framework. This paper is aimed at filling this gap.

1.1 Purpose, method and disposition

Specifically, this paper *compares the results of using either tax rates or revenues to estimate the effect of different tax structures on long run growth, using a panel of 45 Latin American and OECD countries during 1990-2010.*

Econometrically this is done by applying different versions of GMM. The three structures compared are consumption taxes (*vat*), personal income taxes (*pit*) and corporate income taxes (*cit*).

Besides from using both measures, the paper adds value to current research by:

- Expanding the number of countries used in tax rates estimations, by including more OECD countries and adding developing Latin American countries
- Using the GMM estimator
- Adding new control variables

The rest of the essay is divided into five parts. The next section gives a broad theoretical background, including growth theory, description of taxes and the expected relation between the two concepts. Part three discusses empirical strategies and part four gives an explanation of the measure of different variables, as well as descriptive statistics and trends in the data. Results are found in the fifth part, and finally the last chapter concludes.

Chapter 2

Theoretical background - Growth and taxes

The interest of this essay lies in understanding the relation between tax structures and growth. To be able to make such a connection, it is essential to conceptualize taxes into different subcategories. To evaluate each and every one of the taxes within a country is neither possible nor interesting. Hence, this section starts with an introduction to the most common and most important tax structures. Second, the essential features of growth models are discussed, creating an analytical platform for how taxes might affect growth. Third and final, I discuss the plausible effects of different tax structures on growth.

2.1 Taxes

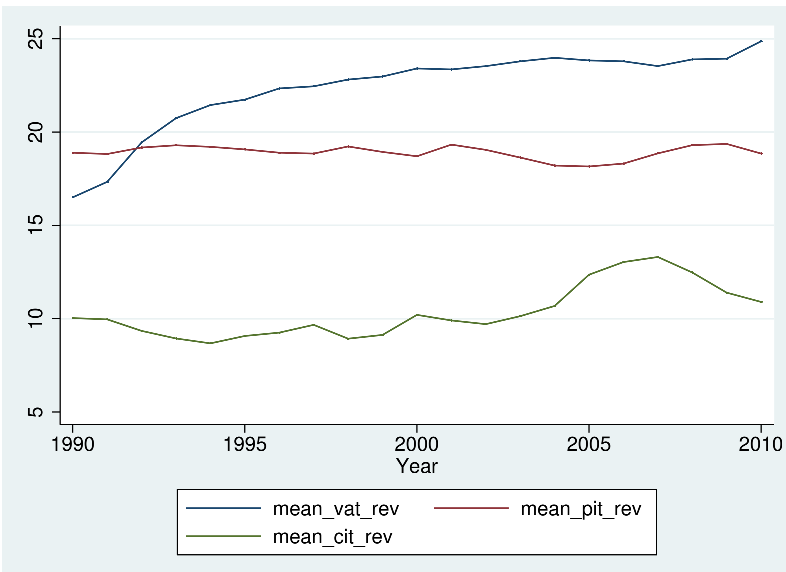
2.1.1 Income taxes

Income taxes are generally parted in two different forms of taxes: personal income taxes (*pit*) and corporate income taxes (*cit*). The former refer to taxes on wage earnings, while the latter are taxes on earnings made from corporate assets. *Pit* and *cit* affect behavior in different ways. Since *pit* is levied on wages it affects labor supply, both negatively and positively.[1] *Cit* on the other hand affects investments. The two are also interconnected. Assuming the *cit* rate keeps decreasing while *pit* stays steady, wage paying citizens would have incentives to register as a corporation, thereby causing unproductive rent seeking. Furthermore, since many countries have different tax rates depending on income (often progressive), it matters whether or not the average or marginal taxes are analyzed.

[1] See Hindriks and Myles (2006: 479-486) for a theoretical and empirical introduction. It is also important to note that some countries include not only wage income but also other forms of unearned income within the concept *pit*.

Pit and *cit* have for long been two of the most important tax sources for a large set of countries. In figure 2.1 the structure of the tax system in OECD and Latin America (measured as revenue share of total tax income) is shown. As can be seen, especially *pit* has long been an important source of revenues. Together with the general consumption tax (retail sales tax or value added tax), they represent somewhat half of all the tax revenues.

Figure 2.1: Percentage of total tax revenues from different tax structures. OECD and Latin America 1990-2010



2.1.2 Consumption taxes

The consumption tax is an increasingly important group of taxes. It inherits any tax on the sales or purchase of goods. Effects are, at least theoretically, easily analyzed. A higher tax raises the price of the good, causing less consumption.[2] How much consumption goes down depends on the demand elasticity of the good.

Consumption taxes include many different kinds of taxes. For example, excise taxes aim directly at decreasing or increasing consumption because of market failures. This includes for example taxation on alcohol, tobacco or fuel.

Almost all countries also have some form of general consumption tax levied on any purchase of goods. This kind of tax can be constructed in different ways. Today the most common is the value added tax (*vat*), which has replaced the

[2]Theoretically it is possible for consumption to go up with higher prices. These kinds of goods are, however, very rare and the standard assumption for almost all goods is that demand decreases with higher prices (normal good).

standard retail sales tax (*rst*) in many parts of the world (Fjeldstat 1995: 2; Bird and Gendron 2007: 16). While the latter taxes only the last chain of the production (e.g. the consumption of the good), the former taxes the value added to the product after each chain of production. Important when analyzing the effect of either *vat* or *rst* is the complexity of the tax. This includes different rates for different goods, and whether corporations of all sizes are tax liable or not.[3]

2.2 Growth Theory

The importance of tax policy became an important part of growth modeling with the development of endogenous models. However, since more or less all endogenous growth models originates from the exogenous Solow model, it might be good to provide the basic outline of the model, and understand the implications for tax policy. Only a couple of brief statements are made here, a full derivation of the Solow model is available in Appendix A.

2.2.1 Baseline model - Exogenous growth[4]

The model assumes a single good economy, were output is either consumed or saved. All savings are invested in capital goods (K). Besides capital, labor (L) is also part of the output function. Solow further assumed a constant depreciation rate of capital (δ), a fixed savings rate (s) and that output per worker is fixed. Population grows at rate n and production inherits constant returns to scale.

Based in the above assumptions, Solow could derive the basic capital accumulation relationship.

$$K_{t+1} = sF(K_t, L_t) + (1 - \delta)K_t \tag{2.1}$$

What 2.1 says is simply that capital in period $t + 1$ equals investments (or savings) plus depreciated capital from period t. Using per capita expressions, it is possible to rewrite the model, and provide steady state expressions as in 2.2 and 2.3:

$$(1 + n)k = sf(k) + (1 - \delta)k \tag{2.2}$$

$$sf(k) - (n + \delta)k = 0 \tag{2.3}$$

Where $k_t = \frac{K_t}{L_t}$. It should be clear from 2.3 that the equilibrium level can be lifted with increased savings, and dampened with population growth. Here, there might be a case for policy in general and tax policy in particular. However, since s is limited ($0 < s < 1$), there is no possibility of sustained growth. Furthermore, a change in the savings rate will not imply a continuous

[3] As a simple example: Sweden has two reduced rates besides the standard rate of 25 %. These are 12 % (hotels, restaurants and food) and 6% (books and public transportation).

[4] This section is based mainly on Myles (2007) and Sørensen and Whitta-Jacobsen (2010).

change in growth, only a one-time shift. Solow therefore leaves very little room for tax policy.

One way to create continuous growth is to include another variable in the production function (A.1), which is often called technological progress (T): $f(k, T)$. In practice, this implies that labor and capital are becoming more productive. The problem with this kind of model is of course that the explanation for growth remains unexplained. All that has been done so far is to assume an exogenous cause of growth. This mechanism is explained in endogenous models.

2.2.2 Endogenous growth

Human Capital

One way to explain and model continuous growth is to add a human capital (H) variable in the production function. This can either be done by adding H as a separate input to K and L, or by writing H as a function of labor time and quality. Using the latter, and assuming a joint constant returns to scale in H and K, one can write:

$$Y_t = F(K_t, H_t) \tag{2.4}$$

2.4 provides a simple case for sustained increased output, which grows with investment, even with fixed labor supply. Now there is a stronger case for economic policy. Regarding taxes, the interesting theoretical case lies in the effect on the decision to invest in human and physical capital. Regarding the former, this practically implies investment in education.

Innovation

The theoretical groundwork on the connection between innovation and growth was delivered by Schumpeter (1934). His idea of creative destruction, which implies the process where older products are replaced by newer superior ones, became the theoretical basics for technological progress. This can either be modelled by using intermediary products, or completely new which replaces the existing ones.

