POLICY PAPER

An Analysis of Tax Forecasting Errors in Ireland

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Abstract: This paper examines the tax revenue forecasting performance of the Department of Finance over the period 1997-2014. While the general forecasting framework used reflects standard international practice, forecasting errors are relatively large by international standards. In almost all cases, we find no evidence of bias in the forecasts when considering the major tax heads over various forecast horizons. A decomposition of the forecast errors reveals substantial contributions from sources other than errors in forecasting the macroeconomic environment or in estimating the previous year's revenue outturn. This suggests that a formal review of specific procedures and assumptions by the Department could yield further improvements in forecasting performance. An innovative exercise examining the routine use of judgement by the Department to adjust the outcome of forecasting equations indicates that this practice often improved the quality of the forecasts.

I INTRODUCTION

The central role played by numerical targets in meeting fiscal rules has underscored the importance of high quality forecasts of government revenue and expenditure streams. This is particularly key in the case of tax forecasts,

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usually the main source of government revenue, accounting for around 70 per cent of General Government revenue in Ireland over the past decade.[1] Forecasting tax revenues relatively accurately is a difficult task, however, encompassing predictions about macroeconomic growth and about the responsiveness of the economy to any tax policy changes, among other factors. Moreover, government commitments to meet certain targets for deficit measures may create incentives to produce *ex ante* revenue forecasts that are either overly optimistic (to create room for additional spending) or deliberately prudent (to ensure targets are met or exceeded). Frankel and Schreger (2012) find that the optimism bias in forecasts for the European countries used in their sample was greater than for others, and questions whether this finding is despite or because of those countries being subject to the Stability and Growth Pact (SGP). In Ireland the Department of Finance is responsible for forecasting tax revenues twice a year, in the Stability Programme and in the budget. When judging the quality of these official forecasts, both the size and the direction of forecast errors are of interest to assess accuracy and un-biasedness.

Some previous work that looked at Irish revenue forecasts in an international context found that the Irish official forecasting performance was on the weaker end of the spectrum. For example, IMF (2005) assessed total revenue forecasting accuracy in Ireland as relatively weak when compared to a group of 11 other countries.[2] That study attributed a dominant role to macroeconomic forecasting errors while also noting evidence of prudence in revenue forecasts. Buettner and Kauder (2010) found that the accuracy of Irish revenue forecasts ranked tenth among 12 OECD countries examined (Figure 1).[3] They also highlighted the potentially important contribution of macroeconomic forecasting errors and noted that Irish GDP Root Mean Square Errors (RMSEs) were by far the largest in the sample (2.5 compared with an average of 1.4 for the 12 countries). These findings are consistent with the tendency for macroeconomic forecasts to be relatively large in small economies where growth is volatile and GDP forecasts are heavily reliant on external

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[1] General Government measures make adjustments for accruals and other exceptional items. The analysis that follows is mostly on an Exchequer basis. In the case of taxes, these measures are often similar.

[2] Other countries included in this analysis were the US, Germany, UK, France, Italy, Canada, Australia, New Zealand, Netherlands, Sweden, and Switzerland. Ireland was placed 10th out of 12 in terms of the root mean square error of its fiscal balance (1991-2003), with revenues accounting for most of the deviation.

[3] Eight of the 11 countries included with Ireland in the IMF study were also part of Buettner and Kauder's work. The additional three countries in Buettner and Kauder (2010) were Japan, Austria and Belgium that replaced Australia, Sweden and Switzerland. Measures of accuracy included standard deviation of the forecast errors and root mean squared forecast errors. Data for Ireland spanned 1998-2008.

assumptions. (See, for example, European Commission, 2012). In a recent study of the European Commission's revenue forecasts, Afonso and Carvalho (2013) reported that the accuracy of the EC's total revenue forecasts scaled by GDP for Ireland ranked 11th of the EU15, with an absolute mean error across three years of 0.532 for Ireland compared with 0.142 for the EU15.[4] As these results compared forecasts across countries that were made by the same institution, the relatively poor performance for Ireland reinforces the idea that forecasting Irish revenues may be particularly challenging. In addition to difficulties in forecasting the macroeconomic drivers of the tax revenue, other factors such as a small number of dominant firms contributing to corporation taxes, complicate the task.

