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How Sensitive is Irish Income Tax Revenue to Underlying Economic Activity?

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Abstract: In this paper we examine the elasticity of Irish income taxation revenue with respect to aggregate national output – both GDP and GNP. This enables us to estimate the sensitivity of this key taxation aggregate with respect to changes in economic activity. It also allows us to compare the elasticity of income taxation across other jurisdictions where similar estimates are available. Understanding the elasticity of the different taxation components vis-à-vis their underlying economic activity should enable policy-makers to place the public finances on a more sustainable footing and hence avoid the sharp booms and busts which has characterized Irish taxation receipts over the past 20 years.

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Introduction

Even by international standards, the Irish taxation base experienced considerable fluctuations over the period from 2000 to the present. In the period preceding 2007, the era commonly referred to as the "Celtic tiger" saw the Irish exchequer enjoy significant returns across all the major tax headings. This was particularly reflected in the taxation receipts accruing due to activity in the Irish housing market where the volumes-based nature of the taxation system ensured that housing related taxation receipts increased substantially on a persistent basis.

The significant fluctuations in the Irish housing sector were mirrored to a large extent by movements in key aggregate economic variables; GDP in real terms, for example, grew by 45 per cent between 2000 and 2007 before contracting by 7 per cent between 2007 and 2010. Similarly, the unemployment rate, which had averaged just over 4 per cent between 2000 and 2007, shot up to nearly 14 per cent in 2010. Overall, as a result of the movements in these indicators, total taxation receipts increased by over 80 per cent between 2000 and 2007. Thereafter, the impact of the international financial crisis compounded by the collapse of the domestic housing market saw the same receipts fall by almost 36 per cent between 2008 and 2011.

While receipts from income tax were not quite as volatile as some of the other major tax categories, any significant movement in this item has profound implications for the state of the Irish public finances owing to its dominant share of the tax base (typically accounting for approximately 33 per cent). The Irish economy had exhibited particularly strong budgetary performances vis-à-vis other European countries in the lead up to the crisis; over the period 2005 to 2007 the Irish Government recorded a General Government (GG)[1] budget surplus in each year of 1.3, 2.8 and 0.3 per cent of GDP respectively, while the GG debt to GDP ratio had, in 2006, fallen to less than 24 per cent. However, the relative collapse in taxation

[1] *The GG balance figures for Ireland refer to the balance excluding the impact of the different banking capitalisation measures which took place. These were particularly large between 2009 and 2011 amounting to a cumulative 27.5 per cent of GDP.*

receipts precipitated an alarming deterioration in the Irish public finances with the debt to GDP ratio quickly escalating to a peak of 123 per cent in 2013. This collapse was also the main reason for the Irish state entering a programme of agreement with the International Monetary Fund (IMF), the European Central Bank (ECB) and the European Union (EU)[2] in late 2010.

In this paper we examine the elasticity of income taxation revenue with respect to aggregate national output – both GDP (i.e. income tax revenue-to-GDP elasticity) and GNP (i.e. income tax revenue-to-GNP elasticity). This enables us to estimate the sensitivity of this key taxation aggregate with respect to changes in economic activity. It also allows us to compare the elasticity of income taxation across other jurisdictions where similar estimates are available. Understanding the elasticity of the different taxation components vis-à-vis their underlying economic activity should enable policy-makers to place the public finances on a more sustainable footing and hence avoid the sharp booms and busts which has characterised Irish taxation receipts over the past 20 years. As we do not compute the income tax revenue-to-taxable income elasticity, we do not take into account the discretionary measures that occur to the Irish tax system in the period examined.

In modelling the sensitivity of income taxation we pay particular attention to the most appropriate measure of economic activity in an Irish context. This involves using Gross National Product (GNP) as well as Gross Domestic Product (GDP); in most jurisdictions, there is very little difference between these concepts, however, in an Irish context a significant difference emerges due to the relatively high level of multinational activity and subsequent repatriation of profits in the domestic economy.

An additional issue which we explore is the role that dis-equilibrium, in both the overall economy and the financial sector, can play in affecting the sensitivity of income taxation to economic activity. This is of particular importance in an Irish context given the significant fluctuations in both the general economy and the Irish credit market; from 2003 until 2007 the Irish economy experienced one of the most significant credit bubbles amongst OECD economies. We address this issue by including the related concepts of the standard output gap and the credit gap in our empirical specifications.

The significant deterioration in the public finances of many countries as a result of the financial crisis inevitably led to the adoption of measures seeking more sustainable public finances. At a European level, a range of initiatives have been undertaken over the past

[2] *Commonly referred to as the "Troika".*

number of years to strengthen the Stability and Growth pact. This has seen the emergence of more fiscal rules (with stricter caps on government spending and borrowing) and much greater levels of macroeconomic and fiscal surveillance. One of the main goals of the fiscal rules is to constrain discretion amongst policy-makers through setting explicit quantitative limits on relevant fiscal aggregates. Much of this work focuses on monitoring well-established fiscal and macroeconomic aggregates such as GDP growth, the GG balance, the government debt to GDP ratio and government expenditure and revenue aggregates.

While the range of measures initiated in the EU to strengthen fiscal frameworks are clearly important, as Addison-Smyth and McQuinn (2015) argue that they are not, in themselves, fully sufficient to identify underlying fiscal vulnerabilities. It is likely, for example, that the application of the current set of fiscal rules in an Irish context in the period immediately preceding the financial crisis would not have revealed the fiscal fragilities which self-evidently existed in the economy at that time. Therefore, it is necessary to complement the increasingly standard measures of assessing fiscal developments with the more granular approach presented here. Such an approach enables a deeper and richer assessment of the sustainability of taxation receipts.

