The Relationship between Tax Rates and Tax Revenues in Eurozone Member Countries - Exploring the Laffer Curve*

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Abstract

We estimate Laffer Curves for direct and indirect taxes for each Eurozone country, using panel data from 1995 to 2011, by means of Seemingly Unrelated Regression (SUR) models. We choose the three taxes that contribute the most to the government tax revenue: the value added tax (VAT), the corporate income tax (CT), and the labour income tax (LT). From our estimated significant parameters, which have the expected signs according to the Laffer Curve theory, we obtained a maximum/optimal tax rate for VAT for Greece, Portugal, and Slovakia and for the majority of the Eurozone countries for direct taxes. We also take into consideration the business cycle. Many countries do not present differences in regime, and when they do, the optimal tax rate is higher during recessions. Finally, we compare the observed tax rates in 2012 to the estimated optimal tax rates, to assess if the 2012 policy was located at the prohibitive range of the Laffer Curve. Our results are important for the discussions about fiscal discipline and harmonization in the Eurozone, since they exhibit important disparities between countries and taxes. We can see that, especially for CT and LT, there is a strong divide between the values of the optimal maximum tax rates for Eastern European countries and Western European economies. Additionally, the economic and financial conditions of each country also influence the value for the tax rate.

JEL Classification: Laffer Curve, Eurozone Countries, SUR models, Business Cycle.
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1 Introduction

A few years ago the European Union member countries, in particular the European and Monetary Union (EMU) countries, have come into a major economic and financial crisis that started in 2008. This crisis severely affected the Eurozone, especially the Southern countries, and from an economic and financial crisis, soon turned into a sovereign debt crisis. Consequently, European governments implemented austerity measures to combat rising public budget deficits and public debts. Since 2008 taxes have been increasing significantly seeking to boost fiscal revenues and decrease budget deficits.

Serious doubts have been raised about the efficiency of these austerity measures to cut public budget deficits. Most of these doubts and the discussion around them were raised based on a concept called the Laffer Curve, which expresses a relationship between tax rates and revenues. This concept was first introduced by Wanniski (1978), when the author defined it as: "there are always two tax rates that yield the same revenue". Using this definition we can infer that the relationship between tax rates and tax revenues is an inverted U-shaped curve, in which there is a unique maximum level to the tax rate and a maximum level of revenues. He gave the name to this Curve honoring the economist Arthur Laffer, the first to talk about this relationship/trade-off.

This work estimates Laffer Curves for the Eurozone member countries, using Seemingly Unrelated Regression (SUR) models allowing for cross-country dependence with or without time dependence. We choose the Eurozone member countries since they share the same monetary regime and face some of the same restrictions in fiscal terms, although still possessing fiscal sovereignty. SUR models are particularly useful since they allow for specific estimations of the countries' optimal tax rates, while still preserving the number/dimension of a panel. We estimate these models and, whenever it exists, calculate the optimal tax rate for three of the most important taxes – the corporate tax (CT), the individual or labour income tax (LT) (these two direct), and the value added tax (VAT) (an indirect tax). **We use either nominal and real revenues.**

The estimations for the direct taxes are for the period 1995-2011, and for the VAT are for 2000-2011. From our estimated significant parameters, which have the expected signs according to the Laffer Curve theory, we **obtained** a maximum/optimal tax rate for VAT for Greece, Portugal, and Slovakia. **Specifically, the maximum tax rate for Slovakia is about the same,**

either using nominal or real values (between 13.4% and 15.6%), while for Greece there is a higher difference between nominal and real revenues (the maximum tax rate goes between 22% for real values and 26% for nominal values). Portugal has the highest maximum tax rate (in real terms) of around 35%. For the majority of the Eurozone member countries and for the direct taxes, a maximum tax rate was also found. For the CT, the optimal rates using nominal or real revenues are quite similar for Cyprus (17%), Estonia (15%), Ireland (21%), Italy (31%), Latvia (15%), and Slovenia (14%), while for the remaining countries, the optimal rates are greater using real revenues: France (26% versus 30%), Greece (25% vs 28%), Luxemburg (24% vs 27%), the Netherlands (30% vs 50%), Portugal (24% vs 27%), Slovakia (25% vs 29%), and Spain (25% vs 31%). By ranking the optimal taxes across the countries, one sees that in general the smaller occur amongst Eastern European countries, like Estonia, Latvia, and Slovenia, while the larger are in Western European economies, such as Italy, the Netherlands, and France. Finally, for the LT, Western European countries like Germany (54.4%-67%), Belgium (39.2%-48.8%), Finland (37.1%-43%), Spain (32.6%-54.8%), Luxemburg (30.7%-64.1%), Portugal (62.3%-65.8%), and France (37.1%-56.5%) have the highest optimal rates, in some cases, well above 50%. The smallest rate is by far in Estonia (14.7%-22.9%), an Eastern European country.

We can see that, especially for CT and LT, there is a strong divide between the values of the optimal maximum tax rates for Eastern European countries (which usually exhibit lower tax rates) and Western European economies (with higher tax rates) and that the economic and financial conditions of each country also influence the value for these tax rates. **We have performed Wald tests for the equality of the tax rates (both for nominal and real revenues) and the results support the previous claim.** Additionally, we test for the influence of the business cycle on our benchmark model by adding this variable to our estimations. Many countries do not present differences in regime, and when they do, the optimal tax rate is higher during recessions.

Another aim is to test for the trade-off between the tax rate and the tax revenue (Laffer, 2004) in light of the austerity measures just recently adopted, i.e., when a government decides to increase one type of tax, ceteris paribus, if that decision leads to an increase or decrease in the revenue for that same tax. In other words, we check if the tax rate was located at the prohibitive range of the Laffer Curve. According to Laffer, this depends on the starting point on the Laffer Curve, when the tax increase is implemented. For that, we compare our estimated optimal tax rates, when available, with the observed tax rates in 2012 for each tax in each country. We conclude that for the VAT, Slovakia is in the prohibitive zone and that the 2012 rate is less than the estimated optimal one for Cyprus, Greece, Ireland, the Netherlands, and Slovakia for the CT and Germany, Portugal, Slovakia, and Spain for the LT. As we can see, countries that have faced impositions by the troika, like Greece and Portugal, always have some tax in the prohibitive range of the Laffer curve.

Our work is important for the current discussion about the efficiency of fiscal austerity policies in Europe and for the future of fiscal policy in the EMU, especially in terms of the possibility of fiscal harmonization/union, given the heterogeneity of our results. The ECB also emphasizes the need for fiscal policy surveillance and discipline in the Euro area context: "The need for fiscal discipline is even stronger in a monetary union, such as the euro area, which is made of sovereign states that retain responsibility for their fiscal policies."[1] Research about this topic for the Eurozone is scarce, and possibly new using our methodology, as we will see in the next section. It is also much needed, given the common currency and fiscal restrictions shared by member countries, which brings about serious implications.

This work is organized in the following way. The next section presents the literature review. Section 3 describes the data set, variables, period, and sources, as well as the econometric methodology applied. Section 4 presents the results and analyses the estimations and draws policy implications, while Section 5 presents results for an exercise in which we estimate Laffer Curves taking into account the position in the business cycle. Finally, Section 6 presents the conclusions.

2 Literature Review

The Laffer Curve concept was first introduced by Wanniski (1978), when he defined it as: "there are always two tax rates that yield the same revenue", i.e., the relationship between tax rates and tax revenues is an inverted U-shaped curve and the curve can give us the maximum tax rate and a maximum level of revenues. The curve is named after the economist Arthur Laffer, as he was the first to talk about this relationship/trade-off. In 2004 Arthur Laffer published an article explaining what he meant by the Laffer Curve, clarifying that it represents a trade-

[1] https://www.ecb.europa.eu/mopo/eaec/fiscal/html/index.en.html

off between two effects on tax revenue – the arithmetic effect and the economic effect. The economic effect "recognizes the positive impact that lower tax rates have on work, output, and employment... The arithmetic effect always works on the opposite direction from the economic effect". The author also explained that in the curve there is also a prohibitive range region, located to the right of the optimal tax rate, i.e., if the tax rate increases, tax revenues decrease. That happens, according to Laffer, because the economic effect is stronger than the arithmetic effect (a situation that occurs when the actual tax rate is higher than the optimal tax rate).

There are some empirical works that estimate the Laffer Curve for individual countries and also for groups of countries. Regarding individual countries, Fullerton (1980) used a general equilibrium model and estimated the curve for the USA for labour income taxes. Depending on different labour-tax elasticities, the optimal tax rate varies between 9.1% and 71.8%. Using a partial equilibrium model Browning (1989) analyzed the relationship between tax revenues and tax rates on labour income (with data for the USA) and its determinants, such as changes in the tax rate structure and the influence of tax preferences on the tax base. For various values of elasticities the optimal marginal tax rate ranges between 33.3% and 69.2%. Hsing (1996) estimated a Laffer Curve for the USA for the period 1959-1991, using the personal income tax, and four specific functional forms - linear, log-log, linear-log, and log-linear. The author confirmed the inverted U-shape for the tax studied, and the tax rate that maximizes revenues was between 32% and 35%. Nutahara (2015) derived a neoclassical growth model to analyse the existence of Laffer curves in the Japanese economy for the labour, corporate, and consumption tax rates and to find their optimal tax rates. Results show that the labour tax is lower than the optimal labour tax, but the capital tax is similar or even higher than the optimal capital tax rate. Results for the consumption tax do not exhibit signs of the existence of an optimal tax rate, since tax revenues are increasing monotonically.

Feige and McGee (1983) estimated a Laffer Curve for Sweden using the income tax rate, using a theoretical model, which they simulated with calibration from empirical data. The authors estimated a Laffer Curve for the marginal tax rate (which included direct and indirect taxes and social security contributions), finding an optimal tax rate for Sweden between 54% and 62%. Ravestein and Vijlbrief (1988) estimated by Ordinary Least Squares (OLS) the Laffer Curve for the Netherlands, over the period 1960-1985, for tax rates on earnings and indirect taxes. They computed the optimal tax rate, for example, for Netherlands in 1970, which they found to be 66.9%.