Formal modeling of this process, however, appeared much later. It is possible to think of this as modeling technology T. The output of a company (Y), is made in a technological process according to 2.5:

$$Y_{it} = A_{it} x_{it}^{\alpha} \tag{2.5}$$

where i is a final good, x is the intermediate good, A is the level of technology and t is a time index. An intermediate good x is given by the innovative firm creating it, causing the technology A of the final good to increase to the highest possible on the market. Since no other company has a comparable technology, the innovative firm now has a monopoly position until another technology comes along. The technology hence increases over time, proportional to the number of innovations in intermediate goods, which in turn depends on the amount of resources deployed in research. The decision for a company is between the costs of research and the profits made from innovations. The role of tax policy is hence to increase the net returns of innovation.

Institutions

A last important factor that stands out from the classical growth models, is that of economic, legal and political institutions. North (1991: 97) defines institutions as "the humanly devised constraints that structure political economic and social interaction". Based in this line of reasoning, institutions matter for growth since it affects transaction costs. The importance of institutions therefore differs somewhat from the theoretical notions discussed above, since transaction costs are disregarded in neoclassical models.

With the definition given by North, institutions capture a great deal of concepts. Since this essay does not concern the link between institutions and growth per se, no in-depth theoretical review will be made. One stratification however deserves mentioning, which is the difference between informal and formal institutions. While formal institutions inherit written legal rules concerning property rights, judiciary and bureaucracy, informal rules is best described by the national, regional or local culture of a country. Williamsson (2000: 597) models this in an appealing matter. While formal rules have great importance as the rule of the game, these rules have to be embedded in an already existing culture. Forcing formal rules into a culture might be dampening for development. In the context of growth regressions over twenty years, informal rules are difficult to test since these do, according to Williamsson, change with a pace of up to several hundred years. Still, it is important to be aware of the complexity of institutional effects.

2.3 The effect of tax structures on growth

Tax policy should foremost effect growth via economic variables discussed in the section above. Starting with personal income taxes, Heckman et al (1998) discusses the effect of progressivity on investment in human capital. Higher marginal taxes might induce lower education. The reason is that, if treated as an investment, the return of human capital decreases with higher marginal income taxes.

Another effect of *pit* concerns the supply of labor. Higher marginal taxes on wages have theoretically two possible effects, most often labeled as income and substitution effects. The former is the effect on your income, which in the case of a tax raise, means lower income. Hypothetically a person would hence have to work more to earn the same amount of money, causing more hours worked. On the other hand, the substitution effect implies that the relative price of leisure goes down, causing less hours worked. The question of the effect of *pit* on work supply hence becomes an empirical question. As noted by Kimball and Shapiro (2008: 1), many economists believe that substitution and income effects are very similar in magnitude, giving a total net effect of close to zero. However, the long run economic implications might differ depending on whether both effects are small or large. Kimball and Shapiro do in fact find the latter to be true:

> High estimates of labor supply elasticities also have implications for public finance. With parameters as large as we find, the long-run effects of taxation on labor supply are likely to yield very substantial distortions and dead-weight burdens (Kimball and Shapiro 2008: 42).

Regarding the rate of innovation, both *pit* and *cit* might be important. Assuming that it is possible for a corporation to register both as corporate and non-corporate, and further assuming higher *pit* than *cit*, it would be possible and beneficial to register profits as corporate and losses as non-corporate. Big differences between the two taxes can therefore induce risk-taking, which possibly is beneficial for innovation (Lee and Gordon 2005). Assuming that all corporate activity is registered as corporate, higher *cit* are, ceteris paribus, bad for the evolution of new technology.

However, higher marginal income taxes or corporate income taxes also bring larger public spending possibilities. Any empirical investigation of the relation should hence control for the possibility of higher investments as well as the discouraging incentive effects.

Regarding consumption taxes, which has not been mentioned so far, the case is less clear, and the theoretical literature is less well developed. It is for example striking that one of the latest examples within previous research, Acosta-Ormaechea and Yoo (2012), find a positive effect on growth from consumption taxes, but fail to give a theoretical explanation to why this relationship might exist. One possibility, described by Gordon and Lee (2005: 1031), is that a higher *vat* might cause lower risk taking, assuming there is no loss-offset for companies within the *vat*-system. This is because a company with a negative value added will not receive any tax rebate. However, if companies with losses are offset by the authorities, a *vat* system should be better from an innovation perspective since the taxes are proportional to the net return.

Arnold et al (2011: 71) concludes that the harmful effects on investments and savings should be small. This however only applies if the structure can be expected to be stable over time, and more importantly if the system is based in a uniform rate. Too many exceptions might be harmful.

All in all, the expected effect and hypothesis of the paper is that, ceteris paribus, moving from income taxes to consumption taxes should have a positive effect on growth. The effect of moving from corporate income taxes to personal income taxes is theoretically largely unclear, and any effect is plausible.

2.4 Previous research

As indicated above, previous research on the relation between tax structures and growth has evolved largely due to the development of endogenous growth models. Hence, the empirical field has grown greatly over the last twenty years, both in matters of measurement and empirical strategies. It should be noted that all of the papers referred to onwards utilize panel data.

One of the earlier examples are Easterly and Rebelo (1993). The authors calculate an average marginal income tax, using both tax revenues and statutory rates, and regress GDP on the calculated measure. The results are significant with a negative trend in a bivariate analysis, but fail to produce significant results in a multivariate framework. Further focusing specifically on a measure of income taxes, are Padovano and Galli (2001). The authors regress total tax revenues on a measure of tax reforms, GDP and the interaction in-between these two variables. The coefficient of tax reform is then treated as the estimated marginal taxes. Using a random effects estimation of OECD countries between 1950 and 1990, the authors conclude that there is a statistically significant negative effect from higher marginal taxes.

More interesting are the papers including several structures. Mendoza et al (1997) are among the early examples. Calculating five-year average effective tax rates for consumption and income taxes in 18 OECD countries, the authors find no significant effect upon growth. While the effect upon investment is significant, it is not large enough to affect growth as well. Kneller et al (1999) use a similar data set (22 OECD countries) but instead compare the effect of five-year averages of distortionary and non-distortionary taxes. Distortionary in this context means all taxes that potentially affects investment, which according to the authors include all taxes except taxes on goods and sales. Hence, non-distortionary taxes are a mixture between everything from property taxes to corporate income taxes. The foremost added value of the paper is, however, the use of a budget constraint. As noted by the authors, only including taxes and not expenditures (such as in Mendoza et al (1997)) will produce a bias towards a zero coefficient. This is because a potentially negative effect from for example high direct taxes will be offset by productive government expenditures. When controlling for this, the authors find a significant negative effect from distortionary taxes over non-distortionary taxes.

Widmalm (2001) measures taxes as revenue-share of total tax revenue, and uses several different structures, such as property taxes, personal income taxes and corporate income taxes. Just as previously mentioned papers, Widmalm uses OECD countries. Applying an extreme bound estimation strategy, she finds some support that consumption taxes are better from a growth perspective. Interestingly, corporate income taxes are found to have a positive "significant but fragile" effect on growth.

The strategy to measure taxes as revenue share of total taxes is further used in two of the most recent papers: Arnold et al (2011) and Acosta-Ormaechea and Yoo (2012). The former again uses OECD countries, but adds the use of pooled mean group (PMG) estimations. This basically implies that coefficients are assumed to be homogenous over countries in the long run but not in the short run. Acosta-Ormaechea and Yoo uses a similar methodology but includes 80 countries, expanding the results to developing countries. Both papers reach similar results, namely that property taxes and consumption taxes seem to be better from a growth perspective as opposed to other taxes.

Using revenue-share of total revenues or different forms of aggregate average or calculated marginal rates, involves several problems. As noted by Myles (2007: 89), these "probably does not affect the rate that any particular economic decision maker is facing." In addition, the effect of revenues is dependent on the degree of tax evasion, which is difficult to account for in panel regression models.

In the tradition of using statutory marginal and average tax rates, very few papers have been written. Two papers that deserve mentioning are Lee and Gordon (2005) and Gemmel et al (2011). The former use a large set of different sources to estimate the effect of statutory tax rates on growth, applied to 70 countries. Results are non-significant for consumption taxes and personal income taxes, while some evidence is put forward that corporate taxes have a negative effect on growth. Following up on the critique from Myles, Gemmel et al (2011) expand the use of statutory rates for income taxes to include it in a PMG-estimation, allowing for short run heterogeneous effects between countries. The results are mostly as expected, meaning significant negative effects from higher marginal income taxes and average corporate income taxes. Important to note, however, is that the authors use a small set of 15 OECD countries, and the estimated coefficients are very small.

Clearly, previous research is not consistent, and the effect of different structures have proven both positive and negative. Also, most research focus on OECD-countries. Results might be very different for developing countries, especially when using tax revenues as share of total taxes. As noted in the introductory section, while many estimation techniques have been used, previous research has failed to compare the two most common measures: tax rates and tax revenues. In the spirit of Myles (2007), the results from using statutory tax rates are believed to better reflect theoretical expectations.