The rest of our paper is laid out as follows; in the next section we document changes in Irish taxation revenues over the past 20 years, a following section outlines some of the relevant literature in this area, while an empirical section outlines the data used in the study, the modelling strategy and the results from the estimation. A final section offers some concluding thoughts.

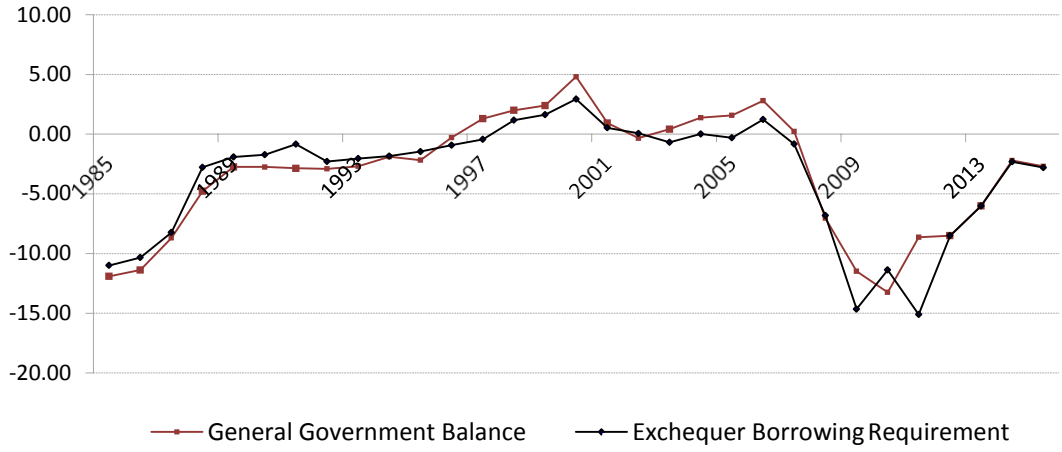
Recent Irish fiscal developments

Given the recent turbulent nature of the Irish public finances, it is useful to examine some of the key Irish fiscal indicators over the past 30 years. The GG budget balance and the debt to GDP ratios are plotted in Figures 1 and 2 respectively.[3] Over the past 30 years, there have been two acute periods of stress in the Irish fiscal accounts. In the mid 1980s, following on from poor policy responses to the oil shocks of the 1970s, the Irish public finances deteriorated considerably with growth in Government expenditure significantly outpacing that of growth in the general economy. From 1985 to 2002, the public finances steadily improved as the economy grew - the latter half of which included the Celtic Tiger era. From

[3] *The Exchequer borrowing requirement is also shown for completeness.*

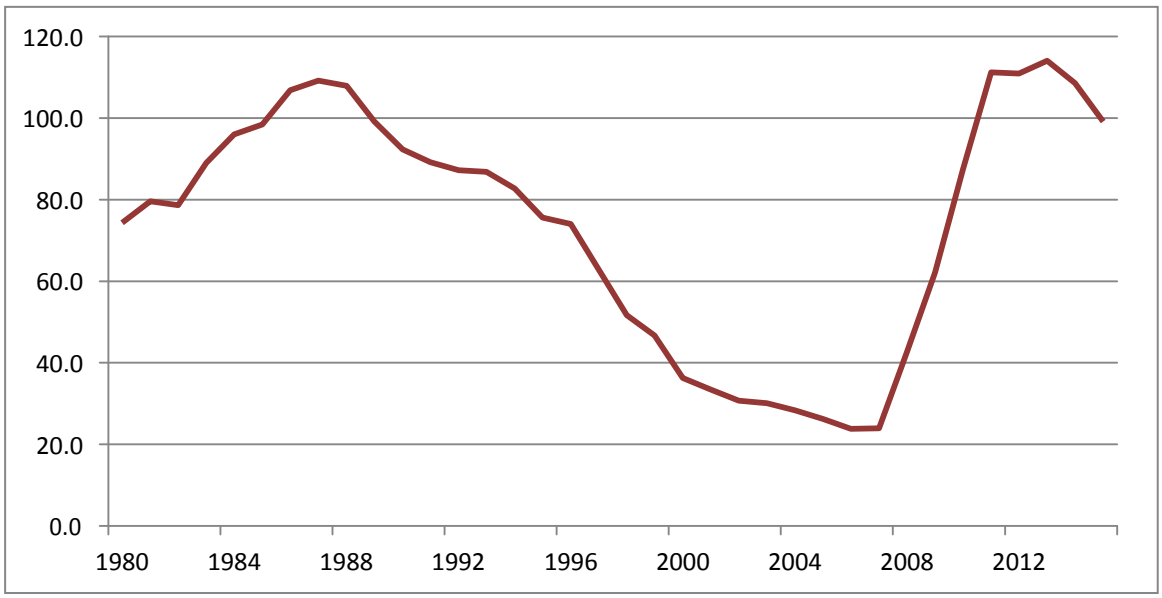
2003 to 2007, the fiscal position dramatically improved helped in part by the bubble in the housing market.

FIGURE 1 *Budget Balance Ratios (%): 1984 – 2015*



Source: Department of Finance.

FIGURE 2 *General Government Debt (as a % of GDP): 1980 – 2015*



Source: Department of Finance.