Heijman and van Ophem (2005) estimate the Laffer curve by optimization methods for Austria, Belgium, Switzerland, Germany, Spain, France, Italy, Ireland, Japan, the Netherlands, Sweden, and the United Kingdom. These authors introduce the "black economy" into their model and according to their assumptions the optimal marginal tax rate is always lower than 36%. Another important conclusion is that when there is an increase in the tax rate there is a negative effect in revenues and a decrease in economic activities in the formal economy, which leads to an increase in the "black economy", or, in others words, informal economy. This conclusion is similar to Matthews' (2003) conclusion, presented below. Ioan (2012) calculated an aggregate Laffer Curve for Romania over the period 1999-2009 with quarterly data using the Linear Probit Model. This model provides information about the probability of changes in tax revenues, when a variation in the tax rate occurs. The author concludes that when government increases tax rates, fiscal revenues fall, and even a stronger conclusion, if taxes decrease, tax evasion also decreases.

For groups of countries there are three studies for OECD countries. Hansson and Stuart (2003) compute the Laffer limits for OECD countries, using data between 1972 and 1992. They estimated the model and calibrate it, using as a dependent variable the tax rate (in their model the tax rates are the marginal tax rates of labour income, capital income, and interest income) and as an independent variable tax revenues. They calculated the Laffer limit as a fraction of Gross National Product (GNP) and the authors concluded that it is hard to maintain the full tax higher than 70%. Brill and Hasset (2007) study the existence (or not) of a corporate Laffer Curve, using a panel for OECD countries over the period 1981-2005. The authors estimate the Laffer Curve for the corporate tax rate and concluded for the existence of a trade-off between the corporate tax rate and corporate tax revenues. The maximum corporate tax rate was estimated at 31%. Clausing (2007) found a "revenue-maximizing corporate income tax rate of 33%" for OECD countries as a whole for the period between 1979 and 2002. Besides using corporate tax rates and revenues, the author also uses as explanatory variables corporate profits and the size of the corporate sector. Tax revenues are in percentage of GDP in this study.

Studies for the European Union are still very scarce. Matthews (2003) for EU-14 used an unbalanced time-series of data for VAT for many countries [Austria (1974-97); Belgium (1971-97); Denmark (1970-95); France (1970-97); Germany (1970-97); Greece (1987-97); Italy (1973-98); Ireland (1972-96); Luxembourg (1971-96); the Netherlands (1970-97); Portugal (1986-97); Spain (1986-97); Sweden (1980-1998); and the UK (1973-98)], to estimate the Laffer Curve, computed using OLS and Least Absolute Deviation (LAD). The maximum range is 18%-19.3%, for EU-14. The author emphasizes that if the government increases VAT, consumption falls, as people try to escape paying VAT.

Trabandt and Uhlig (2011) computed a Laffer Curve for consumption, labour, and capital taxes, for the EU-14 and for the USA. The authors estimate the Curves by calibrating a theoretical model, which they simulate using the period between 1995 and 2007. The authors calculate an optimal tax rate for labour taxes of 30% and 40% for the USA and the EU-14, respectively, while in the case of capital taxes, the optimal tax rates were 40% and 35% for the USA and the EU-14, respectively. According to the authors, only Sweden and Denmark stay on the right side of the optimal tax rate, and the EU-14 stay closer to the optimal tax rate than the USA. In their estimations the authors do not find an optimal tax rate for consumption. In 2013 these two authors performed the same estimation over the period 1995–2010, for the same taxes, and found that countries moved closer to the optimal tax rate in the case of the labour tax rate, but in the case of the capital tax rate, the tax rate moves **further** away from the optimal tax rate. Vogel (2012) applies the QUEST III model, which the author extends by modelling home production (to be a proxy of an informal sector) to include the possibility of tax avoidance, to an average EU economy, to study labour, corporate, and consumption taxes. The author finds an optimal tax rate of 54% and 72% for labour and corporate tax, respectively, but no optimal tax rate for consumption, with revenues always increasing with an increase in the consumption tax. With high substitutability between the market and the informal sector, the optimal tax rate for the labour and corporate tax drop for percentages similar to those observed in the EU-average. The optimal tax rate for consumption is 40% in this case.

Oliveira and Costa (2013) estimate the Laffer Curve for the EU-27 over 2000-2010 using the VAT and panel-data robust (truncated) estimation method. The optimal VAT rate found is 22.5%. The authors used three types of models – the Laffer Curve estimated with all observations; using only observations in which economies experienced periods of low economic growth; and in which economies experienced periods of high economic growth.

Our work will focus primarily on estimating individual Laffer curves for Eurozone member countries for labour, corporate, and consumption taxes. We will also repeat the same exercise taking into account the position of the business cycle, to see if it affects our initial results. Finally, we will discuss the implication of our results, e.g. in terms of budget and fiscal policy for Eurozone countries. This last topic has been approached in theoretical terms by Oudheusden

(2016) and Mendonza *et al.* (2014), with this last work addressing the case of Europe specifically. Additionally, Dalamagas (1998) earlier reached the conclusion that we can assess if a decrease in the tax rate will increase (or decrease) tax revenues only if we take into account the crowding-in or crowding-out characteristics of economies.

3 Empirical Strategy

In this section we describe the data that we use in this work as well as the econometric methodology.

3.1 Data

We analyse the 18 Eurozone member countries, which share the same monetary regime and have some common restrictions in terms of fiscal policy, namely through the Stability and Growth Pact and all the other fiscal and surveillance mechanisms put in place since 2008.[2] The countries are: Austria (AT), Belgium (BE), Cyprus (CY), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Ireland (IE), Italy (IT), Latvia (LV), Luxemburg (LU), Malta (MT), the Netherlands (NL), Portugal (PT), Slovak Republic (SK), Slovenia (SI), and Spain (ES).[3]

Instead of considering the total amount of revenues and an average tax rate, we distinguish between three different type of taxes: the direct taxes on Capital (CT) and on Labour (LT) and the indirect Value Added Tax (VAT) and their respective tax revenues. The CT is imposed upon firms' profits; LT upon individuals' remuneration; and VAT as a form of consumption tax. These three taxes represent the most important revenues for government accounts (together, about 90% of all tax revenues for the central state).

The tax rates and the amount of taxation revenues collected *per* country is observed yearly, from 1995 to 2012 for CT and LT and between 2000 and 2012 for VAT, and the source is the publication *Taxation Trends in the European Union 2014* from the Eurostat Statistical Books. For Germany we also used data from DataStream for CT and LT, since Eurostat does not have information for the period between 1995 and 2000. The German economy is one of the largest in the Eurozone and for that fact we had to use a different data source, not to lose data for this country. The total number of observations is 234 and 324 for the VAT ($n = 18$ countries over

[2] Lithuania joined the Eurozone in 2015, but we decided to analyse the countries that were there at the end of 2014, to be coherent with our data collection.

[3] All the countries' abbreviations follow the official EU eurostat, which are presented at the following link: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Country_codes

$T = 13$ years) and CT and LT ($n = 18$ countries over $T = 18$ years), respectively.

We estimate the models using the period 1995-2011 for CT and LT ($T = 17$) and 2000-2011 for VAT ($T = 12$), retaining the observations on revenues and taxes for 2012 for all countries for the following purpose: to compare our estimated optimal tax rates with the effective tax rates in the last year available. This is not intended to be a standard forecasting exercise but rather to position the most recent tax policy of each country to the estimated Laffer Curve based on information available thus far. In particular, we want to infer how efficient the 2012 policy was by comparing it to the optimal estimated tax rates.

This study also distinguishes between nominal and real tax revenues in order to extract the effect of price levels from the tax revenue data. We used the GDP deflator – Price Deflator of the Gross Domestic Product at Market Prices (PVGD), base year 2005, from Eurostat – to convert the nominal into real tax revenue series, for each of the three tax types.

As is widely known, even though the Eurozone countries share a common currency, the tax rates observed over time vary greatly across countries. In fact, the tax rate barely changes in some countries whereas in others it fluctuates quite often and, at the same time, the tax burden is much higher in some cases when compared to others. For estimation and inference purposes, we dropped the countries whose rates take at most two different values for the time period under analysis. Thus, our empirical study is limited to $n = 6$ countries (72 observations) for VAT (CY, EL, IE, LV, PT, SK); $n = 15$ countries (255 observations) for CT (CY, EE, FI, FR, DE, EL, IE, IT, LV, LU, NL, PT, SK, SI, ES); and $n = 13$ countries (221 observations) for LT (BE, EE, FI, FR, DE, EL, IE, IT, LV, LU, PT, SK, ES). The countries' tax descriptive statistics, including the minimum (min), the average (ave), the median (med), and the maximum (max), are in Table 1.

< Table 1 about here >

Regarding VAT, the highest observed rate averages are for IE, SK, and PT at around 21%/20% and the lowest is for CY (14%). For CT the highest average rates are for DE, IT, FR, EL, ES, LU, PT, and NL, ranging between 42% and 32%, while the lowest are for CY, LV, IE, SI, EE, SK, and FI, between 18% and 27%. In the case of LT most countries have an average tax rate above 40% (with a maximum of 56.7% for BE), while only three countries, EE, LV, and SK, have a rate below this threshold, with 24.3%, 24.9%, and 30.7%, respectively. For the cases of both the CT and LT, Eastern European countries have the lower tax rates, while Western

Europe countries have the higher ones.

In Tables 2, 3, and 4 we present the pairwise countries' tax rates sample correlation coefficients for VAT, CT, and LT, respectively.[4]

< Table 2 about here >

Table 2 shows the correlation coefficients for the VAT rates. SK presents negative correlations because it has been decreasing its rate, contrary to all other countries. LV has high positive correlations with EL and PT, the countries which suffered the most with the financial and sovereignty debt crises. CY and IE, two countries also troubled by financial crises, share a high positive correlation (0.62), as well as CY and PT (0.79), CY and EL (0.38), and IE and PT (0.45), all countries affected by some type of crisis in the recent past. VAT rates time-series for Eurozone countries seem to be significantly affected also by their economic and financial conditions moving together when they are in the same situation, as is the case of CY, EL, IE, and PT, which suffered some kind of crisis that led to an austerity phase.