Chapter 3

Empirical model

This section discusses the empirical strategy. The discussion addresses the issue on how to provide consistent panel estimations. The basic setup is according to 3.1:

$$\Delta y_{i,t} = X_{i,t}\beta_i + Z_{it}\gamma_i + a_i + \epsilon_{i,t} \tag{3.1}$$

Where $y_{i,t}$ represents the log of GDP PPP per capita (*log_gdpp*) and β_i are the coefficients measuring the effect of different tax variables ($X_{i,t}$) (consumption taxes, personal income taxes and corporate income taxes). These will be measured as either statutory tax rates (*cit_rate*, *pit_rate* and *vatgst*) or tax revenues as share of total tax income (*pit_rev*, *cit_rev* and *vat_rev*). Furthermore, γ_i measures a set of covariates, represented by the vector Z_{it}, which includes investment in physical and human capital (*phy_cap* and *hum_cap*), population growth (*pop*), innovation (*high_tech*), quality of legal institutions (*legal*) and the log of total government expenditure (*log_exp*). i and t are indexes of panels and time and a_i is a fixed intercept for each country. $\epsilon_{i,t}$ is as always the error term.

The most common method used to model panel data is probably the pooled fixed or random effects model. "Pooled" does in this context infer that coefficients of the different explanatory variables are similar across panels. While this is a problematic assumption, estimation of models allowing for heterogeneous panels require a lot of data. The assumption of homogeneous panels is further mostly considered a problem in longer time series (Blackburn III and Frank 2007). Since a lot of the tax rate data for the Latin American countries exist only for the latest ten years, pooled regressions will be estimated.

The choice between using fixed and random effects depends on the assumption made regarding the term a_i. Statistical tests (i.e. Hausman tests) often point towards using fixed effects, since the method solves a common problem within panel data, which is that unobserved country effects are correlated with the explanatory variables. Formally this implies that $\mathrm{E}(Z_i\epsilon_{it}) \neq 0$ (Angrist and Pischke 2009: 244).

Neither random nor fixed effects are, however, consistent in a dynamic context. Assuming a lagged dependent variable, such as in 3.1, $y_{i,t-1}$ is by construction correlated with a_i, ruling out random effects. And even if individual effects are left out, the estimator is inconsistent, since a transformed dependent variable will be corrlated with the transformed error term, creating biased estimates (Angrist and Pischke 2009: 245). Intuitively it is reasonable to assume dynamics in a model with GDP growth. This year's economic performance should be dependent on last year's performance. A different estimation strategy is hence necessary.

3.1 GMM estimator

The most commonly used GMM approach, the Arellano and Bond estimator (ABGMM), uses first difference of all the variables in the regression. In this manner the model accounts for possible unobserved heterogeneity. It further instruments the first difference of the lagged dependent variable with past levels, causing less correlation with the error term. In this manner the model reduces the problem above. Since the number of instruments are many, coefficients are found via the method of moments, rather than OLS.

Using a simple dynamic model without exogenous covariates, the starting point is 3.2, which is transformed using first differencing, leaving 3.3.

$$\Delta y_{i,t} = a_i + \epsilon_{it} \tag{3.2}$$

$$\Delta y_{i,t} = \gamma \Delta y_{i,t-1} + \Delta \epsilon_{it} \tag{3.3}$$

Taking for example $t = 3$, $y_{i,2} - y_{i,1}$ can be instrumented with $y_{i,1}$, since it is correlated with $y_{i,2} - y_{i,1}$, but not with the error term $v_{i3} - v_{i,2}$ (assuming no lasting serial correlation). The method continues to add an extra instrument for each period. This leaves 3.4,

$$E[Z_i \Delta \epsilon_i] = 0 \tag{3.4}$$

where Z_i is a matrix of instruments. 3.4 is now the general moment condition.

Besides from this version of GMM there is another more efficient way (Blundell and Bond) to treat the instrumentation process. (From now on referred to as "System GMM"). Instead of taking the first difference of the baseline model and using levels of the endogenous variable, it is possible to use the levels of the baseline variable and first difference the instruments. In other words one flips the order of the first differencing. Roodman (2006: 29) describes this accordingly: "In a nutshell, where Arellano-Bond instruments differences with levels, Blundell-Bond instruments levels with differences.". The method therefore resembles the first difference GMM in most ways. Only now we must use another moment condition: $\mathrm{E}[\Delta Z_{i,t-1} \epsilon_{it}] = 0$. Note the difference from 3.4.

In the case of growth regressions this is a restrictive statement, since the implication in practice is that lagged growth levels can not be correlated with fixed country effects. If convergence is influential, this assumption will not hold for different initital GDP levels. For OECD countries, this could be considered of less importance, since the current growth levels can be expected to be closer to the long term convergence values. Further, since most of the countries in this data set are OECD countries, the assumption could hold. It does, however, rest on very fragile grounds. Therefore both System GMM and ABGMM are included.

A couple of specific issues regarding GMM are worth noting. First, the estimator is found using a positive weighting matrix. This matrix can either be specified in a one-step procedure were homoskedasticity is assumed, or in a more general procedure were this is not assumed. Based on recommendation in previous research, this paper uses the one-step procedure (Verbeek 2008: 387).

Second, the number of instruments easily becomes too many. Since the number of lags increases with a larger sample, GMM estimations can cause overidentification. To solve this problem, I follow the recommendation from Mehrhoff (2009: 8,9), who uses principal components analysis (pca) and collapsed instruments to limit the number of instruments used.[5]

Third, unit roots can imply problems with weak instruments. Based in the moment condition in 3.4, an AR(1) process with close to a unit root implies a very weak instrument (Madsen 2003: 6,7). It is therefore relevant to be aware of unit roots.

It should be noticed that this method is especially relevant with small T and large N. This is because in cases of longer time periods, fixed effects shocks can be expected to die out. Consequently, correlation between the error term and the explanatory variables should be less significant. In this case, the available time periods are not too many ($T = 21$), which strengthens the case for the use of GMM.

[5]A complete explanation of GMM and the methods used for limiting the number of instruments is found in Appendix C.

Chapter 4

Data

The total data-set includes 45 countries and 21 years (1990-2010). Out of the 45 countries only 10 are non-OECD countries, all of them Latin American.[6] The fact that only 10 countries are non-OECD is important to keep in mind when analyzing the data, since the conclusions might be more relevant for OECD countries. A further way to show this is by looking at means for GDP levels. In table 4.1 these are visible for the full sample, OECD countries and Latin American countries. Clearly the mean is skewed towards the mean of the richer countries.

Table 4.1: GDP PPP per capita level in OECD and Latin America

Variable	Full sample	OECD.	Latin America
gdp_ppp mean	20833	25122	10276
observations	945	672	273

Numbers are in 2005 international USD

A couple of things are noticeable regarding the tax variables. First, the tax variables using tax revenue as share of total tax income are all available for the full sample (945 observations). The tax variables representing stationary tax rates include a smaller sample, for some countries available only for ten years. Second, the variance is smaller within the tax rate variables, as is to be expected. Basic descriptive statistics including mean, standard deviations and the number of observations are available for all the variables in Appendix B.

4.1 Trends

As was visible in figure 2.1, the revenues drawn from consumption taxes have steadily been increasing over the past twenty years, while revenues from *pit* and

[6] Important to note is that one country, Chile, is both a Latin American and OECD country. In this context the country will be analyzed as an OECD country.

cit has remained somewhat similar on average. Regarding rates, what is seen in figure 4.1, is a similar picture, only less pronounced. Out of the three tax rates, only consumption taxes show a non-diminishing development. A striking feature is the large dip in *cit*, which has dropped steadily from around 38 % on average to under 30 %. This drop is driven mostly by the OECD countries.

Figure 4.1: Mean of statutory tax rates, full sample 1990-2010

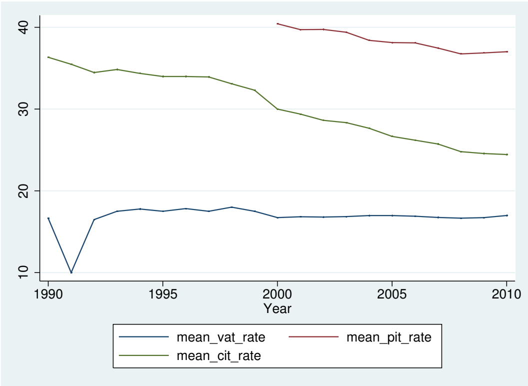
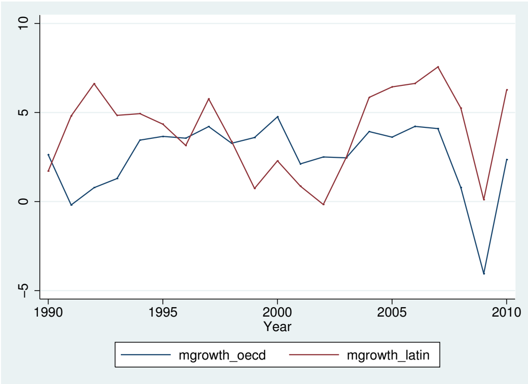


Figure 4.2: Trend of gdp growth in Latin America and OECD 1990-2010



A last interesting look is at the trend of GDP. A development we might expect according to the theoretical works of Solow, is a convergence effect where poorer countries (ceteris paribus) on average experience higher growth rates. To see this, I added a final figure with the evolution of growth in the Latin American and OECD countries over the past twenty years. While the Latin American countries do not consistently experience higher growth than OECD countries, there is some tendency for higher average growth in Latin America. This difference, while not very large, further motivates the use of both system GMM and ABGMM for the sake of robustness.