Figure 1: *Forecasting Performance in an International Context*
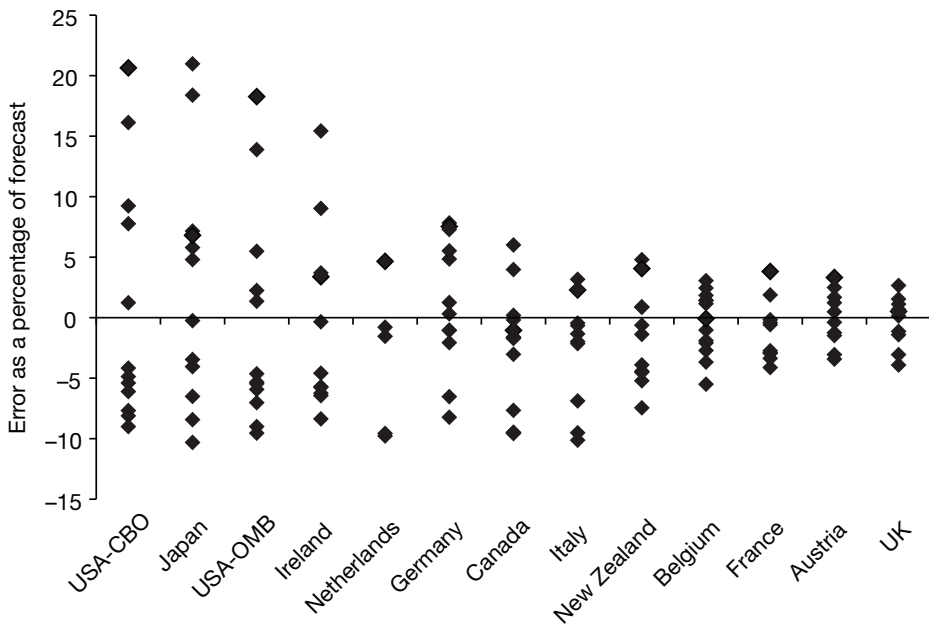
Source: Buettner and Kauder (2010).
Note: CBO: US Congressional Budget Office. OMB: US Office of Management and Budget. The Figure displays the forecast errors for total tax revenues in percentage for up to 13 years in each country, each point representing one forecast. A positive (negative) value denotes overestimation (underestimation). The forecasts are arranged in descending order of the standard deviation of the respective forecast errors. The two US forecasts only refer to federal taxes. The comparison of taxes is on an accruals basis. The analysis that follows is not.

[4] This is based on the average mean error for total revenue as a percentage of GDP for forecasts for *t*, *t*+1 and *t*+2 based on the ESA95 definition of total revenue for 1999-2012.

The most comprehensive study focussing exclusively on official tax fore-casting errors in Ireland is the analysis of the Tax Forecasting Methodology Review Group (TFMRG) published in 2008.[5] That study outlined the forecasting methodology used by the Department of Finance and analysed the size of forecast errors over the 1999-2006 period. The report found that, even when macroeconomic forecast errors were controlled for, overall forecast errors remained significant. VAT forecasts were most accurate while the largest forecast errors were observed for capital gains tax, stamp duty and corporation tax. The influence of property market developments on tax revenues over that period was highlighted and recommendations were made to incorporate such developments into forecasts for VAT and stamp duty. The report also called for more regular analysis of tax forecasting performance, including analyses of one-off factors affecting tax revenue, and for the annual publication of such analyses by the Department of Finance. Since the publication of the 2008 report some of the recommendations have been implemented, but there has not been another review of that kind in the meantime. A summary of the report's main recommendations can be found in Appendix A.

This paper undertakes a comprehensive analysis of official tax forecast errors for the period 1997-2014. Some of the analysis builds upon material from the TFMRG report and publications by the Irish Fiscal Advisory Council (IFAC, 2014). Section II contains a brief description of the structure of the Irish tax system and outlines the general forecasting approach employed by the Department of Finance. The remainder of the paper evaluates the Department of Finance's tax forecasting performance. Of interest is both the overall accuracy of the forecasts and whether there is any evidence of bias in the forecasting process. Section III looks at the size and direction of forecast errors, discussing whether forecasts are persistently optimistic or pessimistic, as well as examining the relative contributions of different tax categories to the overall error. In Section IV, the errors for each major tax category are decomposed to determine whether they primarily arise from errors in macroeconomic forecasts or other sources. Section V analyses the degree to which forecasts are subjected to discretionary upward or downward adjustments by the Department of Finance while Section VI provides some conclusions.

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[5] The TFMRG was given the task of reviewing tax forecasting performance and methodologies and was required to make methodological recommendations where appropriate. The working group consisted of 11 members: five from the Department of Finance; two from the Revenue Commissioners; two from the Economic and Social Research Institute; one from the Central Bank of Ireland; and one from the European Commission.

II TAX REVENUE IN IRELAND

2.1 *Structure of the Irish Tax System*

Tax revenue (including direct and indirect taxes but not social security contributions) amounted to 21.8 per cent of GDP (25.3 per cent of GNP) in 2014. While this ratio has been slightly below the Euro Area average in recent years, Ireland relies relatively more on direct and indirect taxes than on social security contributions compared with the average in the Euro Area (European Commission, 2013).

The relative contribution of the main tax heads towards overall tax revenue in Ireland between 1997 and 2014 is shown in Figure 2. Despite a reduction in the number of people at work from 2008-2013, the contribution of income rose over that period, reaching over 40 per cent in 2011 (due to changes in tax credits, standard rate bands as well as the phasing out and abolition of certain reliefs). The introduction of the Universal Social Charge contributed to continued strength in subsequent years.