< Table 3 about here >

Table 3 exhibits the results of the sample correlation coefficients for CT rates. For all countries, except Finland, correlations are above 0.5. CT rates in these countries have been declining, sometimes in a very extreme way, especially for Eastern European countries.

< Table 4 about here >

In Table 4 we can see the sample correlation coefficients for LT rates. Correlations are high, as with the CT rates, with most countries also showing a downward trend, but with more exceptions. In particular, PT has negative correlations with almost every country besides EL and LV. EL and LV in turn have positive yet low correlations with all countries (except the negative correlation between EL and EE). Contrary to what happens with the CT, the LT rates were affected by the financial and economic conditions, especially in PT. The LT rate has much greater oscillations than the other two tax rates.

[4] We did not test for its statistical significance because the time series are not long.

3.2 Methodology

According to Wanniski (1978), the Laffer Curve represents a non-linear relationship between tax revenue and tax rate, usually represented by a concave quadratic function. In the traditional baseline model, empirical estimations of the Laffer Curve use only the tax rate as explanatory variable and the tax revenues as the dependent variable

$$Rev = a + bTax + cTax^2, \tag{1}$$

where "a", "b" and "c" are unknown coefficients, "Rev" represents the tax revenues and "Tax" the tax rate, in percentage. According to theory, the existence of a Laffer Curve requires a negative and significant value for the coefficient "c" and a positive value for the coefficient "b". Moreover, we impose the restriction $a = 0$ because, by definition, no Revenues can be obtained for a tax rate of zero.[5] Previous empirical estimations have followed the same assumption, as in Hsing (1996) and Heijman and van Ophem (2005). The optimal tax rate, in the sense of maximizing the tax revenues that a given state can collect, is $Tax^* = \frac{-b}{2c}$ and the corresponding optimal tax revenue $Rev^* = -\frac{b^2}{4c} = \frac{b}{2}Tax^*$.

The purpose of this paper is to draw conclusions related to the Laffer Curve estimated for the Eurozone countries. By the fact that the countries share a common currency, our modelling strategy takes into account the cross-countries' dependencies and at the same time allows for distinct Laffer Curves at the countries' level, since countries have some fiscal sovereignty, thus refuting standard panel-data techniques. Both hypotheses are accordingly tested. Note that using a system of country-specific equations enlarges the dimension of the sample and increases the variability of the observed values for the variables of interest in the model.

The benchmark econometric specification is the parametric SUR model

$$Rev_{it} = b_i Tax_{it} + c_i Tax_{it}^2 + u_{it}, \qquad \text{(country) } i = 1, ..., n, \qquad \text{(time period) } t = 1, ..., T, \tag{2}$$

where $\beta = \left(\beta_1', ..., \beta_n'\right)' = (b_1, c_1, ..., b_n, c_n)'$ is the model's coefficients and u is the unobservable error term that accounts for the informal economy, for instance, and that satisfies the usual assumptions in regression analysis. We consider two estimation procedures. For the first one - Feasible Generalized Least Squares (FGLS) - there is cross-section dependence across coun-

[5] Preliminary SUR estimation results show that $a = 0$ has strong empirical support. The results are available upon request.

tries but no serial correlation, and the second estimator (FGLS(ar1)) preserves cross-country interactions besides time dependence (AR(1) type). To infer about the statistical validity of our model, we consider two specification tests. First, we test for (no) cross-sectional dependence, $Cov\left(u_{it}, u_{jt}|X\right) = 0, i \neq j, \forall t$, and, second, we test for (no) country-specific heterogeneity, $\beta_1 = ... = \beta_n$. For further details about estimation and inference in parametric SUR models, see Zellner (1962), Pesaran *et al.* (2008) and the textbooks by Hayashi (2000) and Greene (2011), among others.

4 Results

In this section we provide the results for the FGLS and FGLS(ar1) estimations and present a discussion on their implications, based on the baseline model for the Laffer Curve. To strengthen our conclusions and analyse the Eurozone as a whole, we also compute Wald test statistics[6] for the equality of two countries' optimal maximum tax rates using the consistent FGLS formula, thus avoiding the risk of assuming a possibly misspecified AR(1) model for the error terms. The corresponding null hypothesis is the nonlinear function of the model's coefficients, $\frac{-b_i}{2c_i} = \frac{-b_j}{2c_j}$ for any pair of countries (i, j), where $i \neq j$. After discussing the results, we infer the efficiency of the 2012 policy in light of the in-sample estimations. We analyse the three types of taxes separately and, for each, the differences of using real and nominal revenues. In italics we highlight the estimates that match the conclusions drawn from the Durbin-Watson (DW) statistic that tests for AR(1)-type errors. Table 5 provides the results for the LM and W test statistics. All pvalues are below 0.012, which confirms the existence of cross-country dependencies and country-specific heterogeneity, thus giving full support to our choice of model specification: the SUR.

< Table 5 about here >

4.1 Estimation of the SUR models

Tables 6 and 7 present results for VAT, Tables 8 to 10 for CT, and Tables 11 to 13 for LT. In Tables 6, 8, and 11, whenever we write "min", we are stating that the estimation presents a U-shaped relationship and not an inverted U (parabola), i.e., the parameters have the wrong sign.

[6] We used a 10% significance level.

VAT The results for the estimations for VAT are in Table 6.

<Table 6 about here>

In Table 6 we can see that for EL and SK (both nominal and real revenues) and for PT (only for real revenues) we obtain a maximum rate, i.e., there is an inverted U-curve (parameter b has a positive sign and parameter c has a negative sign), which is in accordance with the Laffer curve theory. For CY the maximum is not statistically significant. The remaining two countries (IE and LV) have a U-shaped relationship between rates and revenues, i.e., opposite to what was expected. Comparing nominal and real revenues, the optimal rates for SK are about the same, whereas their difference for EL is significant (26% nominal and 22% real). Of the three countries, SK has the smallest optimal rate (13%, for nominal revenues) and PT the highest (35%, for real revenues). EL is somewhere in between the two. In Table 2 of the Data section (sample correlations) we notice that for the countries that have a significant maximum in Table 6, i.e., EL, PT, and SK, the correlation between SK and both EL (-0.36) and PT (-0.70) is negative, while between EL and PT it is positive (0.73).

Table 7 corroborates the results of the previously mentioned tables. One cannot reject the hypothesis of the optimal tax rate for EL and PT being equal, while for the pairs SK and EL and SK and PT, the tests show strong evidence that they are different. In fact, SK presents an optimal tax rate of 14.62%, which is much smaller than EL and PT, 22.18% and 29.02% respectively. VAT tax rates in SK have been falling during the sample period, while for EL and PT have been rising, mainly due to the troika intervention and their demands for fiscal austerity.

< Table 7 about here >

CT Table 8 presents the estimation results for the CT.

< Table 8 about here >

For most of the countries, and according to the FGLS, the signs of the parameters exhibit what theory demands for the existence of a Laffer Curve and hence a maximum can be computed, except for FI and DE, where a minimum is achieved. Using the FGLS (ar1) estimator, for FI, NL, SI, and ES, the maximum is not statistically significant. The case of DE is clearly rejected in both estimators.

The optimal rates using nominal or real revenues are quite similar for CY (17%), EE (15%), IE (21%), IT (31%), LV (15%), and SI (14%), based on the FGLS. For the remaining countries, the optimal rates are greater using real revenues: FR (26% versus 30%), EL (25% vs 28%), LU (24% vs. 27%), NL (30% vs. 50%), PT (24% vs. 27%), SK (25% vs. 29%), and ES (25% vs. 31%). The same occurs for the FGLS (ar1) estimator, except for the case of SK, where nominal and real revenues give similar optimal tax rates (29%). By ranking the optimal taxes across the countries, one sees that in general the smaller occur amongst Eastern European countries, like EE, LV, and SI, while the larger are in Western European economies, such as IT, NL, and FR. For the CT, Tables 9 and 10 present pvalues of the Wald test for equality of two countries' optimal tax rates, for nominal and real revenues values. Although we see from Table 3 (Data section) that sample correlations for the countries under study are all above 0.5, the Wald tests for equality show that very few pairs of countries have the same optimal tax rate. For nominal revenues, we have evidence of equality of the optimal rates between ES and SK (pvalue of 0.88), ES and EL (0.86), ES and PT (0.67), ES and LU (0.62), and ES and FR (0.51). Moreover, for PT, we have additionally: PT and LU (0.71), PT and EL (0.39), and PT and SK (0.12); for EL: EL and SK (0.51) and EL and LU (0.29); and for EE: EE and LV (0.72) and EE and SI (0.48). Finally, FR and SK (0.24), NL and IT (0.31), and SI and LV (0.98).

As a general conclusion, it appears that Eastern European countries present similarities (EE, LV, SI), while Western European countries also share some resembles in terms of optimal tax rates (ES, EL, FR, LU, PT). The exception is SK, which shares similarities with PT, FR, EL, and ES. The results of the Wald tests using real revenues are very similar, but the pairs (EE, SI), (NL, IT), (SK, EL), and (SK, PT) no longer share the same optimal tax rate. Additionally, there is a new pair of countries sharing the same optimal tax rate for CT: (ES, IT) with a pvalue of 0.64.

< Table 9 about here >

< Table 10 about here >

LT The results for the LT can be found in Table 11.

< Table 11 about here >

For the FGLS estimator, we **obtained** a maximum tax rate for all countries, except LV and PT. For the FGLS (ar1) a minimum is computed for LV and LU (nominal). The optimal rates using nominal or real revenues are about the same for FI (39%), EL (31%), and LU (33%) in the case of the FGLS estimator, adding BE (49%) and ES (55%) for the FGLS (ar1). With the exception of EL and IT (FGLS (ar1) estimator), optimal rates using real revenues are greater than with nominal. With respect to EL, 37% (nominal) compares to 35% (real) and in IT, 45% to 41%. Clearly, Western European countries, like DE, BE, FI, ES, LU, PT, and FR have the highest optimal rates, in some cases, well above 50%. The smallest rate is by far in EE, an Eastern European country.