4.2 Variables

4.2.1 Dependent variable - GDP PPP per capita

The variable GDP purchasing power parity (PPP) per capita (*gdp_ppp*) is collected from World Development Indicators (WDI 2013) and represents the gross domestic product converted to international dollars using purchasing power parity rates. Data are in 2005 international dollars. Important to note is that different authors have used different measures. Arnold et al (2011) uses GDP per capita, while Gemmel et al (2011) use growth levels. When using GMM, such as in this paper, GDP per capita should be a better choice due to first differencing of the variables.

4.2.2 Independent variables - Tax structure

To measure tax structures, both actual statutory rates and revenue shares will be used. Regarding the former, OECD country-data is collected from the OECD tax database (OECDa 2013). Rates are available for top marginal personal income tax (*pit_rate*) between 2000-2011, average corporate tax rate (*cit_rate*) from 1990 and consumption taxes (*vatgst*) every second year from 1990 and yearly from 2000. For Latin American countries, all rates are available from 2000 to 2011, and are taken from the Inter-American Centre for Tax Administration (CIAT 2013).

It is important to note that the rates on consumption taxes do not separate between VAT and other sales taxes. One should hence be careful when modeling this. Since sales tax rates are generally lower, any differences between results from tax rates instead of revenues could be due to the failure to separate between the two structures. In the current data set this should be of less significance. Consumption taxes in almost all countries in the data set are constructed as value added tax systems. An important exception is United States, a country that still has no consumption tax on federal level. The US is hence excluded when estimating *vat*.

The data on revenues are all collected for personal income taxes (*pit_rev*), corporate income taxes (*cit_rev*) and consumption taxes (*vat_rev*) from the OECD revenue share database (OECDb 2013). This database has available data both regarding OECD countries and Latin American countries for the entire period 1990-2011.

4.2.3 Covariates - Baseline model

From standard growth theory it is possible to infer three variables as essential. These are more or less always present in empirical estimations. These are **population growth** and investment in **physical-** and **human capital**.

Starting with the former and least complex, population growth (*pop*) is collected from WDI, and is simply measured as the yearly percentage growth in population over time.

Physical capital (*phy_cap*) is also collected from WDI, and is, according to the World Bank: "outlays on additions to the fixed assets of the economy plus net changes in the level of inventories". Practically, additions to assets implies for example construction of roads, schools or railways and land improvements, while inventories are firm stocks to meet unexpected fluctuations (WDI 2013).

What should be included in the concept of human capital (*hum_cap*) is up for debate, and even if one decides on the simplest interpretation - the average number of schooling years - one faces a lot of missing data over time. Barro and Lee (2010) solve this by using extrapolation forward as well as backward over time, which works according to the following:

The authors draw numbers from Eurostat, UNESCO and national statistic agencies on educational levels for citizens older than 15. This data is segmented in age groups with five year intervals. For ages higher than 25, it is assumed that most education is finished. Hence, missing data is filled in using forward extrapolation, meaning that years of schooling for those aged 30-34 in period t, is the same as that of those aged 25-29 in period $t-5$. The formula is adjusted for those older than 65, accounting for heterogeneity in mortality rates over countries.

For those aged younger than 25, school is assumed still in progress. Barro and Lee instead use backwards extrapolation where a person aged 20-24 at t is assumed to have the same education as 25-29 in $t+5$.

Since the data set only includes numbers for every fifth year, I use linear interpolation to create yearly numbers. This method has earlier been used by for example Acosta-Ormaechea et al (2012). It is, however, important to note the possibilities of measurement errors.

4.2.4 Other control variables

Some additional control variables are included to account for any other causal mechanisms outside that of taxes and the basic model described above.

Research and development is important from the point of view of innovation. The most intuitive measure is collected from WDI, and inherits spending on research and development as a percentage of GDP (WDI 2013). The biggest problem with the variable is the large amount of missing data. Large gaps in both specific panels and time series will unfortunately cause serious estimation problems. A second variable (*high_tech*) is therefore included, which measures the percentage of all manufactured exports which can be classified as high-technology manufacture. This include, according to WDI, "aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery" (WDI 2013). The latter variable has a better data coverage, and could function as a reasonable approximation of the level of innovation in a panel.

Also important are institutions. A recent attempt to create a generic measure is made by Kuncic (2012). Kuncic separates three different forms of institutions. These are legal institutions, representing quality of the judiciary and security of property rights, political institutions, which means for example limits to government power and electoral rules, and finally economic institutions, implying ease of doing business and paying taxes.

Kuncic collects already existing empirical indexes, based in the best coverage and whether or not the index has a proven track-record in academic literature. He then separates these into the three categories described above. Averages of all indexes are calculated to create a new index, spanning from 1990-2010. Measures are indexed on an interval from 0 to 1, where 1 is the highest possible score. Because of the broad coverage both time and panel wise, the variables are suitable for this study.

Most important is perhaps government expenditure (*exp*), which is to represent the expenditure as percentage of GDP. As noted earlier, this is to control for any positive expenditure effect from raising higher taxes. The variable is collected from WDI (2013).

Chapter 5

Results

In this section the main regression results are presented. The main section includes results using system GMM. Firstly, results using tax rates as explanatory variable are presented. Secondly, results when using tax revenues as share of total tax revenue are estimated. Thirdly, ABGMM estimations are included as a robustness check. All estimations are executed using Stata 12.

5.1 Regressions using statutory tax rates

The initial results are presented in five columns in Table 5.1, were the first column represents the baseline model and the second includes legal institutions (*legal*) and innovation (*high_tech*). I choose to include legal institutions rather than economic since the latter variable measures tax-levels, and might therefore override the effect of tax structures. Column 3-5 add tax variables and the log of expenditure (*log_exp*). In each column one of the three tax structures is left out. This is done to be able to interpret the coefficients as changes in the structure. If we see a positive coefficient of *vatgst* when *cit_rate* is left out, one can hence conclude that relying more on consumption taxes than corporate income taxes is positively correlated with growth. In the bottom of each column one can note the number of instruments and a Hansen-test for overidentification.

As discussed in the empirical strategy, to avoid overidentification, the number of instruments are limited using collapsed instruments and pca-techniques. All regressions are estimated using robust standard errors. Further diagnostic checks include tests for unit roots and collinearity. Normality is assumed on the account of the large amount of observations. Some variables indicate a unit root, which potentially could be a problem. The problem diminishes when using logs, however, it should be remembered that the regression could suffer from weak instruments. A cross correlation table for the baseline variables in the model indicate no problems with collinearity in the explanatory variables. Unit root tests and a collinearity table are found in Appendix B.

Looking at the baseline model in table 5.1, the investment variables are

Table 5.1: System GMM estimations of growth using statutory tax rates: 1990-2010. Level equation instrumented with first difference lags of *log_gdpp* and explanatory variables.

VARIABLES	(1) log_gdpp	(2) log_gdpp	(3) log_gdpp	(4) log_gdpp	(5) log_gdpp
L.log_gdpp	0.742***	0.774***	0.715***	0.667***	0.771***
	(0.064)	(0.063)	(0.099)	(0.095)	(0.076)
hum_cap	0.066***	0.056***	0.005	0.069***	-0.016
	(0.020)	(0.019)	(0.049)	(0.022)	(0.034)
phy_cap	0.008***	0.008***	0.007***	0.007***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
pop	-0.019	-0.009	-0.005	-0.071**	-0.078***
	(0.019)	(0.019)	(0.028)	(0.033)	(0.022)
legal		-0.194**	0.611***	0.566**	0.389
		(0.093)	(0.172)	(0.253)	(0.372)
high_tech		0.000	-0.001	0.003	0.003*
		(0.001)	(0.002)	(0.002)	(0.002)
log_exp			0.107	0.101	0.142**
			(0.124)	(0.091)	(0.066)
pit_rate			0.005*		0.002
			(0.003)		(0.003)
cit_rate			-0.001	0.005	
			(0.004)	(0.006)	
vatgst				0.001	0.024**
				(0.006)	(0.011)
Observations	899	899	462	570	445
Number of instruments	21	40	55	55	52
Hansen test	40.11	41.91	38.03	36.60	38.13
	(0.011)	(0.137)	(0.760)	(0.810)	(0.642)

Robust standard errors in parentheses (Hansen test shows p-values)
*** p<0.01, ** p<0.05, * p<0.1

significant and the coefficients are as expected. Human capital has a large positive effect, while the effect of physical capital is smaller yet still significant. The lagged level of GDP is significant and has the expected positive sign. Population growth is not consistently negative, but is negative as expected.