Between 2008 and 2010, the public finances went into free-fall with the onset of the financial and housing market crisis. This resulted in Ireland being placed in an Excessive Deficit Procedure (EDP) in 2009 and ultimately having to enter into a formal EU/IMF assistance programme in late 2010. The period post-2010 has seen a steady recovery in the public finances as government receipts and expenditure were brought under control

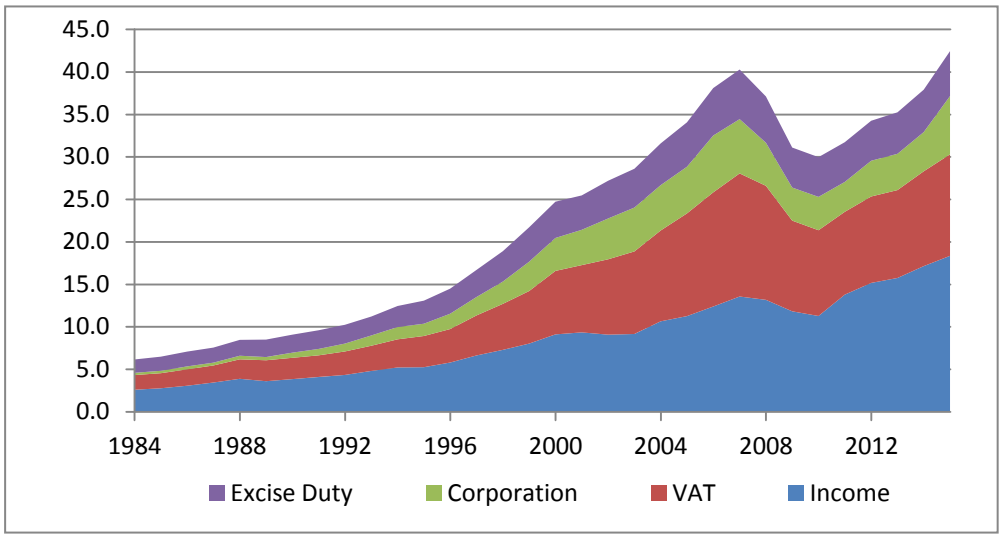
following a series of consolidation budgets. By 2015, the deficit had fallen to an estimated 1.1 per cent of GDP (from a peak of 11.7 per cent in 2009).

Fiscal developments can also be observed from Exchequer tax data. In Figure 3, we plot annualised select Exchequer taxes by tax type. Exchequer tax receipts capture cash inflows into central government. This is a narrower concept than GG taxes as these encompass inflows into all arms of Government (central, local, non-commercial state sponsored bodies, etc.). For example, in 2013, Exchequer taxes in Ireland amounted to about 90 per cent of GG taxes. Across all of the major tax aggregates the substantial increase in the tax take can be seen from the start of the Celtic tiger era. Excise, VAT and Corporation taxes increased particularly sharply over this period before all items registered significant falls post 2007. The recent recovery in the fiscal accounts is clear from about 2012 onwards with a sharp increase evident in all tax items.

In Figure 4 we plot the coefficient of variation for the growth rates in key Irish macroeconomic data over the period 1992 to 2015. This coefficient is a standardised measure of dispersion of a probability distribution and is defined as the standard deviation of a series divided by the mean.[4] Variations are measured for changes in real GDP and real house prices along with the unemployment rate. It can be seen that across all three variables, there is a significant increase in the volatility of the different series post 1996. House price growth exhibits particularly strong fluctuations, with GDP also changing considerably over the period. Overall, therefore, it is clear that the changes observed in key fiscal indicators over the past 20 years are set against significant changes in the Irish economy generally.

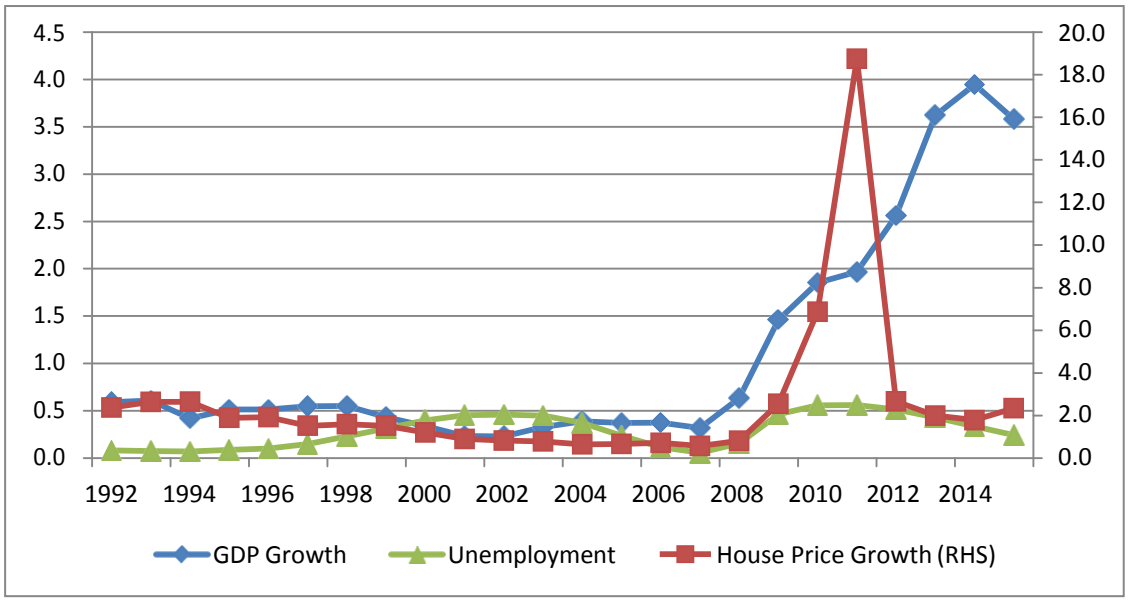
FIGURE 3 *Annualised Select Exchequer Taxes (€ billions): 1995 – 2015*

[4] *The standard deviation is measured over the preceding, rolling 8 year window for each variable.*



Source: Department of Finance.