Analysing the results for the tests for equality of two countries' optimal tax rates in Table 12 (nominal revenues), we notice that we have several pairs of countries with large pvalues, such as (FR, FI) with 0.87, (LU, IT) with 0.56, (SK, IE) with 0.19, and (ES, EL) with 0.44. Table 13 has results similar to those in Table 12, although it includes further pairs of countries with similar maximum tax rates, such as (EL, IT), (EL, LU), (EL, SK), (SK, IT), (SK, LU). But again, with the exception of SK (with some countries), there is a divide between Western European economies and Eastern European ones.

< Table 12 about here >

< Table 13 about here >

4.2 Efficiency of the 2012 Tax Policies

In this section we further discuss our results by summarizing the main conclusions drawn from the estimated Laffer Curves and, from that, draw some inferences about the adoption of the 2012 fiscal policy by the Eurozone member countries during the course of the Stability and Growth Pact and all the other fiscal and surveillance mechanisms. We consider the 2012 fiscal policy to be "inefficient" if the observed tax rate is greater than the estimated optimal one - the prohibitive range of the Laffer Curve. Consequently, "inefficiency" will translate into collected tax revenues that are less than optimal.

Regarding this notion of "efficiency", two remarks are worth mentioning. First, when the observed tax rate is smaller than the estimated optimal one it may as well be considered "economically inefficient", but that may follow from authorities targeting a "welfare efficient" situation.

Given the shape of the Laffer Curve, it should not be indifferent for policy makers to choose between the two distinct tax rates that give the same amount of revenues. Secondly, measuring "efficiency" by evaluating the tax rates is not the same as doing so by using the tax revenues. We believe that comparing tax rates is more accurate. The optimal rate is the maximum of a (revenues) function, whereas the optimal revenue includes other determinants besides the tax rate. That is, by definition the difference between the observed revenue and the optimal revenue is equal to the model's residual at the optimal tax rate.

Concerning the VAT and both nominal and real estimations, results for countries that have estimated (and significant) parameters' signs according to the Laffer curve theory - EL, PT, and SK - show that SK is setting its tax rate in the prohibitive range of the Laffer curve, when we compare our estimations of the optimal rate with the standard VAT rates in year 2012 (Figure 1). EL is doing the same using real revenues, whereas EL (for nominal revenues) and PT (for real revenues) are below the optimal tax rate. As a consequence, SK and EL (real) will probably face severe difficulties if they have to increase their tax rates, because there is a strong possibility of tax revenues decreasing. In fact, when we look at the evolution of the difference between the estimated optimal revenue and the revenue collected, in Figure 2, we see that SK shows a closing of the gap. For EL and PT we see the same until 2007, then an increase until 2009, and thereafter EL exhibits a drop in 2010 but increases the gap again and PT shows a closing of the gap again. Especially for EL, which shows a tax rate (with real revenues) in the prohibitive range of the Laffer curve (possibly caused by the troika impositions, and because the country has faced difficult circumstances in terms of fiscal and budget policy in the last years), these conclusions may indicate that EL has little, if any, degree of freedom in terms of this tax.

< Figure 1 about here >

< Figure 2 about here >

For 13 of the 18 Eurozone member countries, we have significant parameters with the expected estimated signs according to the Laffer curve theory, for corporate taxes (CT). Of these 13 countries, 5 present simultaneously, in nominal and in real terms, evidence that their tax rates in 2012 are located in the prohibitive range of the Laffer curve - EE, FR, LU, SI, and PT. For the estimations using nominal values, IT, LV, and ES also have tax rates located in the prohibitive range. Based on these results, we can infer that more countries are located out of the prohibitive zone. However, our results also show very different fiscal policies for each member country (e.g., some influenced by the sovereignty crisis and the fiscal austerity measures then imposed by the troika, which led to an increase in CT rates, as in the case of PT, which has the rate in the prohibitive range of the Laffer curve). Results are shown in Figure 3. Countries like CY (10%), EL (20%), IE (12.5%), NL (25%), and SK (19%) have the possibility of increasing corporate taxes, since the observed tax rate in 2012 (in parentheses) is very far away from the estimated optimal tax rates. The fact that many countries are out of the prohibitive range of the Laffer curve is also shown in the evolution of the gap between the estimated optimal revenue and the collected revenue, averaged across countries. Although we observe a closing trend, the gap presents a more cyclical behaviour, as we can see from Figure 4.

< Figure 3 about here >

< Figure 4 about here >

For labour taxes, 12 countries exhibit the expected signs for the parameters according to the Laffer curve theory. Compared to the CT, more countries are located in the prohibitive range in 2012, especially the estimations using nominal revenues, as we can see in Figure 5. BE (54%), FI (49%), EL (49%), IE (48%), and IT (47%) are always in the prohibitive range (nominal and real). For EL, a possible cause for being in the prohibitive range of the Laffer curve is the troika impositions. For all other countries, situations vary. For nominal revenues, EE, FR, and LU are also in the prohibitive range of the Laffer curve. DE, PT, SK, and ES present flexibility in terms of the possibility of tax increase for LT. SK is the only country that presents flexibility in terms of the possibility of tax increase in terms of both CT and LT. More countries located in the prohibitive range of the Laffer curve for LT compared to CT is also evident in Figure 6, in which we see a closing gap between the average estimated optimal revenue and the collected revenue.

< Figure 5 about here >

< Figure 6 about here >

As we can conclude from our analysis, fiscal policy is very diverse within the Euro area. In the context of the European and Monetary Union, these results show a different pattern per member, and in each member, per tax. In the current economic context, the discussion for the fiscal integration in the Eurozone, as a possible solution to remedy asymmetric shocks or sovereign debt problems, or a combination of them, will involve a deep restructuring of the fiscal system of each country and also a thorough analysis of the implications for the economic dynamics of each member country. A fiscal union can involve a solidary or competitive fiscal system or a combination of both, but any system is extremely hard to implement in a fiscal and economic environment such as the one in which the Euro area member countries exist.

5 Laffer Curve and the Level of Economic Activity

In this section we introduce the position of the business cycle as a possible influence in the level of tax revenues that the government can collect. The reason for choosing this variable among other possible explanatory variables is because it can shift the position of the Laffer Curve and potentially change the optimal tax rates. This also has an impact on the tax collection of the Government.

5.1 The Model Including the Business Cycle

The parametric SUR model representing the Laffer curve that extends the specification (2) to include differences over the position of the business cycle (BC_{it}) is defined as:

$$\begin{aligned} Rev_{it} &= b_i Tax_{it} + c_i Tax_{it}^2 + d_i BC_{it} Tax_{it} + e_i BC_{it} Tax_{it}^2 + u_{it} \\ &= \begin{cases} (b_i + d_i)\, Tax_{it} + (c_i + e_i)\, Tax_{it}^2 + u_{it} \text{ if } BC_{it} = 1 \\ b_i Tax_{it} + c_i Tax_{it}^2 + u_{it} \text{ if } BC_{it} = 0 \end{cases}, \end{aligned} \tag{3}$$

where $BC_{it} = 1$ if the economy i at time t is in an expansion or $BC_{it} = 0$ if it is facing a recession. In this paper we use the GDP to calculate the BC_{it} for each country i by means of the Hodrick-Prescott filter.

The model's coefficient is $\beta = \left(\beta_1', ..., \beta_n'\right)' = (b_1, c_1, d_1, e_1, ..., b_n, c_n, d_n, e_n)'$ and Rev_{it}, Tax_{it} and u_{it} are defined as before. We consider the same estimation procedures and specification tests defined in Section 3. The conditions for the existence of optimal rates under recessions and expansions follow from the discussion in Section 3. If they do exist, $Tax_0^* = \frac{-b}{2c}$ if $BC_{it} = 0$ and $Tax_1^* = \frac{-(b+d)}{2(c+e)}$ if $BC_{it} = 1$, which are equal if $d = e = 0$. Thus, the standard test of joint statistical nonsignificance of $d = 0$ and $e = 0$ is important to determine whether optimal rates in expansions and recessions are necessarily different. On the other hand, for distinct optimal rates, the expected maximum revenue in an expansion is greater than the one in a recession if

$$-\frac{(b+d)^2}{4\,(c+e)} = \frac{(b+d)}{2}Tax_1^* > -\frac{b^2}{4c} = \frac{b}{2}Tax_0^*.$$

There are two issues with this model: first, the perfect colinearity in the cases of $BC_{it}Tax_{it}$ is constant for the nonzero entries (*i.e.,* same rates for all t at the expansion regime). Second, the optimal rates in recession and in expansion are equal if $\frac{e}{c} = \frac{d}{b}$, even for $d, e \neq 0$ (this is a sort of identification problem). In theory, it is possible that for any fixed rate, expansions have higher revenues than in recessions with both optimal rates equal ($d_i Tax_{it} + e_i Tax_{it}^2 > 0$). The alternative is imposing $d = 0$ or $e = 0$, but in either case the optimal rate in expansion is higher than in recession, which may go against economic theory.[7] For $d \neq 0$ and $e \neq 0$, we can have expansions with higher revenues than in recessions and optimal rates in expansions smaller than in recessions.

5.2 Results

We estimate the model (3) including all countries for which we found statistically significant parameters and with the expected signs according to the Laffer curve theory, in Section 3. Table 1 (in Section 3) contains the results for the LM and W test statistics and we can conclude that there are cross-country dependencies and country-specific heterogeneity in all cases, except for the CT using real revenues. In this situation we cannot reject the assumption of no cross-sectional dependence.

All the results for the VAT are uninteresting: for EL, we found minimums; for PT, d and e are not statistically significant meaning that there are no differences in regimes (see Section 3 results in this case); and for SK we have no results due to perfect colinearity in the model (see explanation above).

The results for the CT are in Table 14.