Striking is the non-significance and somewhat irregular sign of *high_tech* and *legal*. This might be due to many things. It cannot be ruled out that innovation and institutions, as measured in this context, simply have no effect on the development of growth. To capture the full effect of institutions is difficult due to the relation between informal and formal institutions, and the measure of innovation used here (the share of total export defined as high technology exports) simply does not capture the full range of the concept. Another possibility is that some of the effect is diminished by the estimation technique, which uses first differences. I will come back to this theory later in the section.

Regarding the tax variables in column 3-5, *vatgst* is significant when *cit_rate* is left out. The variable is as expected positive, which in this scenario would imply that strengthening consumption taxes over corporate income taxes causes lower gdp. This is in line with previous work, both theoretical and empirical. The fact that *cit_rate* and *pit_rate* are non-significant when one or the other is removed from the equation, is not surprising. As discussed in section three, while there is a theoretical case for choosing consumption taxes over income taxes, the case is not as strong when it comes to choosing in-between the two income tax structures.

More surprising is that *pit_rate* turns positive when *vatgst* is left out. This would imply that a shift from consumption taxes to personal income taxes gives a positive change in GDP. Noticeable in table 5.1 is also that human capital turns non-significant with the addition of *pit_rate*. Several explanations are possible. One plausible is that some of the effect of the personal income tax is picked up by the human capital variable. In line with some previous research, it is hence interesting to look at a model excluding the baseline model and covariates. *log_exp*, *L.log_gdpp* and *legal* are left in the model. The reasons are in turn that it is still necessary to control for potential expenditures and the dynamics in the model, while *legal* is kept since the effect of taxes is not expected to work through institutions. This is seen in Table 5.2.

As can be seen in the table, *vatgst* is still positive and significant. While the variable is now only significant on a ten percent level, it is noticeable that the p-value is only slightly larger than 0.5. This holds both for a move to consumption taxes from corporate taxes as well as from personal income taxes. The biggest effect is given with a move from corporate income taxes to consumption taxes. The results hence resemble the ones in Table 1, meaning that *vatgst* should be preferred over *cit_rate*. Also, as expected, the effect of *pit_rate* in column (1) is no longer significant nor positive. In fact, it is sufficient to lift the human capital variable from the regression to make sure that *pit_rate* is no longer significant.

Using tax rates does hence support some of the theoretical predictions. While none of the tax structures proved consistently highly significant in a neither positive nor negative direction, numbers indicate a positive effect on GDP growth from moving from a *cit* or *pit* to *vat*. While the short time span

Table 5.2: System GMM estimations of growth using statutory tax rates. No baseline model: 1990-2010. Level equation instrumented with first difference lags of *log_gdpp* and explanatory variables.

	(1)	(2)	(3)
VARIABLES	log_gdpp	log_gdpp	log_gdpp
L.log_gdpp	0.611***	0.745***	0.559***
	(0.143)	(0.198)	(0.176)
log_exp	0.076	0.151	0.115
	(0.061)	(0.156)	(0.087)
legal	1.289***	1.227***	1.168**
	(0.201)	(0.283)	(0.546)
pit_rate	-0.000		-0.003
	(0.003)		(0.007)
cit_rate	-0.003	0.006	
	(0.004)	(0.012)	
vatgst		0.020*	0.037*
		(0.010)	(0.019)
Observations	462	570	445
Number of instruments	31	29	26
Hansen test	36.39	37.01	35.30
	(0.066)	(0.032)	0.019

Robust standard errors in parentheses. (Hansen test shows p-values)
*** p<0.01, ** p<0.05, * p<0.1

should raise caution, the results strengthen current predictions on consumption taxes being a more suitable tax from a growth perspective.

5.2 Regressions using tax revenues as share of total tax income

Turning to the use of tax revenues instead of rates, Table 5.3 downwards demonstrate the results of the full model with baseline variables included.

Similarly to the estimations using tax rates, GMM estimations are used with robust standard errors, and instruments are limited with collapsed instruments and pca-techniques. Starting with the baseline model, results resemble the ones found in the previous section. *phy_cap* is consistently significant with a positive effect, while *hum_cap* behaves in a somewhat irregular way when personal income taxes are included.

Looking at the variables of interest, the effects seem to differ from what was found in the previous model. The effect of consumption taxes is no longer significant. Interesting is that *cit_rev* is significant on a five percent level with a positive sign in column (1) when the full specification of the model is used. Also, the effect of personal income taxes are significant and negative in column three, implying a positive effect when moving from corporate income taxes to personal income taxes. These results do not at all resemble the results, which were find in the prior section, with the use of statutory tax rates.

Just as before I also include a measure with no baseline model. This can be seen in Table 5.4. The results now show a tendency which is partly in line with theory, and partly against it. A consistent effect is the negative effect of personal income taxes. In column (3) the effect of *pit* is negative when *cit* is dropped from the estimation, and in column (2), dropping *pit* has a positive effect on both *cit* and *vat*. Unlike in the case of the full model, *vat* is now positive in at least one of the cases, which is according to the expectations.

Intersting is that the effect of corporate income taxes, again is positive and significant. This time the effect stands regardless of whether the change is from personal income taxes or consumption taxes.

It should be noted that a positive effect from corporate income taxes has been found in some previous research. For example, Widmalm (2001) showed significant but "fragile" effects from her extreme bound estimates on OECD countries. Widmalm then gave the following explanation to her findings:

> The conclusion must be that corporate taxations effects on the incentives of firms are not properly captured by the ratio of corporate income taxes to total tax revenue. Another possibility is that to the extent that monopolies are prevalent in the OECD economies, taxes on corporate profits need not have large effects (Widmalm 2001: 209).

The latter idea, on monopolies, can of course not be ruled out. However, it lies outside the scope of this paper to investigate measures of competition

Table 5.3: System GMM estimations of growth using tax revenues as share of total taxes: 1990-2010. Level equation instrumented with first difference lags of *log_gdpp* and explanatory variables.

VARIABLES	(1) log_gdpp	(2) log_gdpp	(3) log_gdpp
L.log_gdpp	0.789***	0.760***	0.793***
	(0.077)	(0.058)	(0.054)
hum_cap	0.011	0.070***	0.060***
	(0.024)	(0.025)	(0.021)
phy_cap	0.007***	0.009***	0.009***
	(0.001)	(0.001)	(0.001)
pop	-0.068***	-0.015	-0.012
	(0.014)	(0.024)	(0.021)
legal	-0.065	-0.063	-0.130*
	(0.089)	(0.102)	(0.078)
high_tech	0.002***	0.000	0.001
	(0.001)	(0.001)	(0.001)
log_exp	0.078*	-0.036	-0.018
	(0.040)	(0.042)	(0.048)
pit_rev	-0.001		-0.004**
	(0.003)		(0.002)
cit_rev	0.003**	0.002	
	(0.001)	(0.002)	
vat_rev		-0.000	-0.002
		(0.001)	(0.002)
Observations	899	899	899
Number of instruments	62	58	62
Hansen test	38.50	40.60	40.89
	(0.918)	(0.767)	(0.867)

Robust standard errors in parentheses. (Hansen test: p-values)
*** p<0.01, ** p<0.05, * p<0.1

Table 5.4: System GMM estimations of growth using tax revenues as share of total taxes. No baseline model: 1990-2010. Level equation instrumented with first difference lags of *log_gdpp* and explanatory variables.

VARIABLES	(1) log_gdpp	(2) log_gdpp	(3) log_gdpp
L.log_gdpp	0.863***	0.860***	0.860***
	(0.045)	(0.058)	(0.048)
log_exp	0.076**	0.010	0.058
	(0.036)	(0.048)	(0.040)
legal	0.087	0.198	-0.078
	(0.102)	(0.156)	(0.219)
pit_rev	-0.005		-0.008*
	(0.003)		(0.005)
cit_rev	0.004***	0.008***	
	(0.001)	(0.002)	
vat_rev		0.005**	0.003
		(0.003)	(0.003)
Observations	900	900	900
Number of instruments	37	34	38
Hansen test	42.56	42.94	43.31
	(0.081)	(0.035)	(0.088)

Robust standard errors in parentheses. Hansen test: p-values
*** p<0.01, ** p<0.05, * p<0.1

within the countries in the sample. The former of the two theories laid forward by Widmalm is theoretically appealing. Returning to the ideas of Myles (2007), it is a fact that no incentives of any financial actor is affected by revenue shares, but by actual tax rates.