FIGURE 4 *Coefficient of Variation (%) for Select Irish Macroeconomic Variables (%): 1992 – 2015*



Sources: Own estimates.

Literature review

One key concept used to assess the sustainability or otherwise of taxation revenues is that of revenue elasticities. Creedy and Gemmell (2003) define these elasticities as follows: "Revenue responsiveness is the extent to which tax revenues respond to changes in some tax base, usually income, in the absence of any discretionary action by the fiscal authority, and it is typically measured by the elasticity of tax". Tax revenue elasticity estimates are important components of tax forecasting and macroeconomic models (see Giles and Hall, 1998). An accurate knowledge of tax revenue elasticities enables policy makers to identify to what extent tax revenue changes in a particular year arise from changes in fiscal policy or are due to other policy-induced or exogenous changes in the economy. This in turn feeds

into an understanding of how changes in tax policy might impact on revenues separately from how these revenues would change as a result of the underlying economic environment.

Hutton and Lambert (1980) use analytical expressions for tax revenue elasticities to capture automatic revenue growth. They show that this simple methodology is an important tool to understand the revenue implications of the tax structure in an economy. In terms of estimated elasticities, Dye and McGuire (1991), using US data, find evidence that income taxes are in general more elastic and thus less stable than sales taxes. However, they suggest that exceptions are possible such that income taxes can sometimes be the more stable of the two tax sources – this depends largely on how broadly the sales tax base is defined and how progressive the income tax system is.

Furthermore, they find that there is a great variety in taxation structure between states and thus tax revenue elasticities differ across states. Sobel and Holcombe (1996) use time-series data to provide unbiased estimates of the long-run growth potential (long-run elasticity) and the cyclical variability (short-run elasticity) of all major state/local tax bases. Van den Noord (2000) suggests that although the derivation of the elasticity is mainly done via theoretical considerations, time-series analysis provides an important means of identification as well.

The importance of the tax revenue elasticity from a fiscal policy aspect is also evident from Saez (2001) who derives an optimal income tax formula using compensated and uncompensated elasticities of earnings with respect to tax rates, giving policy makers another important method of implementing tax policy. Creedy and Gemmell (2003, 2004) estimate the revenue elasticities of income and consumption taxes in the UK over the period 1989-2000 at an individual and aggregate level. Their analysis provides an important assessment of how budgetary changes have affected income elasticities.

Wolswijk (2007) estimates the base elasticities of Dutch taxes for five tax categories (i.e. VAT, personal income tax, corporate income tax, other indirect and other direct taxes). The results indicate that short-run elasticities are often lower than long-term ones. Wolswijk (2007) estimates both long- and short-term elasticities, whereby long-term elasticities are computed through a standard OLS regression and a difference equation approach is then used to derive the short-term elasticities.

Comparing the elasticities of several types of taxation, Garrett (2009) suggests that their respective sizes are important in determining which tax exhibits greater variability over the business cycle. Using data from the US, Garrett (2009) presents estimates whether a State's portfolio is constructed to minimize the variance in total state tax revenue. In general, the results indicate that corporate income taxation presents the greatest short-run variability, followed by personal income taxes, sales taxes and excise taxes. Understanding these

differences in elasticities and variability has the potential to provide valuable input into designing stable taxation systems.

In related analysis, Koester and Priesmeier (2012) estimate the long-run tax revenue elasticities by applying dynamic models to a disaggregated dataset for Germany, and find that the value of the elasticity depends on whether the tax is profit-related, wage, or value-added. Creedy and Gemmell (2012) consider the case of New-Zealand and examine the circumstances under which the estimates of the elasticity of taxable income can be expected to exceed values which generate revenue-reducing responses to marginal tax rates, meaning that they try to find the negative slope part of the Laffer curve[5]. Finally, Princen et al. (2013) refer to several types of tax revenue elasticities considering the tax base, i.e. the elasticity of revenue with respect to the output gap, the elasticity of tax revenue with respect to its specific tax base, and the elasticity of tax revenue with respect to GDP. The paper analyses discretionary tax measures and their impact on tax elasticities in the EU over the period 2001-2012.

Our analysis builds on the work of Wolswijk (2007) and Van den Noord (2000) by empirically estimating the income tax revenue elasticity for Ireland. Although, in contrast with Wolswijk (2007) we use GDP as the base of our elasticity and thus our series need not to be net of discretionary measures. We use nominal GDP as our definition of the tax base (i.e. we compute the elasticity of tax revenue with respect to GDP) in order for our analysis to match the measure of the tax base used by OECD. However, we also examine how sensitive the results are to alternative measures of economic activity.

Data and variables

Our paper focuses on the income tax revenue elasticity using, as a baseline activity, the output/total product of the Irish economy in order to be able to have a comparable measure of this elasticity with other countries and other types of taxation. In general, the elasticity measures the response in income tax receipts following a 1% change in the baseline activity (i.e. output). The elasticity is given by:

$$\eta_{TR_Y} = \frac{\partial TR_Y / TR_Y}{\partial Y / Y} = \frac{mtr_Y}{atr_Y} \quad (1)$$

Where TR_Y are the income tax revenues, Y is the total product of the economy, mtr_Y is the marginal income tax revenue, and atr_Y is the average income tax revenue.