< Table 14 about here >

There are no differences in regime for CY, EL, and LU. When differences exist, they are in

[7] If $d = 0$, and with $c < 0$ and $b > 0$ (existence of maximum in recessions), we need $e > 0$ (expansions have higher revenues) which implies that the optimal rate in expansion is higher than in recession (also need $|e| < |c|$ so that the maximum exists, $c + e < 0$). If $e = 0$, we need $d > 0$ (expansions have higher revenues) which implies an optimal rate in expansion higher than in recession.

the majority of the cases of a higher optimal rate during recessions. The only case in which the optimal rate in expansions is greater than the one in recessions is for SK. Moreover, when differences do exist, the optimal rates of Section 3 are in general values that lie between the two estimated rates for recessions and expansions (as mentioned before, the latter is the smaller). This fact makes sense in terms of estimating econometric models. The cases in which this does not happen are EE, LV, and PT, all smaller than in Section 3 (SK is also smaller). Note as well that for ES a minimum is attained and for NL the estimated optimal rate has no economic meaning. Both cases happen during recessions and using real revenues.

For the LT, the results can be found in Table 15.

< Table 15 about here >

For PT there is no Laffer curve because a minimum is attained in both regimes. Again, we find no differences in regime for a reasonable number of countries, namely, FR, IT, DE, IE, LU, and SK, the last four using real revenues. For the remaining cases, there is a higher optimal rate during recessions, except for BE. Also, when differences exist, the optimal rates of Section 3 lie between the two estimated in this Section for FI, EL, and SK. The rates of Section 3 are larger for BE, EE, IE, and ES. Finally, we observe a few number of cases in which the optimal revenue during expansions is smaller than the optimal revenue during recessions: BE, DE, and LU, all using nominal revenues.

6 Conclusions

Using a single and coherent tax database containing a panel of 18 Eurozone member countries observed from 1995 to 2011, we estimate Laffer Curves for direct and indirect taxes that contribute the most to the government tax revenue. We estimate them for each country under the SUR specification, thus preserving the dimension of the panel data, for corporate taxes (CT), labour taxes (LT), and value added taxes (VAT), in both nominal and real tax revenues.

According to the Laffer curve theory, the expected signs of parameters "b" and "c" are positive and negative, respectively. We find significant estimated parameters that **are an indication of** a Laffer's curvature for the VAT for Greece, Portugal, and Slovakia and for the majority of the Eurozone member countries for the direct taxes - 13 for CT and 12 for LT. **The estimations for the direct taxes are for the period 1995-2011, and for the VAT are for 2000-**

2011. From our estimated significant parameters, which have the expected signs according to the Laffer Curve theory, we obtained a maximum/optimal tax rate for VAT for Greece, Portugal, and Slovakia. Specifically, the maximum tax rate for Slovakia is about the same, either using nominal or real values (between 13.4% and 15.6%), while for Greece there is a higher difference between nominal and real (the maximum tax rate goes between 22% for real values and 26% for nominal values). Portugal has the highest maximum tax rate (in real terms), around 35%. For the majority of the Eurozone member countries and for the direct taxes, a maximum tax rate was also found. For CT, by ranking the optimal taxes across countries, one sees that in general the smaller occur amongst Eastern European countries, like Cyprus (17%), Estonia (15%), Latvia(15%), and Slovenia (14%), while the larger are in Western European economies, such as Italy (31%), the Netherlands (30 vs. 50%), and France (26& vs. 30%). Finally, for the LT, either in nominal and real revenues, clearly, Western European countries, like Germany (54.4%-67%), Belgium (39.2%-48.8%), Finland (37.1%-43%), Spain (32.6%-54.8%), Luxemburg (30.7%-64.1%), Portugal (62.3%-65.8%), and France (37.1%-56.5%) have the highest optimal rates, in some cases, well above 50%. The smallest rate is by far in Estonia (14.7%-22.9%), an Eastern European country.

We also perform Wald tests for the equality of a given pair of countries' optimal maximum tax rates. We conclude that, especially for CT and LT, there is a strong divide between the values of the optimal tax rates for Eastern European countries and Western European economies and that the economic and financial conditions of each country also influence the value of these tax rates, taking as an example the troika impositions for countries like Greece and Portugal. We also take into consideration the position of each economy in the business cycle. For corporate taxes, Cyprus, Greece, and Luxembourg do not present differences in regime. When differences exist, optimal tax rates are higher during recessions (except for Slovakia). For individual income taxes (labour taxes) the same occurs. There is no difference in regime for France, Italy, Germany, Ireland, Luxembourg, and Slovakia. For the remaining countries (except Belgium), the optimal tax rate is higher during recessions. Results for VAT do not have economic meaning.

In the context of the recent Stability and Growth Pact and all the other fiscal and surveillance mechanisms, we compared the tax rates observed in 2012 to the estimated optimal tax rates with the intent of inferring if the 2012 fiscal policy adopted was in some sense "efficient". In particular, we looked at the cases in which the policy was "inefficient" because the 2012 tax rate was located at the prohibitive range of the Laffer Curve: In these cases, if authorities need to raise taxes, it is expected that revenues will decrease! We conclude that for the VAT, Slovakia is in the prohibitive zone and that more countries are in that zone for the LT compared to the CT. These results, for some of the countries, like Greece and Portugal, can also be caused by the troika impositions to raise indirect and direct taxes, which led the countries into the prohibitive range of the Laffer curve. Strong evidence of cases in which the 2012 rate is smaller than the estimated optimal one include Cyprus, Greece, Ireland, Netherlands, and Slovakia for the CT and Germany, Portugal, Slovakia, and Spain for the LT. That is, Slovakia is the only "efficient" country in both CT and LT.

Stringent austerity measures were recently put in practice in some Eurozone countries due to high levels of debt and budget deficits. In particular, Greece, Ireland, and Portugal all received massive bailouts from the EU and the IMF. Countries such as Spain, Italy, and France also had to cut state spending and raise taxes. What we conclude from our results is that raising taxes in the period 2012-2018 is likely to be ineffective for Greece (using VAT and LT), France (CT), Portugal (CT), Ireland (LT), and Italy (LT) as it leads to a decrease in tax revenues, thus not helping to cut deficits. On the contrary, Greece and Ireland are advised to raise corporate taxes. For Spain there is no strong evidence on what to do. Our results are also important for the discussions about fiscal harmonization/union in the context of the Eurozone, since they exhibit important disparities between countries and between taxes. Fiscal policy is very diverse within the Euro area, for each country and for each tax. This diversity implies a greater difficulty in implementing any type of fiscal policy rule, discipline, harmonization, or a combination of all three.

An interesting line for future research includes specifying the Laffer Curve through semiparametric models. In particular, we suggest extending the original parametric relationship between tax rates and tax revenues by including a component with an unknown functional form, $m(\cdot)$. By not choosing a full nonparametric model, one is less exposed to obtaining multiple optimal rates, which would go against the original claim by Wanniski (1978). The semiparametric SUR model and its estimation can be found in Wang (2012, 2015) and Ullah and Wang (2014). The estimation procedures include the local linear least squares estimator and the local linear weighted least squares estimator. A Bayesian approach can be found in Koop et al. (2005), for example. The estimation of the Laffer Curves using this semiparametric SUR model is quite challenging when the number of cross-sections is large, as is the case for the EU. Due to the existence of a nonparametric part in the model, the estimation of the revenue function implies fixing the value for Tax at which one estimates $(m(\cdot), \beta)$. In this SUR specification, Tax is not a scalar but a vector of the size of the total number of countries in the model, which is quite large!

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Table 1: Tax Rates Descriptive Statistics

	VAT				CT				LT			
	min	**ave**	**med**	**max**	**min**	**ave**	**med**	**max**	**min**	**ave**	**med**	**max**
BE	-	-	-	-	-	-	-	-	53.70	56.67	53.70	60.60
CY	10.00	14.00	15.00	15.00	10.00	18.23	15.00	29.00	-	-	-	-
EE	-	-	-	-	21.00	24.29	26.00	26.00	21.00	24.29	26.00	26.00
FI	-	-	-	-	25.00	27.29	28.00	29.00	49.00	53.55	52.20	62.20
FR	-	-	-	-	34.40	36.38	35.40	41.70	45.80	53.35	54.80	59.60
DE	-	-	-	-	29.80	42.30	38.70	56.80	44.30	50.81	51.20	57.00
EL	18.00	19.25	19.00	23.00	20.00	34.26	35.00	40.00	40.00	42.97	42.50	49.00
IE	20.00	20.96	21.00	21.50	12.50	20.38	12.50	40.00	41.00	43.35	42.00	48.00
IT	-	-	-	-	31.40	39.78	38.30	53.20	44.10	46.50	46.00	51.00
LV	18.00	18.33	18.00	21.00	15.00	19.76	19.00	25.00	23.00	24.94	25.00	26.00
LU	-	-	-	-	28.60	33.38	30.40	40.90	39.00	43.04	39.00	51.30
NL	-	-	-	-	25.00	31.56	34.50	35.00	-	-	-	-
PT	17.00	19.83	20.00	23.00	26.50	32.35	33.00	39.60	40.00	41.40	40.00	50.00
SK	19.00	20.17	19.00	23.00	19.00	27.05	25.00	40.00	19.00	30.70	38.00	42.00
SI	-	-	-	-	20.00	23.88	25.00	25.00	-	-	-	-
ES	-	-	-	-	30.00	33.67	35.00	35.00	43.00	47.82	45.00	56.00

Table 2: VAT Rates Sample Correlations

	CY	**EL**	**IE**	**LV**	**PT**	**SK**
CY	1.00					
EL	0.38	1.00				
IE	0.62	0.17	1.00			
LV	0.21	0.85	0.05	1.00		
PT	0.79	0.73	0.45	0.62	1.00	
SK	-0.90	-0.36	-0.53	-0.09	-0.70	1.00