5.3 Robustness check: ABGMM estimations

Since the assumptions regarding system GMM are very restrictive, results using ABGMM are estimated as well. Primarily results using tax rates are shown in Table 5.5, and results using tax revenues are shown in Table 5.6. Column 1-3 show the full model, and column 4-6 show results with no baseline model. Since the interest only lies in investigating robustness for tax variables, none of the other variables are shown in the Tables.

The results when using statutory tax rates are all with coefficients close to zero. A simple, yet somewhat technical reason is the first differencing of the the variables. Since ABGMM uses first difference of the estimated coefficients, this eradicates some of the effect of a variable with little or no variation over

Table 5.5: ABGMM estimations of growth using tax rates. 1990-2010. First difference equation instrumented with lags of *log_gdpp* and first difference of explanatory variables

VARIABLES	(1) log_gdpp	(2) log_gdpp	(3) log_gdpp	(4) log_gdpp	(5) log_gdpp	(6) log_gdpp
pit_rate	0.000		-0.001	0.000		-0.001
	(0.002)		(0.002)	(0.002)		(0.002)
cit_rate	-0.008*	-0.005		-0.001	-0.011	
	(0.005)	(0.004)		(0.007)	(0.009)	
vatgst		-0.004	0.008		-0.005	0.004
		(0.007)	(0.015)		(0.010)	(0.025)
Observations	414	438	394	414	438	394
Number of instruments	53	53	48	28	29	26
Hansen-test	39.22	39.65	40.17	35.53	39.66	35.23
	(0.676)	(0.658)	(0.418)	(0.046)	(0.023)	(0.027)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

time. This in turn implies that the small changes in tax variables visible over time causes a bias towards non-significance. This theory is further strengthened by looking at the coefficients in Table 5.6, where results using tax revenues are shown. Since the variance in revenue is larger over time, the coefficients are also larger.

While the estimated results overall are less significant then when using system GMM, it is clear that the general picture is similar. When using tax rates, the corporate income taxes show a negative sign, which is in line with theory. The result is also significant in one of the cases, although only at a ten percent level. Moving to the results from tax revenues one can see that significance levels are generally higher, and just as system GMM estimations, corporate income taxes are now positive.

At last, several of the estimation performed when excluding the baseline model (both for system GMM and ABGMM) statistically indicate problems with overidentification. Here, I rely on the rule of thumb described by several researchers on GMM, which is that the number of instruments should be fewer than the number of panels. As this is the case in almost all estimations, overidentification is deemed to be less of a problem.

Table 5.6: ABGMM estimations of growth using revenues as share of total tax income. 1990-2010. First difference equation instrumented with lags of *log_gdpp* and first difference of explanatory variables.

VARIABLES	(1) log_gdpp	(2) log_gdpp	(3) log_gdpp	(4) log_gdpp	(5) log_gdpp	(6) log_gdpp
pit_rev	-0.006		-0.006*	-0.020***		-0.016***
	(0.004)		(0.003)	(0.005)		(0.006)
cit_rev	0.005***	0.004		0.006***	0.012***	
	(0.001)	(0.002)		(0.002)	(0.003)	
vat_rev		0.003*	-0.000		0.011***	-0.000
		(0.002)	(0.002)		(0.004)	(0.003)
Observations	854	854	854	855	855	855
Number of instruments	57	54	58	35	32	36
Hansen-test	43.11	42.86	40.96	37.56	39.67	40.72
	(0.673)	(0.563)	(0.786)	(0.161)	(0.055)	(0.114)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 6

Conclusion

In this essay I used data on both statutory tax rates and tax revenues as share of total tax income to estimate a relationship between different tax structures and GDP growth. I focused on three of the most common: consumption taxes, personal income taxes and corporate income taxes. The full sample included 45 countries over the years 1990-2010. Most of the countries (35) are OECD countries, the rest were Latin American non-OECD countries. Estimations were executed using GMM estimators (instrumented using both system GMM and Arellano and Bond GMM) with the key aim to compare how results using tax rates and tax revenues might differ.

Primarily by comparing the two most common measuring approaches, but also by using countries from different levels of the development scale, GMM and new control variables, this paper provides an added value to ongoing research. Theoretically the expectation and prediction was that a change towards more reliance on consumption taxes imply higher growth. The empirical research supporting this notion has, however, been thin and not robust.

Interestingly, results were not similar for the different structures. Some significant positive effects from consumption taxes were found in both the case of tax rates and revenues. Also, results pointed towards negative effects from personal income taxes in both regressions.

An important distinction, however, lies in the difference between the interpretation of corporate income taxes. Results were strongly positive in the case of revenues, but pointed towards a negative effect in the case of tax rates. As noted in the result section, this essay is not the first to find a positive effect from corporate income tax revenues, which brings about the important question if there is something specific regarding corporate income tax revenues that makes it particularly ill fitted for estimating tax structures. While this might be the case, nothing theoretically leads to a conclusion were revenues would be a worse measure of corporate income taxes than personal income taxes. A possible conclusion is that the locational decision and investment decisions of companies are affected by several concepts which are not possible to capture here. A country which has been able to gain a lot of revenues from corporate income taxes might in fact have many non-tax advantages (policies, infrastructure etc.) which may all give more corporate activity and bigger revenues from corporate income taxes. If this is the case, the positive effect of corporate income tax revenue is in fact a reflection of a well functioning entrepreneurial environment.

As always, the results provided above have a couple of drawbacks. Firstly, pooled regressions such as Arellano and Bond GMM and system GMM estimations assumes that the slope of the different groups are homogeneous. Practically this implies that all countries included in the data set have similar correlations between the explanatory variables and growth. Just as different panels need different intercepts, it might be that countries have differences in the slope of the coefficient. For example, the effect of economic institutions on growth might be continually different in Sweden as opposed to El Salvador. Secondly, It is fully possible that the regressions performed in this paper suffers from reverse causality. Important to note is, however, when the main target is to look at the possible differences between measures, problems with endogeneity arise primarily if reverse causality can be expected to be *larger or smaller for either revenues or rates*. Whether this is the case is difficult to say, but since it cannot be ruled out, future research can be strengthened by a combination of heterogeneous panels and good exogenous instruments.

Even with this in mind, comparing the two pooled estimations, based in either tax rates or revenues, leaves the simple conclusion that what kind of measure that is used has an impact on the result. Despite using the same estimation technique, the same panels and similar covariates, the effect of tax structure were different. Important to keep in mind is that not only did the statistical results differ, the economic interpretation is not the same. In one case the recommendation is to use mainly consumption taxes, while in the other recommendations also lean towards increasing the use of corporate income taxes. In future research, more care and time should be spent on arguments regarding the choice of measure.

References

Acosta-Ormaechea Santiago and Yoo Jiae (2012). "Tax Composition and Growth: A Broad Cross-Country Perspective". In *IMF Working Paper*, **257**.

Angrist Joshua D. and Pischke Jörn-Steffen (2009). "Mostly Harmless Econometrics. An empiricist's companion". Princeton University Press. Oxfordshire.

Arnold, Jens Matthias; Brys, Bert; Heady, Christopher; Johansson, Åsa; Schwellnus, Cyrille; Vartia, Laura (2011). "Tax policy for economic recovery and growth". In *The Economic Journal*, **121** (February): 59-80.

Barro, Robert and Jong-Wha Lee, (2010). "A New Data Set of Educational Attainment in the World, 1950-2010." In *NBER Working Paper*, **15902**.

Bird, R and Gendron, P-P (2007). "The VAT in developing and transitional countries". Cambridge University Press. New York.

Blackburn III, Edward F. and Frank, Mark W (2007). "Estimation of non-stationary heterogenous panels". In *The Stata Journal*. **7**, 2: 197-208.

CIAT (2013). "CIATData". Retrieved 2013-04-05.

[http://www.ciat.org/index.php/en/products-and-services/ciatdata.html].

Easterly, Williams and Rebelo, Sergio (1993). "Marginal income tax rates and economic growth in developing countries". In *European Economic Review*, **37**: 409-417.

Fjeldstad, Odd-Helge (1995). "Value added taxation in Tanzania?". In *Chr. Michelsen Institute working paper*, **5**.

Gemmel, Norman; Kneller, Richard; Sanz, Ismael (2011). "The Growth effects of corporate and personal tax rates in the OECD". In *Bond University Working Paper*, **49**.

Heckman, James: Lochner, Lance; Taber, Christopher (1998). "Tax policy and human capital formation". In *American Economic Review*, **88**: 293 297.

Hindriks Jean and Myles D. Gareth (2006). "Intermediate Public Economics". MIT Press. Camebridge.