[5] *A Laffer curve represents the relationship between rates of taxation and tax revenue.*

The approach we use to derive the elasticity is based on the time-series analysis of Van de Noord (2000) and Wolswijk (2007). The reason we follow a time-series analysis is that in contrast with an analytical computation of the elasticity, the econometric analysis allows us to control for macroeconomic, government, and other fiscal policy factors. The general form of the empirical model for estimation is as follows:

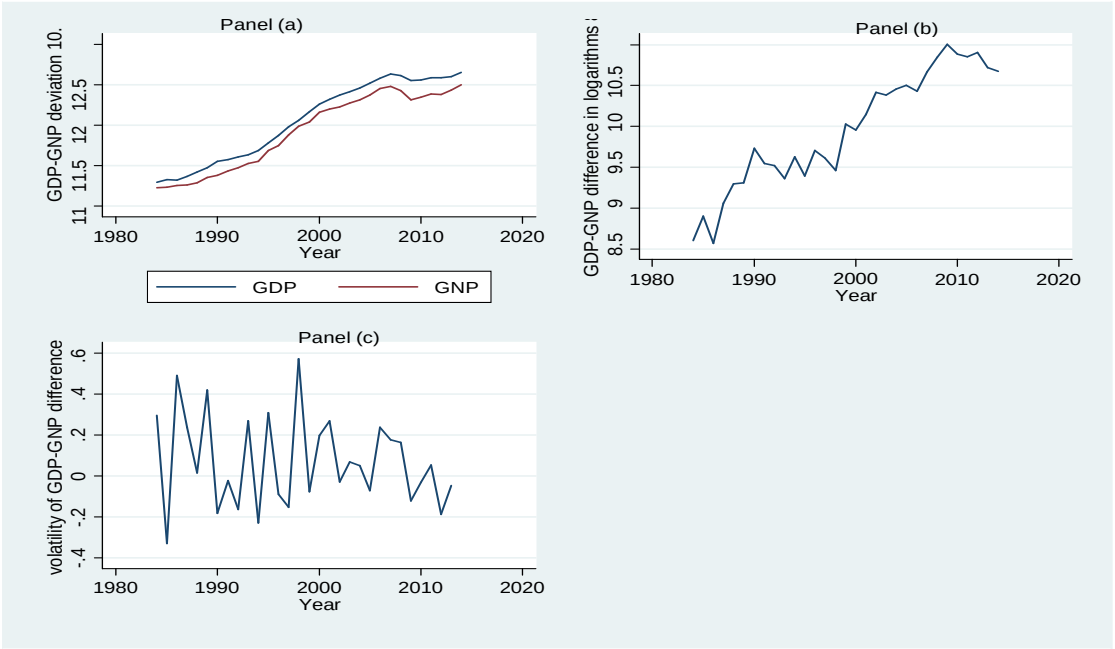
$$logTR_t = \alpha_0 + \alpha_1 logY_t + \alpha_2 X_t + \mu_t \quad (2)$$

In equation (2) $logTR_t$ represents the logarithm of total income tax revenue received at time t, $logY_t$ represents the logarithm of the main explanatory variables of this model, X_t is a vector of control variables that explains the income tax revenues, and μ_t is the remainder disturbance. Notice that the size of the coefficient α_1 represents the income tax revenue elasticity.

To examine the value of the income tax revenue elasticity we use time-series data, which are drawn from a number of sources. The income tax revenue data are from the Revenue Commissioners statistical reports and cover the period 1984 - 2013. In particular, we use data on the distribution of taxable income for all the tax categories (i.e. singles, couples with one earning income, couples with two earning incomes, and widowed persons). Combining the number of the cases in each income band and the collected tax revenues we obtain the total income tax revenue, which is our dependent variable measured in millions of euro.
In the empirical analysis, we estimate the effect of the total product of the Irish economy on the income tax revenue. As measures of the total product we use either Gross Domestic Product (GDP) or Gross National Product (GNP).[6] The reason we use both GDP and GNP is that in the case of Ireland GNP is often regarded as a more accurate measure of domestic economic activity. Figure 5 shows the difference between GDP and GNP for Ireland over the period 1984-2013. From panel (a) of Figure 5 we see that GNP changed more during the years of the crisis. Panel (b) provides us with the difference between GDP and GNP during the period examined. We see that the trend of the difference is always increasing, capturing the increased degree of profit repatriations by multinational companies based in the country. Finally Panel (c) shows the volatility of the difference between GDP and GNP. The data for GDP and, GNP were obtained from CSO's database and were deflated using the deflator obtained from the World Bank. Moreover, to compare these elasticities with the tax buoyancy we estimate an additional regression where the dependent variable (base of the elasticity) is the taxable income. As in this regression we are not able to take the revenue series net of discretionary measures, the outcome is not the tax revenue elasticity but the tax buoyancy.

Figure 5: GDP-GNP Differences

[6] *We have also experimented with using the Gross Value Added (GVA) and the Gross National Income (GNI) as a baseline activity. The results of these regressions are very similar to the ones that use GDP and GNP as baseline activity and that is why they are not presented here.*



In our empirical framework we try to control for a number of macroeconomic and financial factors that may affect the income tax revenue elasticity. In particular, in order to capture the pro-cyclical or counter-cyclical effects of taxation we control for the output gap of the Irish economy.[7] In particular we wish to establish whether taxation receipts may increase or decrease depending on whether the economy is above or below its potential level.