Tables and Figures

Table 3: CT Rates Sample Correlations

	CY	EE	FI	FR	DE	EL	IE	IT	LV	LU	NL	PT	SK	SI	ES
CY	1.00														
EE	0.83	1.00													
FI	0.64	0.73	1.00												
FR	0.69	0.63	0.42	1.00											
DE	0.75	0.77	0.30	0.81	1.00										
EL	0.76	0.77	0.50	0.67	0.73	1.00									
IE	0.74	0.62	0.14	0.75	0.92	0.70	1.00								
IT	0.72	0.74	0.26	0.62	0.90	0.67	0.90	1.00							
LV	0.96	0.80	0.52	0.78	0.84	0.78	0.85	0.79	1.00						
LU	0.83	0.72	0.31	0.75	0.91	0.77	0.95	0.88	0.92	1.00					
NL	0.84	0.99	0.71	0.64	0.77	0.80	0.65	0.74	0.81	0.74	1.00				
PT	0.87	0.76	0.41	0.88	0.88	0.71	0.92	0.86	0.96	0.93	0.78	1.00			
SK	0.80	0.71	0.31	0.92	0.92	0.75	0.96	0.85	0.92	0.94	0.72	0.96	1.00		
SI	0.64	0.89	0.56	0.70	0.70	0.71	0.47	0.67	0.61	0.59	0.89	0.55	0.54	1.00	
ES	0.66	0.91	0.57	0.72	0.72	0.63	0.49	0.69	0.63	0.60	0.91	0.59	0.56	0.98	1.00

Table 4: LT Rates Sample Correlations

	BE	EE	FI	FR	DE	EL	IE	IT	LV	LU	PT	SK	ES
BE	1.00												
EE	0.71	1.00											
FI	0.85	0.72	1.00										
FR	0.85	0.94	0.79	1.00									
DE	0.90	0.70	0.89	0.82	1.00								
EL	0.41	-0.03	0.29	0.17	0.43	1.00							
IE	0.85	0.65	0.97	0.74	0.89	0.38	1.00						
IT	0.62	0.45	0.84	0.54	0.76	0.45	0.82	1.00					
LV	0.10	0.17	0.11	0.14	0.08	0.41	0.10	0.09	1.00				
LU	0.90	0.57	0.92	0.71	0.90	0.54	0.95	0.83	0.09	1.00			
PT	-0.48	-0.75	-0.52	-0.67	-0.44	0.51	-0.46	-0.14	0.14	-0.30	1.00		
SK	0.90	0.83	0.79	0.91	0.91	0.26	0.75	0.58	0.12	0.76	-0.56	1.00	
ES	0.85	0.67	0.96	0.77	0.87	0.37	0.93	0.81	0.11	0.90	-0.42	0.78	1.00

Table 5: Specification Tests (pvalues)

		LM	W
VAT Laffer Curve (Nominal)	FGLS	0.000	0.000
	FGLS(ar1)	0.000	0.000
VAT Laffer Curve (Real)	FGLS	0.011	0.000
	FGLS(ar1)	0.007	0.000
CT Laffer Curve (Nominal)	FGLS	0.000	0.000
	FGLS(ar1)	0.000	0.000
CT Laffer Curve (Real)	FGLS	0.000	0.000
	FGLS(ar1)	0.000	0.000
LT Laffer Curve (Nominal)	FGLS	0.000	0.000
	FGLS(ar1)	0.000	0.000
LT Laffer Curve (Real)	FGLS	0.000	0.000
	FGLS(ar1)	0.000	0.000
CT Laffer Curve with BC (Nominal)	FGLS	0.000	0.000
	FGLS(ar1)	0.002	0.000
CT Laffer Curve with BC (Real)	FGLS	0.327	0.000
	FGLS(ar1)	0.999	0.000
LT Laffer Curve with BC (Nominal)	FGLS	0.000	0.000
	FGLS(ar1)	0.000	0.000
LT Laffer Curve with BC (Real)	FGLS	0.000	0.000
	FGLS(ar1)	0.000	0.000

Table 6: VAT Laffer Curve

	FGLS				FGLS(ar1)					
	Nominal		Real		Nominal			Real		
	Max	Zero	Max	Zero	Max	Zero	DW	Max	Zero	DW
CY	min		min		_18.36_	36.72	0.56*	_25.70_	51.41	0.68*
EL	75.58	151.17	_22.18_*	44.36	_26.15_*	52.31	0.60*	23.50*	47.01	0.99
IE	min		min		_94.40_	188.80	0.82*	_min_		0.71*
LV	min		84.30	168.61	_min_		0.44*	_min_		0.61*
PT	_min_		_29.02_*	58.04	min		1.55	35.22*	70.44	1.61
SK	_13.38_*	26.76	_14.62_*	29.25	15.32*	30.65	1.09	15.60*	31.21	1.41

Note: * stands for statistically significant; _min_ stands for minimum

Table 7: VAT Wald Tests for Equal Optimal Rates, Real Revenues (pvalues)

	EL	**PT**	**SK**
EL	-		
PT	0.35	-	
SK	0.00	0.00	-

Table 8: CT Laffer Curve

	FGLS				FGLS(ar1)					
	Nominal		Real		Nominal			Real		
	Max	Zero	Max	Zero	Max	Zero	DW	Max	Zero	DW
CY	16.37*	32.75	16.98*	33.96	_22.39_*	44.78	0.62*	_23.27_*	46.55	0.65*
EE	14.18*	28.37	_15.55_*	31.10	_14.49_*	28.99	1.06*	15.79*	31.58	1.13
FI	min		min		_34.82_	69.65	1.02*	_140.35_	280.70	1.10*
FR	_26.18_*	52.36	_29.77_*	59.54	27.33*	54.66	1.35	39.49*	78.99	1.25
DE	min		min		_min_		0.92*	_min_		0.95*
EL	24.51*	49.03	27.79*	55.58	_32.59_*	65.19	0.80*	_40.09_*	80.18	0.64*
IE	20.48*	40.96	21.53*	43.06	_16.83_*	33.67	0.47*	_19.30_*	38.60	0.49*
IT	_30.97_*	61.94	_31.83_*	63.67	34.25*	68.51	1.28	36.92*	73.84	1.47
LV	14.45*	28.91	15.31*	30.63	_14.38_*	28.77	1.08*	_17.03_*	34.06	1.01*
LU	_23.83_*	47.66	_27.06_*	54.13	24.07*	48.15	1.38	26.99*	53.99	1.17
NL	29.67*	59.34	50.49*	100.99	_32.93_*	65.86	1.04*	_64.81_	129.63	1.09*
PT	_24.18_*	48.36	_26.82_*	53.65	25.94*	51.88	1.15	32.42*	64.84	1.15
SK	25.10*	50.21	29.05*	58.10	_28.90_*	57.81	0.51*	_28.48_*	56.97	0.59*
SI	14.06*	28.12	14.50*	29.00	_26.99_	53.98	0.31*	_63.83_	127.67	0.35*
ES	24.80*	49.61	31.07*	62.15	_1.66_	3.32	0.44*	_5.72_	11.44	0.50*

Note: * stands for statistically significant; _min_ stands for minimum

Table 9: CT Wald Tests for Equal Optimal Rates, Nominal Revenues (pvalues)

	CY	**EE**	**FR**	**EL**	**IE**	**IT**	**LV**	**LU**	**NL**	**PT**	**SK**	**SI**	**ES**
CY	-												
EE	0.00	-											
FR	0.00	0.00	-										
EL	0.00	0.00	0.07	-									
IE	0.00	0.00	0.00	0.00	-								
IT	0.00	0.00	0.00	0.00	0.00	-							
LV	0.00	0.72	0.00	0.00	0.00	0.00	-						
LU	0.00	0.00	0.00	0.29	0.00	0.00	0.00	-					
NL	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	-				
PT	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.71	0.00	-			
SK	0.00	0.00	0.24	0.51	0.00	0.00	0.00	0.08	0.00	0.12	-		
SI	0.00	0.48	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	-	
ES	0.00	0.00	0.51	0.86	0.01	0.00	0.00	0.62	0.00	0.67	0.88	0.00	-

Table 10: CT Wald Tests for Equal Optimal Rates, Real Revenues (pvalues)

	CY	**EE**	**FR**	**EL**	**IE**	**IT**	**LV**	**LU**	**NL**	**PT**	**SK**	**SI**	**ES**
CY	-												
EE	0.07	-											
FR	0.00	0.00	-										
EL	0.00	0.00	0.01	-									
IE	0.00	0.00	0.00	0.00	-								
IT	0.00	0.00	0.00	0.00	0.00	-							
LV	0.00	0.15	0.00	0.00	0.00	0.00	-						
LU	0.00	0.00	0.00	0.91	0.00	0.00	0.00	-					
NL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-				
PT	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.47	0.00	-			
SK	0.00	0.00	0.69	0.03	0.00	0.00	0.00	0.04	0.00	0.00	-		
SI	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	-	
ES	0.00	0.00	0.86	0.39	0.02	0.64	0.00	0.43	0.00	0.36	0.77	0.00	-

Table 11: LT Laffer Curve

	FGLS				FGLS(ar1)					
	Nominal		Real		Nominal			Real		
	Max	Zero	Max	Zero	Max	Zero	DW	Max	Zero	DW
BE	39.18*	78.37	45.65*	91.31	_46.52*_	93.04	0.61*	_48.76*_	97.53	1.07*
EE	14.72*	29.44	17.86*	35.72	_16.04*_	32.09	0.89*	_22.93*_	45.86	0.91*
FI	37.12*	74.24	_39.94*_	79.89	_38.71*_	77.42	0.87*	42.97*	85.95	1.23
FR	37.11*	74.23	40.84*	81.68	_46.67*_	93.34	0.77*	_56.54*_	113.08	0.67*
DE	54.35*	108.70	_67.14*_	134.28	_61.31*_	122.62	0.71*	66.42*	132.85	1.31
EL	29.66*	59.33	31.29*	62.59	_37.11*_	74.23	0.12*	_35.44*_	70.8	0.30*
IE	26.86*	53.72	30.35*	60.70	_30.74*_	61.49	0.70*	_39.19*_	78.39	0.77*
IT	29.98*	59.97	32.65*	65.31	_44.98*_	89.96	0.17*	_41.44*_	82.89	0.58*
LV	min		53.94	107.88	_min_		0.22*	_min_		0.30*
LU	30.70*	61.40	32.50*	65.01	_min_		0.05*	_64.13*_	128.27	0.15*
PT	min		min		_62.26*_	124.52	0.43*	_65.82*_	131.65	0.62*
SK	_27.71*_	55.42	32.30*	64.61	27.52*	55.05	1.27	_32.85*_	65.71	1.10*
ES	32.60*	65.21	36.75*	73.50	_53.06*_	106.12	0.51*	_54.76*_	109.52	0.65*