Im, Kyong So; Pesaran, Hashem M.; Shin, Yongcheol (2003). "Testing for unit roots in heterogenous panels". In *Journal of Econometrics*, **115**: 53-74.

Kimball, Miles S. and Shapiro, Matthew D. (2008). "Labor supply: are the income and substitution effects both large or both small?". *NBER Working paper*, **14208**.

Kneller, Richard; Bleany, Michael F; Gemmel, Norman (1999). "Fiscal policy and growth: evidence from OECD countries". In *Journal of Public Economics*, **74**: 171-190.

Kuncic, Aljaz (2012). "Institutional quality database". In *Kiel advanced studies working paper*, **457**. Kiel Institute for the World Economy.

Lee, Young and Gordon, Roger. H (2005). "Tax structure and economic growth". In *Journal of Public economics*, **89**: 1027-1043.

Madsen, Edith (2003). "GMM Estimators and unit roots tests in the AR(1) panel data model". In *Centre for Applied Microeconometrics working paper*.

Mehrhoff, Jens (2009). "A Solution to the Problem of Too Many Instruments in Dynamic Panel Data GMM" In *Diskussionsbeitrag aus dem Fachbereich Wirtschaftswissenschaften*, **171**. Universitat Duisburg-Essen.

Mendoza, Enrique.G; Milesi-Ferretii, Gian Maria; Asea, Patrick (1997). "On the ineffectiveness of tax policy in altering long-run growt: Harberger's superneutrality conjecture". In *Journal of Public Economics*, **66**: 99-126

Myles, Gareth. D (2007). "Economic growth and the role of taxation". Working paper prepared for the OECD. University of Exeter and IFS.

North, Douglas C (1991). "Institutions". In *The journal of economic perpectives*, **5**, 1: 97-112.

OECDa (2013). "OECD stats extracts". Retrieved 2013-04-05.

[http://stats.oecd.org/Index.aspx].

OECDb (2013). "OECD tax database". Retrieved 2013-04-10.

[http://www.oecd.org/tax/tax-policy/oecdtaxdatabase.htm].

Padovano, Fabio and Galli, Emma (2001). "Tax rates and economic growth in the OECD countries (1950-1990)". In *Economic Inquiry*, **39**, 1: 44-57.

Pesaran, Hashem M. (2012). "On the interpretation of panel unit root tests". In *Economic Letters*, **116**: 545-546.

Roodman, David (2006). "How to Do xtabond2: An Introduction to Difference and System GMM in Stata". In *Center for global development working paper*, **103**.

Roodman, David (2009). "Practioners corner. A Note on the Theme of Too Many Instruments". In *Oxford Bulletin of economics and statistics*, **71**, 1: 135-158.

Schumpeter, J. A. (1934). "The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle". Harvard University Press. Camebridge. Reprint 1983: Transaction Inc.

Sørensen Peter and Whitta-Jabobsen, Hans (2010). "Introducing advanced macroeconomics - growth and business cycles". McGraw Hill. New York.

Verbeek, Marno (2008). "A guide to modern econometrics". Wiley.

Widmalm, Frida (2001). "Tax structure and growth: Are some taxes better than others?". In *Public Choice*, **107**: 199-219.

Williamsson, Oliver E (2000). "The new institutional economics: taking stock, looking ahead". *Journal of economic litterature* **38**: 595-613.

WDI (2013). "World developement indicators". Retrieved 2013-04-10.

[http://data.worldbank.org/data-catalog/world-development-indicators]

Appendix A

Solow Model - exogenous growth

A.1 Basic setup

The model assumes one good which can be consumed or saved. If saved, the good is invested in capital (K). There is one additional input, which is labor (L). K depreciates with usage, L is fixed for a single worker. Population grows at a constant rate.

The output level is hence, (where t represents time):

$$Y_t = F(K_t, L_t) \tag{A.1}$$

A.1 assumes constant returns to scale. An important assumption is further that savings (s) are fixed. This can be written as $0 < s < 1$. Since all savings are invested, savings must equal investments (I).

$$I_t = sF(K_t, L_t) \tag{A.2}$$

Making the model intertemporal, we know that K depreciates. Assuming this rate is also fixed (δ):

$$K_{t+1} = sF(K_t, L_t) + (1 - \delta)K_t \tag{A.3}$$

A.3 is the first basic result, and is sometimes called the basic capital accumulations relationship. What it says is simply that capital in period $t + 1$ equals investments (or savings) in period t plus depreciated capital from period t. Further denoting population growth by n, A.3 can be expressed in per capita terms by dividing with labor.

$$(1 + n)k_{t+1} = sf(k_t) + (1 - \delta)k_t \tag{A.4}$$

Where k_t equals $\frac{K_t}{L_t}$. All we need now is a production function, an initial value of capital and values for the unknowns of the model: depreciation rate

(δ), population growth (n), savings rate (s), and we can trace the evolution of capital accumulation over time.

A.2 Steady state

A simulation of capital over time would show a convergence towards a so called steady state. In formal terms, this is when the capital stock is constant, and $k_t = k_{t+1}$. Removing the time trends we end up with the long run equilibrium capital/labor ratio (A.6):

$$(1+n)k = sf(k) + (1-\delta)k \tag{A.5}$$

$$sf(k) - (n+\delta)k = 0 \tag{A.6}$$

The steady state is hence where investment per worker ($sf(k)$) equals $(n+\delta)k$. Here the capital/labor ratio hence remains. Returning to A.1, it can be seen that output per worker will remain as well. Output now only grows with population.

A.3 Convergence

A last implication of the Solow model is that two countries with similar production technologies (i.e. the same capital/labor ratio) and saving rate should converge to the same steady state levels. Based in this, and the fact that capital depreciates over time, countries with lower levels of k should grow faster. Repeating A.6, the steady state is given by $sf(k) - (n+\delta)k$. Dividing by k, we get the growth rate (g_k) of the steady state:

$$g_k = \frac{sf(k)}{k} - (n+\delta) \tag{A.7}$$

Using the derivative of growth with respect to the capital/labor ratio, we see that output grows slower with higher levels of k.

$$\frac{\partial g_k}{\partial k} = \frac{s}{k}(f'(k) - \frac{f(k)}{k}) < 0 \tag{A.8}$$

Appendix B

Diagnostic tests and descriptive statistics

B.1 Descriptive statistics

Table B.1: Summary statistics

Variable	**Mean**	**Std. Dev.**	**N**
gdp_ppp	20833.684	12405.298	945
log_gdpp	9.722	0.729	945
growth	2.95	3.568	945
phy_cap	21.749	4.449	945
hum_cap	9.321	2.016	945
pop	0.887	0.792	944
high_tech	12.671	10.106	945
legal	0.736	0.166	945
log_exp	10.372	0.845	945
cit_rev	10.338	7.483	945
pit_rev	18.91	13.254	945
vat_rev	22.367	12.259	945
pit_rate	38.329	9.939	462
vatgst	16.958	5.7	621
cit_rate	29.404	8.188	747

B.2 Diagnostics

Assuming a variable is generated from an autoregressive process such as in B.1, it is possible to rewrite it as B.2, and perform tests of unit roots.

$$y_{it} = (1 - \sigma_i)\mu_i + \sigma_i y_{i,t-1} + \epsilon_{it} \tag{B.1}$$

$$\Delta y_{it} = \alpha_i + \rho_i y_{it-1} + \epsilon_{i,t} \tag{B.2}$$

where $\rho = -(1 - \sigma_i)$ and $\alpha_i = (1 - \sigma_i)\mu_i$. A standard panel unit root tests investigates equation B.2, and the basic hypothesis of $\rho_i = 0$ versus $\rho_i < 0$.

I use the Im-Pesaran-Shin test (Im et al 2003), which allows for different ρ across panels. The null hypothesis is the same as in a standard test (all panels have unit roots), but the alternative is now that a fraction of the panels are stationary. Formally this means:

$H_0 : \rho_i = 0$ for all i

$H_1 : \rho_i < 0,\ i = 1, 2..., N_1,\ \rho_i = 0,\ i = N_1 + 1, N_1 + 2, ..., N$

The Im-pesaran-shin test then utilizes dickey fuller tests for each panel and produces an average. In the table downwards W-t-bar statistics and p-values are reported. Three different functional forms are tested. The first one includes a trend an cross sectional means, the second a trend but no cross sectional mean and the final third includes neither trend nor mean. Lags are included according to the akaike information criteria (AIC).

As noted by Im et al (2003) and more recently Pesaran (2012), it is important to note that a rejection of the null does not necessarily imply that there are no problems with unit roots. We do not know how many panels might be stationary, nor do we know which ones. However, how to estimate the fraction of panels that are stationary or non-stationary, is still an issue for debate an development. Time consuming efforts such as estimating a single unit root test for every panel within every series is not time within the scope of this essay.