Owing to the persistently high level of activity in the residential and commercial sector, the Irish economy experienced a substantial credit bubble between 2003 and 2007 (see McCarthy and McQuinn (2013) for more on this). The substantial increase in lending engaged in by Irish financial institutions was facilitated by developments in international finance where credit institutions in one country were increasingly able to lend to institutions in another jurisdiction. We examine whether the subsequent increase in credit along with the contraction in lending which occurred post 2008 has had an impact on tax revenues. We control for the credit gap (constructed as the deviation from trend of private sector credit), using data from the Central Bank of Ireland. To capture the possible impact of changes in the tax rates or the income thresholds during the period examined we use data from the Revenue Commissioners statistical reports and the print journal "Taxation Summary" to create variables that capture the deviation of the tax rate and the threshold from the previous trend. We are then able to control for any discretionary fiscal policy measures that occur and hence isolate the elasticity of income tax from impacts of these discretionary measures.

[7] *Our estimate of the output gap is the official European Commission estimate taken from the AMECO database.*

The control variables mentioned above are included in the basic specification of our model. We have also experimented with a set of other controls that cover a range of different factors including GDP growth, labour force participation rate, unemployment rate, the National House Price Index (NHPI), private sector financial credit and funding gaps. Formal definitions of all variables are provided in Table 1 and summary statistics in Table 2.

Table 1. Variable definitions and sources

Variable	*Description*	*Source*
A. Dependent variable		
Income tax revenue	*The total income tax revenue for each year.*	*Statistical Reports (Revenue Commission)*
B. Main explanatory variables		
GDP	*Gross Domestic Product at constant prices .*	*CSO and World Bank*
GNP	*Gross National Product at constant prices.*	*CSO and World Bank*
C. Control Variables		
Output gap	*The gap between the actual and potential GDP at 2010 reference levels, measured as a percentage and in constant prices.*	*AMECO*
Gap TA	*The gap between actual and trend GDP at 2010 reference levels, measured as a percentage and in constant prices.*	*AMECO*
LPR	*The labour force participation rate.*	*Labour force survey and CSO Quarterly National Household Survey*
NHPI	*The National Household Price Index, index of house prices.*	*Department of environment and CSO*
Unemployment	*The unemployment rate.*	*Labour force survey and CSO Quarterly National Household Survey*
Credit gap	*Private sector credit gap, constructed by the private sector credit and its deviations from its trend.*	*Central Bank of Ireland*
Funding gap	*Private sector funding gap, constructed by the private sector credit when we subtract the private sector deposits.*	*Central Bank of Ireland*
Financial credit gap	*Private sector financial credit gap, constructed by the real financial credit and its deviations from its trend.*	*Central Bank of Ireland*
SD tax	*Standard deviation of the tax rate from the mean indexed from tax year 1981.*	*Statistical Reports (Revenue Commission)*
SD threshold	*Standard deviation of the tax thresholds from the mean indexed from tax year 1981.*	*Statistical Reports (Revenue Commission)*

Difference mean tax rate	*The difference in the tax rate from the mean rate indexed from tax year 1981.*	*Statistical Reports (Revenue Commission)*
Difference mean threshold	*The difference in the tax threshold from the mean threshold indexed from tax year 1981.*	*Statistical Reports (Revenue Commission)*
Growth	*GDP growth rate.*	*OECD*

Table 2. Summary Statistics

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Dependent variable					
Income tax revenue	*30*	*8.662*	*0.556*	*7.818*	*9.416*
Main explanatory variables					
log GDP	*31*	*11.560*	*0.496*	*10.820*	*12.148*
log GNP	*31*	*11.421*	*0.469*	*10.724*	*11.999*
Control variables					
Output gap	*31*	*-0.377*	*2.691*	*-5.591*	*4.631*
Credit gap	*32*	*-0.005*	*0.168*	*-0.460*	*0.341*
SD tax	*32*	*0.049*	*0.005*	*0.040*	*0.055*
SD threshold	*32*	*6072*	*4383*	*1500*	*13004*
Difference GDP-GNP	*31*	*9.454*	*0.717*	*8.068*	*10.507*
Volatility of difference GDP-GNP	*30*	*0.069*	*0.224*	*-0.330*	*0.570*

Estimation results

We start with a set of OLS regressions that measure the effect of GDP on income tax revenue. All variables expressed in absolute terms are transformed into logs and the Newey-West correction was applied to reduce inconsistency of the standard error estimations. In Table 3 we report four variants of equation (2) based on the use of different control variables. In the specifications presented in Table 3 the control variables used do not present a high correlation among each other. In the first column of the Table 3 we present the baseline of a simple OLS regression between GDP and income tax revenue. In the second column we control for overall economic activity and add controls for the output gap and the credit gap to capture deviations from trend in both the general economy and the financial sector.

In the third column we toad controls which capture the effects of changes in the tax rates on the income tax revenues. In particular, we include in our regressions the variable SD tax that

captures the deviations of the tax rate from the trend. Finally in the fourth specification we use the same controls, but now instead of using the variable SD tax we use the variable SD threshold that captures the change of the threshold incomes in the tax system of Ireland.