Note: * stands for statistically significant; *min* stands for minimum

Table 12: LT Wald Tests for Equal Optimal Rates, Nominal Revenues (pvalues)

	BE	**EE**	**FI**	**FR**	**DE**	**EL**	**IE**	**IT**	**LU**	**SK**	**ES**
BE	-										
EE	0.00	-									
FI	0.00	0.00	-								
FR	0.00	0.00	0.87	-							
DE	0.00	0.00	0.00	0.00	-						
EL	0.00	0.00	0.00	0.00	0.00	-					
IE	0.00	0.00	0.00	0.00	0.00	0.00	-				
IT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-			
LU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	-		
SK	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	-	
ES	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	-

Table 13: LT Wald Tests for Equal Optimal Rates, Real Revenues (pvalues)

	BE	**EE**	**FI**	**FR**	**DE**	**EL**	**IE**	**IT**	**LU**	**SK**	**ES**
BE	-										
EE	0.00	-									
FI	0.00	0.00	-								
FR	0.00	0.00	0.74	-							
DE	0.00	0.00	0.00	0.00	-						
EL	0.00	0.00	0.00	0.00	0.00	-					
IE	0.00	0.00	0.00	0.00	0.00	0.00	-				
IT	0.00	0.00	0.00	0.00	0.00	0.76	0.01	-			
LU	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.95	-		
SK	0.00	0.00	0.00	0.00	0.00	0.45	0.09	0.33	0.24	-	
ES	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-

Table 14: CT Laffer Curve with BC

	FGLS				FGLS(ar1)					
	Nominal		Real		Nominal			Real		
	Exp	Rec	Exp	Rec	Exp	Rec	DW	Exp	Rec	DW
CY	#	#	#	#	#	#	0.88*	#	#	0.94
EE	13.98*	14.19*	#	#	14.16*	14.46*	1.53	#	#	1.58
FR	23.95*	33.41*	26.73*	40.80*	24.52*	28.21*	1.51	26.50*	45.97*	1.71
EL	23.28*	25.02*	24.79*	33.10*	#	#	0.89*	#	#	0.73*
IE	15.47*	21.55*	16.77*	22.51*	14.79*	20.93*	2.11	16.05*	22.40*	2.11
IT	24.72*	31.17*	26.83*	32.95*	24.48*	32.78*	1.64	27.42*	35.25*	1.69
LV	13.14*	13.72*	13.75*	16.58*	13.42*	14.11*	1.18	13.76*	17.21*	1.72
LU	#	#	#	#	#	#	1.46	#	#	1.34
NL	25.28*	34.23*	31.86*	%	25.37*	45.20*	1.71	32.84*	min	1.96
PT	23.08*	23.89*	25.57*	26.47*	23.47*	25.87*	1.38	#	#	1.96
SK	23.61*	22.59*	26.82*	24.55*	23.51*	25.59*	1.00	25.95*	27.02*	1.38
SI	13.55*	14.50*	14.17*	17.03*	15.02*	22.64*	0.68*	16.07*	%	0.73*
ES	20.64*	32.79*	25.48*	min	24.00*	min	1.03	#	#	1.11

Note: * stands for statistically significant (d or e); #: d and e not statistically significant; *min* stands for minimum; % means no economic meaning (> 100 or < 0)

Table 15: LT Laffer Curve with BC

	FGLS				FGLS(ar1)					
	Nominal		Real		Nominal			Real		
	Exp	Rec	Exp	Rec	Exp	Rec	DW	Exp	Rec	DW
BE	& 40.67*	37.22*	47.90*	43.51*	#	#	1.11	&48.87*	43.06*	2.17
EE	13.94*	15.32*	15.80*	20.09*	14.47*	15.25*	1.39	16.71*	21.94*	1.48
FI	33.01*	37.30*	15.80*	41.14*	33.46*	38.38*	0.92	34.85*	41.33*	2.30
FR	#	#	#	#	&41.75*	37.55*	1.48	#	#	1.32
DE	#	#	#	#	& 63.90*	88.14*	0.63*	#	#	1.61
EL	24.14*	min	25.70*	46.28*	#	#	0.97	#	#	1.04
IE	24.59*	26.89*	#	#	#	#	1.04	#	#	1.06
IT	#	#	#	#	#	#	0.60*	#	#	0.91
LU	#	#	#	#	& 60.27*	70.83*	0.10*	#	#	0.24*
PT	min	min	min	min	min	min	0.86*	#	#	1.03
SK	26.13*	28.00*	#	#	28.05*	28.32*	1.12	#	#	1.16
ES	30.57*	33.90*	33.79*	39.28*	42.00*	49.96*	0.43*	40.43*	50.28*	0.54*

Note: * stands for statistically significant (d or e); #: d and e not statistically significant; *min* stands for minimum; &: Rev(Exp) smaller than Rev(Rec) at opt. rate