Table B.2: Panel unit root tests

	Trend and constant	Only trend	No trend nor constant
log_gdpp	1.9512	2.2725	0.4200
	(0.9745)	(0.9885)	(0.6628)
growth	-9.0656	-7.8367	-9.9841
	(0.0000)	(0.0000)	(0.0000)
phy_cap	-5.1418	-2.6928	-4.5707
	(0.0000)	(0.0035)	(0.0000)
hum_cap	0.9757	0.1869	-2.9862
	(0.8354)	(0.5741)	(0.0014)
pop	-16.6702	-10.5709	-5.0257
	(0.0000)	(0.0000)	(0.0000)
legal	-4.4283	-6.3489	-5.9811
	(0.0000)	(0.0000)	(0.0000)
high_tech	1.6306	3.123	-0.6246
	(0.9485)	(0.9991)	(0.2661)
log_exp	0.8162	-1.1008	-2.7227
	(0.7928)	(0.1355)	(0.0032)
cit_rate	.	-2.7142	-2.2881
	(.)	(0.0033)	(0.0111)
vatgst	.	-3.6125	-7.2439
	(.)	(0.0002)	(0.0000)
pit_rate	.	.	.
	(.)	(.)	(.)
cit_rev	-3.6085	-3.3247	-4.3725
	(0.0002)	(0.0004)	(0.0000)
vat_rev	.	-8.6422	-10.5528
	(.)	(0.0000)	(0.0000)
pit_rev	.	-1.5413	-2.6354
	(.)	(0.0616)	(0.0042)

p-values in parentheses.

Table B.3: Cross-correlation table

Variables	gdp_ppp	hum_cap	phy_cap	pop	legal	high_tech	exp	vatrev	citrev	pitrev	vatgst	citrate
gdp_ppp	1.000											
hum_cap	0.549	1.000										
phy_cap	0.151	0.286	1.000									
pop	-0.241	-0.420	-0.139	1.000								
legal	0.611	0.591	0.074	-0.357	1.000							
high_tech	0.397	0.427	0.027	-0.106	0.463	1.000						
exp	0.499	0.424	0.002	-0.283	0.447	0.403	1.000					
vat_rev	-0.564	-0.458	-0.156	0.233	-0.488	-0.275	-0.520	1.000				
cit_rev	-0.166	-0.120	0.040	0.239	-0.175	-0.107	-0.002	0.044	1.000			
pit_rev	0.583	0.595	0.036	-0.303	0.741	0.408	0.490	-0.495	-0.225	1.000		
vatgst	-0.039	0.170	-0.116	-0.357	0.226	-0.008	-0.065	0.162	-0.272	0.202	1.000	
cit_rate	0.042	-0.090	-0.002	-0.102	0.005	-0.094	0.207	-0.107	-0.034	0.074	0.126	1.000
pit_rate	0.437	0.384	-0.116	-0.216	0.570	0.219	0.512	-0.394	-0.237	0.649	0.270	0.131

Appendix C

ABGMM estimation technique

The following is a detailed description of GMM estimation using Arellano and Bond. The system GMM is exactly the same in its approach, only that C.1 is not first differenced. Instead the instruments are first differenced.

Using a simple dynamic model without exogenous covariates, the starting point is C.1, which is transformed using first differencing, leaving C.2.[7]

$$\Delta y_{i,t} = a_i + \epsilon_{it} \tag{C.1}$$

$$\Delta y_{i,t} = \gamma \Delta y_{i,t-1} + \Delta \epsilon_{it} \tag{C.2}$$

From C.2 one can see that y_{t-2} is correlated with $\Delta y_{i,t-1}$ but not with $\Delta \epsilon_{it}$. The latter conclusion assumes no autocorrelation in the first differenced errors, or formally.

$$plim \frac{1}{N(T-1)} \sum_{i=1}^{N} \sum_{t=2}^{T} (\epsilon_{it} - \epsilon_{i,t-1}) y_{i,t-2} = E[(\epsilon_{it} - \epsilon_{i,t-1}) y_{i,t-2}] = 0 \tag{C.3}$$

C.3 is one of the moment conditions to use. Assuming moment conditions are valid, additional conditions strengthens the efficiency of the estimation. Plus, using further lags might limit the vulnerability towards no serial correlation somewhat. Arellano and Bond hence add even further lags. For example, for $T = 4$, there are three possible moment conditions.

$$E[(\epsilon_{i4} - \epsilon_{i,3}) y_{i,2}] = 0 \tag{C.4}$$

$$E[(\epsilon_{i4} - \epsilon_{i,3}) y_{i,1}] = 0 \tag{C.5}$$

$$E[(\epsilon_{i4} - \epsilon_{i,3}) y_{i,0}] = 0 \tag{C.6}$$

(C.7)

[7] This section is based on Verbeek 2008: 377-383, Roodman 2009 and Mehrhoff 2009.

Writing C.4-C.6 in a more compact way brings 6.7, which can be used in a GMM framework.

$$E[Z_i \Delta\epsilon_i] = 0 \tag{C.8}$$

where Z_i is an instrument matrix containing the lagged values of the dependent variable and $\Delta\epsilon_i$ is a matrix with the differenced error terms.

$$Z_i = \begin{pmatrix} [y_{i0}] & 0 & \cdots & 0 \\ 0 & [y_{i0}, y_{i,1}] & & 0 \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & [y_{i0}, \cdots, y_{i,T-2}] \end{pmatrix}$$

$$\Delta\epsilon_i = \begin{pmatrix} \epsilon_{i2} - \epsilon_{i1} \\ \cdots \\ \epsilon_{i,T} - \epsilon_{i,T-1} \end{pmatrix}$$

The ABGMM estimator is then found by minimizing the sample moments with respect to γ. This is done by rewriting the error term in C.8 as $\Delta\epsilon_i = \Delta y_i - \gamma_\Delta y_i - y_{i,-1}$. This gives C.9, and by algebra the estimator in C.10. W_N is a positive weighting matrix. In this paper, the standard matrix, assuming homoskedasticity, is used. While this may cause some problems, Verbeek (2008: 387) reports that a general weighting matrix has standard errors which are biased downwards, and that several papers recommends using the simpler one.

$$min_\gamma \left[\frac{1}{N} \sum_{i=1}^{N} Z_i'(\Delta y_i - \gamma \Delta y_{i,-1} \right]' W_N \left[\frac{1}{N} \sum_{i=1}^{N} Z_i'(\Delta y_i - \gamma \Delta y_{i,-1}) \right] \tag{C.9}$$

$$\begin{aligned} \hat{\gamma}_{GMM} = & \left(\left(\sum_{i=1}^{N} \Delta y_{i,-1}' Z_i \right) W_N \left(\sum_{i=1}^{N} Z_i' \Delta y_{i,-1} \right) \right)^{-1} \times \\ & \left(\left(\sum_{i=1}^{N} \Delta y_{i,-1}' Z_i \right) W_N \left(\sum_{i=1}^{N} Z_i' \Delta y_{i,-1} \right) \right) \end{aligned} \tag{C.10}$$

Imortant to note is that explanatory variables are added to the instrument list. Since the model is in first difference form, all the explanatory variables are added as first difference in the Z_i matrix.

C.1 Limiting instruments with pca and collapse

I use two methods to limit the number of instruments. The first one is often described as "collapsing" the number of instruments. Intuitively, this is done by shrinking the instrument matrix Z_i horizontally. A mathematical illustration is according to the following, where Z_1 is the full instrumentation, and Z_2 represents a collapsed instrument set.

$$Z_1 = \begin{pmatrix} [y_{i1}] & 0 & 0 & 0 & 0 & 0 \\ 0 & y_{i1} & y_{i2} & 0 & 0 & 0 \\ 0 & 0 & 0 y_{i3} & y_{i2} & y_{i1} & \end{pmatrix}$$

$$Z_2 = \begin{pmatrix} [y_{i1}] & 0 & 0 \\ y_{i1} & y_{i2} & 0 \\ y_{i3} & y_{i2} & y_{i1} \end{pmatrix}$$

This means that the orthogonality between $y_{i,t-l}$ and $\Delta\epsilon_i$ still applies. Instead of minimizing moments for each t and l, the estimator now only uses l, thereby minimizing the number of instruments (Roodman 2009).

The other approach to minimize the number of instruments uses principal components analysis. This method has been developed and evaluated by Mehrhoff (2009). The idea is to sort the covariance matrix of Z_i according to highest eigenvalues, and choosing a subset of the full instrument set based in this ranking. By choosing a subset of the instruments the method allows for keeping the instruments that has the highest explanatory power of the variance in the data. In his paper Mehrhoff also uses Monte Carlo analysis to show the advantage of using pca-techniques. The conclusion is that it is recommended in combination with collapsed instruments.