The results from the first three specifications indicate that the magnitude of the income tax revenue elasticity is about 1.1, while the result of the last specification suggests that when we control for the changes in the income threshold[8] the elasticity is reduced just below one taking the value of 0.95. These results suggest that on average a 1% increase in the GDP will cause a 1.1% increase in the income tax revenues. We see that the above results remain relatively unchanged across the different specifications, suggesting that the results are always statistically significant and robust.[9] In the column V of Table 3 we estimate the tax buoyancy using as a base the taxable income reported in the statistical reports of the Revenue Commissioners. When we compare the size of the value of the income tax revenue-to-GDP elasticity reported in column II with the one of the tax buoyancy presented in column V we see that the former is larger. The reason behind this is that the GDP captures more volatile components, such as investment, and takes into account the macroeconomic fluctuations, whereas taxable income presents a more stable behavior

Table 3. Income tax revenue elasticity with GDP baseline activity
The table reports coefficients and t-statistics (in parentheses). The dependent variable in all regressions is the income tax revenue. The variables are defined in Table 1. All regressions are estimated with OLS correcting for the standard errors with the Newey-West correction methodology. Wald is the p-value of the Wald test, which shows the joint statistical significance of the coefficient estimates. The *, **, *** marks denote statistical significance at the 10, 5, and 1% level respectively.

	I	II	III	IV	V
Log GDP	1.107***	1.088***	1.112***	0.946***	
	(-28.986)	(-23.412)	(-26.334)	(-9.284)	
Log Taxable income					0.565***
					(23.38)
Output gap		-0.014**	-0.026**	-0.004	0.01
		(-2.301)	(-2.575)	(-0.462)	(1.15)
Credit gap		0.347*	0.603**	0.221	-0.04
		(-1.89)	(-2.187)	(-1.252)	(-0.21)
SD tax			-11.022*		
			(-1.789)		
SD threshold				0.000*	
				(-1.712)	
Constant	-4.111***	-3.905***	-3.653***	-2.370**	
	(-9.687)	(-7.453)	(-5.501)	(-2.135)	
obs	30	30	30	30	30
Wald test (p-value)	0.000	0.000	0.000	0.000	0.000

[8] *The income threshold that if a tax payer surpasses then the tax rate the individual tax payer faces increases.*

[9] *When we use a different set of control variables the results always remain quantitatively the same and the same variable are always statistically significant. We are reluctant to control for many variables in order not to lose too many degrees of freedom. Also, the fact that we do not control for the SD threshold and SD tax at the same time arises from the fact that these two variables display a high degree of correlation.*

Regarding the control variables, we see that the output gap displays a negative coefficient which is significant in most of the specifications. This result suggests that when the Irish economy is above potential GDP and the gap increases, then income tax revenue decreases, though the true effect is very small. This behaviour could be explained by the fact that when the economy is operating above capacity the extra income earned may take the form of share options or different types of income that are less liable to taxation. In terms of the credit gap, from Table 3 we can see that it is not always statistically significant. The positive sign of the coefficient for the credit gap though does suggest that when credit levels in the economy are above trend, and thus the credit gap is positive, an increase in the credit gap increases the income tax revenue. This may be explained by the fact that more private credit increases peoples' ability to spend and hence generates greater levels of economic activity for a given income level. This may then result in an increase in total income tax revenues. Finally, we see that the effect of the standard deviation of the tax rate and the threshold are significant only at the 10% level. The SD tax variable measures the standard deviation of the tax rate. A one percent increase in the tax rate results in just a 0.2% increase in the SD tax variable. With an estimated coefficient of -11.022 a 1% increase in the SD tax results in a 5% increase in the tax rate, which results in an 11% decrease in the income tax revenues. Thus, apart from the fact that this coefficient is barely significant, the magnitude of this effect is reduced by the fact that the variable does not capture a 1% increase on the tax rate but a 1% change on the standard deviation of the tax rate from its mean.

Finally, we test whether there exists a structural break in our income tax revenue series when combined with GDP. The fact that there was a big change in the Irish tax system together with the implementation of the euro during the earl 2000s may imply an altered behaviour of the income tax revenues. Table 4 presents the outcome of the Wald test used to examine the existence of such a structural break. The interesting result arising is that although we do not observe a structural break in the early 2000s, the combination of the data with GDP, or GNP, suggest that there is a break in 1989. This may be arising from the 1988 tax amnesty that led to the whitewash of previous indiscretions under section 72 of the Finance Act. Another possible explanation for this structural break may be the Social Partnership agreement, a process that was initiated in 1987 and that affected to the change of the wages since then.

Table 4. Structural break test

The table reports the Wald test for structural break. The dependent variable in the regression is the income tax revenue and the independent variable is the GDP. The variables are defined in Table 1. All regressions are estimated with OLS correcting for the standard errors with the Newey-West correction methodology. Wald is the p-value of the Wald test, which shows the joint statistical significance of the coefficient estimates.

Number of observations	30	
Full sample	1-30	
Trimmed sample	6-26	
Estimated break date	1989	
Test	Statistic	p-value
swald	132.098	0.000

The results for the elasticity when we use GNP as the baseline activity are presented in Table 5. The specifications are exactly the same as reported in Table 3 where the baseline activity was GDP. We can see than now the size of the coefficient is slightly bigger and always larger than one. In particular the results suggest that a 1% increase of the GNP results to an almost 1.17% increase of the income tax revenue. It is important here to note that this value of this

elasticity is closer to the values of other countries such as UK or Netherlands. When GNP is used, the results for the output and the credit gap are significant, and the result for the output gap is significant at the 1% level. This suggests that GNP is a more accurate measure in the case of Ireland in capturing movements of the economic cycle.

Table 5. Income tax revenue elasticity with GNP baseline activity

The table reports coefficients and t-statistics (in parentheses). The dependent variable in all regressions is the income tax revenue. The variables are defined in Table 1. All regressions are estimated with OLS correcting for the standard errors with the Newey-West correction methodology. Wald is the p-value of the Wald test, which shows the joint statistical significance of the coefficient estimates. The *, **, *** marks denote statistical significance at the 10, 5, and 1% level respectively.