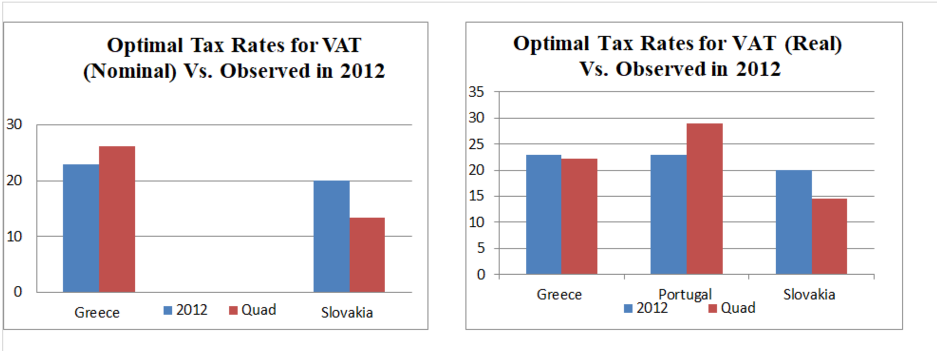

Figure 1 - Comparison Between the 2012 VAT Rate and the Estimated Optimal Rate

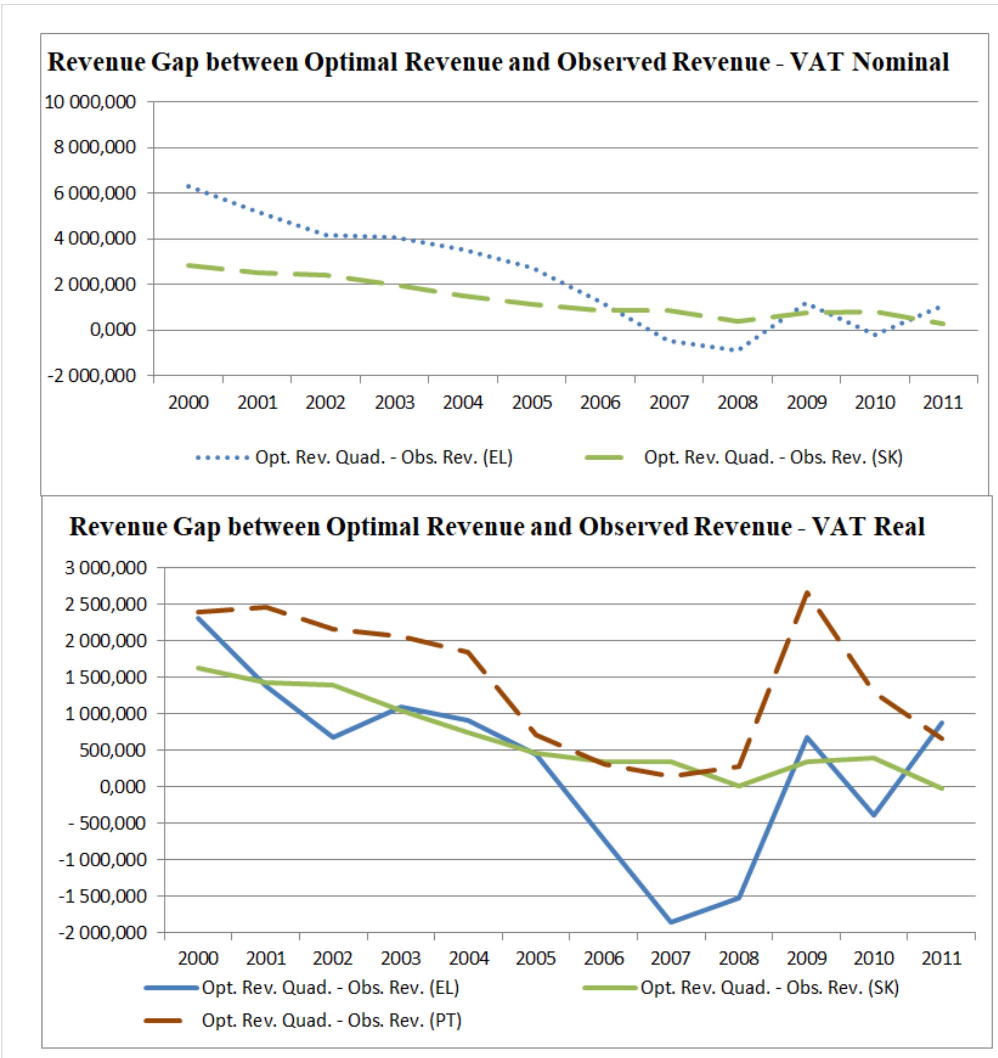

Figure 2 - Revenue Gap in VAT

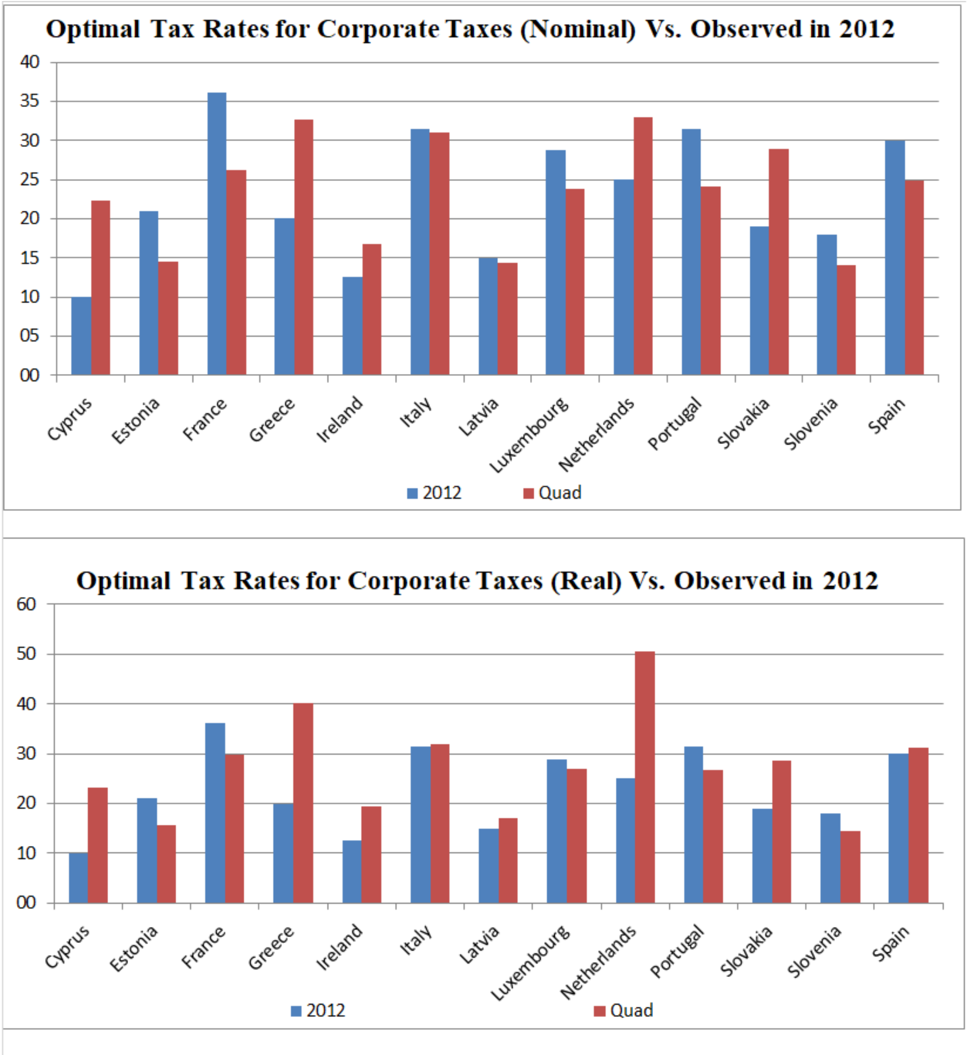

Figure 3 - Comparison Between the 2012 CT Rate and the Estimated Optimal Rate

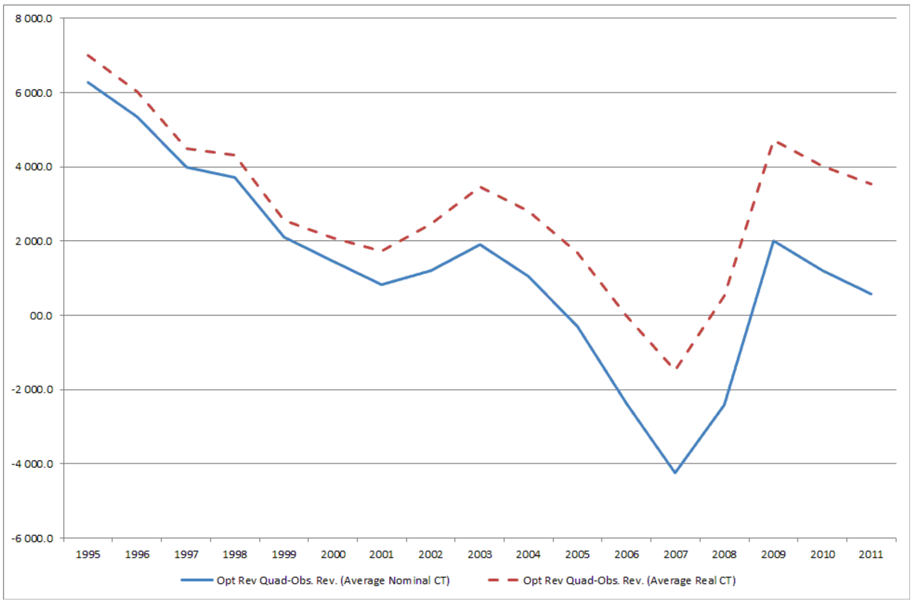

Figure 4: Average Revenue Gap for CT

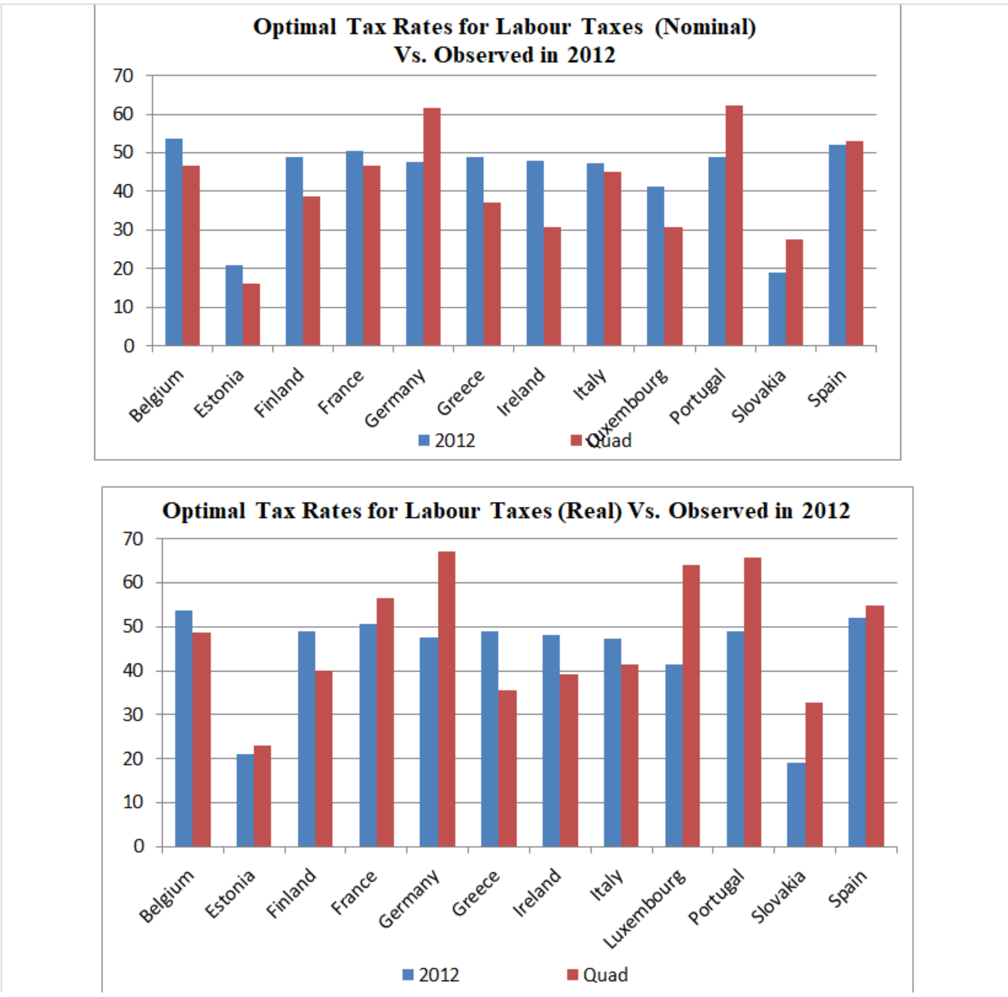

Figure 5 - Comparison Between the 2012 LT Rate and the Estimated Optimal Rate

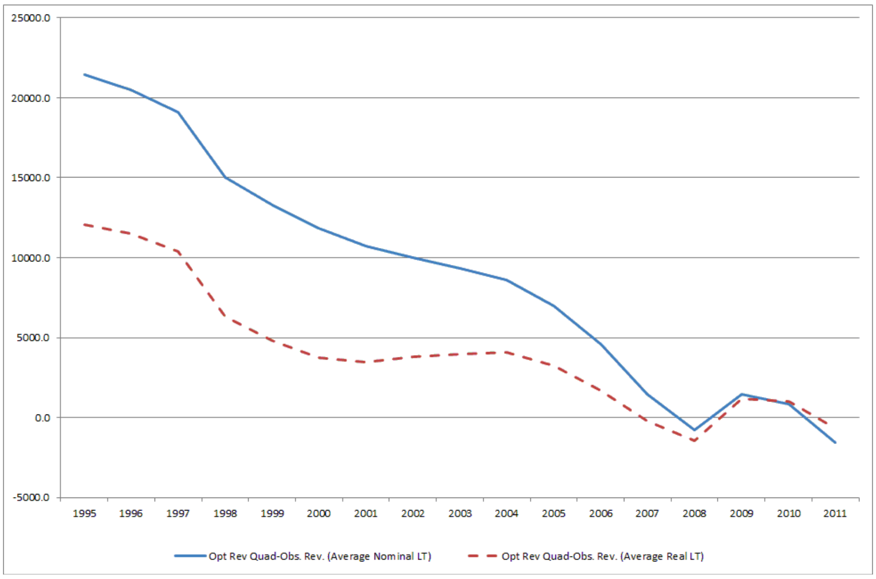

Figure 6: Average Revenue Gap for LT