	I	II	III	IV
Log GNP	1.174***	1.160***	1.184***	1.025***
	(-31.905)	(-25.785)	(-27.491)	(-11.982)
Output gap		-0.016**	-0.028***	-0.007
		(-2.650)	(-2.873)	(-0.803)
Credit gap		0.343**	0.588**	0.229
		(-2.064)	(-2.344)	(-1.316)
SD tax			-10.549*	
			(-1.840)	
SD threshold				0.000*
				(-1.86)
Constant	-4.725***	-4.575***	-4.342***	-3.122***
	(-11.675)	(-9.081)	(-6.875)	(-3.388)
obs	30	30	30	30
Wald test (p-value)	1.47E-23	3.21E-22	5.57E-23	3.59E-21

Finally, we estimate the two models (using GDP and GNP) together using the seemingly unrelated regression methodology and test whether the coefficients of the two specifications (i.e. with GDP or GNP) display statistically significant differences, using a Wald test.[10] Table 6 shows the results from the Wald test. As we can see the chi-square coefficient is very large so we reject the null hypothesis that the coefficients do not have statistical significant differences. Therefore we conclude that there is an important difference when we use GNP instead of GDP as a baseline activity for the income tax revenue elasticity. Because GNP is a better measure of Irish economic activity, the slightly higher estimates of the elasticity produced by the regression in Table 5 should be used for evaluating the sensitivity of taxation revenues to changing economic circumstances.

[10] *The seemingly unrelated regressions model is a generalization of the linear regression model that consists of several different regressions, each having the same dependent variable and potentially different sets of explanatory variables.*

Table 6. Wald test for the difference between the GDP and GNP elasticities

Chi2(1)	76.04
Prob > chi2	0.000

The elasticity estimates for Ireland can also be compared with those for other countries. A tax revenue elasticity greater than 1 implies an increasing tax revenue to tax base ratio through time. The larger the size of the elasticity the faster is the rise in the tax ratio and the size of the elasticity is affected by several parameters, such as progressive elements in the tax system and the distribution of the income across individuals. Table 7 provides a comparison of the tax revenue elasticities for Ireland the UK and the USA, where the baseline activity is GDP. The elasiticity for Ireland is similar to that of the USA but significantly smaller than that for the UK. Although the periods displayed are different within the countries, it is safe to assume that the general level of the elasticity does not vary significantly throughout time.

Table 7. Elasticities of UK, USA, and Ireland with GDP as a baseline activity

These values for the elasticity of the income tax revenues with GDP as a baseline activity are from the study of Choudhry (1979).

Country	Period	Elasticity
UK	1955-1974	1.45
US	1955-1975	1.08
Ireland	1984-2013	1.11

Conclusions

Given the high levels of volatility in the Irish economy over the past decade, both in terms of overall economic performance and in government finances in particular, it is clearly important to understand the drivers of tax receipts in order to work towards a stable and resilient path for public finances. This paper takes a first step in this process by examining the sensitivity of income tax revenues to changes in economic activity. Income tax receipts make up a considerable fraction of total government revenues and are therefore of central importance in economic and tax modelling and forecasting.

We use a long time span of Irish data on income taxes and economic indicators from the mid-1980s up until 2013. The key research question is the extent to which economic activity drives tax revenues. In the Irish context, the choice of economic activity measure is an important decision as, unlike in most other countries, there is a large divergence in the size of the economy as measured by GDP compared to GNP as a result of the impact of the multinational sector. We therefore take both indicators into consideration and test if they give different results. We furthermore control for a number of other factors that may have had an effect on income tax elasticities over the period in question, specifically indicators of the output gap and excess credit. In any long time span of this nature, there will have been changes in the tax code that could have changed the elasticity estimates, and ideally we

would like our estimate of the elasticity to be isolated from the consequences of any such discretionary policy measures. We therefore control in our empirical strategy for variations in the tax rate and tax thresholds.

Across all specifications, we find a consistent positive relationship between economic activity and income tax revenues, with elasticity greater than unity in all but one case. Nonetheless, we find that there is a statistically significant difference between the estimates produced when using GDP compared to those where GNP is the measure of baseline activity. Taking into account international comparisons and also the levels of statistical significance of the other control variables, we would argue that the results coming from the GNP regressions are more likely to be an accurate reflection of the impact of the economic cycle on Irish income tax revenues. This gives us a baseline estimate of the revenue elasticity in the order of 1.17 (with the range of estimates varying between 1.025 and 1.184 depending on the other controls). This means that a 1 per cent increase in GNP translates into a 1.17 per cent increase in income tax revenues. The greater than proportionate response reflects the progressive nature of the income tax system.

We find that disequilibrium in both the general economy and the financial sector has implications for the sensitivity of taxation receipts to economic activity. The output gap is found to have a moderating effect with a positive output gap having a progressively more negative effect on tax revenues. We interpret this as an indicator that temporary above trend performance in the economy does not feed into income tax receipts in the same way as general economic growth, perhaps due to increased incomes associated with above trend performance being more likely to be in the form of tax efficient share options or invested in pension funds. When credit levels in the economy are above trend it has the opposite effect and increases the revenue elasticity. This is possibly due to excess levels of credit facilitating higher wages and increased spending. The contrasting effects of the two measures of disequilibrium underscore the need to accommodate both concepts when examining this issue. In that context, it may well be worth exploring the effect of the finance gap as outlined in Borio et al. (2013) on taxation receipts, however we leave this for future work. In other future work, we also plan to extend this analysis by examining in more depth how income tax responses may vary over time and across different types of taxpayer.

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