VAT is the second biggest tax category, contributing 29 per cent of total tax revenue on average between 1997 and 2014. Its contribution peaked at 33 per cent in 2008 (and overtook income tax as the largest category) driven by very high levels of consumer spending and VAT related property transactions. Since then, its contribution has fallen and is now back below the period average.

Figure 2: *Structure of Tax Revenue*
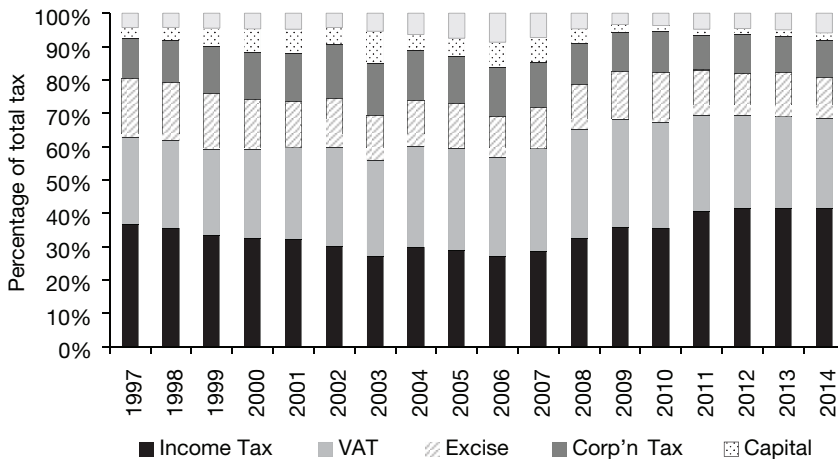
Source: Department of Finance.
Note: Income tax includes the Universal Social Charge (USC) from 2012 onward. Other includes Local Property Tax (LPT) from 2013 on.

Excise and corporation tax each account for about 14 per cent of total tax revenue. Although revenue from excise increased in absolute terms, its contribution towards total tax revenue decreased during the boom period.

The remaining two categories are capital taxes, comprising capital gains tax and capital acquisitions tax (5 per cent of total) and "other", which includes stamp duties and customs duties (5 per cent of total). Revenue from both of these categories increased steadily during the "Celtic Tiger" era, with the contributions of capital and other taxes reaching 8 and 9 per cent of total tax revenue respectively in 2006. With the collapse in the property market, revenue from these categories has fallen sharply in more recent years.

2.2 *Department of Finance Tax Forecasting Methodology*

The forecasting procedure employed by the Department of Finance is described in the 2008 TFMRG report and can be summarised using the following equation:

$$Rev_{t+1} = (Rev_t - T_t)(1 + (B_{t+1}^G E)) + T_{t+1} + M_{t+1} + J_{t+1} \tag{1}$$

where Rev_{t+1} is the one-year-ahead forecast for a particular tax head, Rev_t is an estimate of the yield for that tax head in the current year, i.e. the year in which the forecast is made, T_t are one-off (temporary) items affecting the yield in the current year, B_{t+1}^G is the projected growth rate in the appropriate macroeconomic driver (i.e. the main economic variable that drives receipts) for a particular tax for the year ahead, E is the elasticity measuring the responsiveness of tax revenue to the tax base, T_{t+1} are one-off items affecting the yield in the coming year, M_{t+1} is the estimated static yield from any changes in policy affecting receipts for a particular tax in the coming year and J_{t+1} is a judgement factor applied by the Department of Finance. The relevant macro driver for each tax head is shown in Table 1.[6]

The elasticity factor, E, in Equation (1) measures the response of tax revenue to changes in the macro driver. An elasticity of 1 is used[7] except in the case of PAYE, which uses time-specific earnings and employment elasticities. Most recently, the Department of Finance assumes that the elasticity of PAYE is 2.15 with respect to growth in earnings per head and 0.9 with respect to growth in employment. [8]

The same basic procedure used to forecasts taxes in $t+1$ is applied to $t+2$ and $t+3$. The forecasts for all taxes are then aggregated to total tax revenue

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[6] Table 1 excludes DIRT, self-assessed income tax, USC and local property tax.

[7] TFMRG (2008) specifies the elasticity used in the case of each tax head.

[8] PAYE's elasticity with respect to earnings per head has varied between 1.95 and 2.18 since 2004. The elasticity with respect to employment has varied between 0.7 and 1.0.

Table 1: *Macro Driver by Tax Head*

Tax Head	Macro driver
VAT	Nominal personal consumption adjusted for tourist spending.
Corporation Tax	Nominal GDP until 2008, since then Gross Operating Surplus.
Excise Duties excl. Vehicle Registration Tax (VRT)	Nominal personal consumption adjusted for tourist spending and spending on transport equipment.
VRT	Projected change in the price of new cars and the volume of new car sales.
PAYE[9]	Non-agricultural employment and non-agricultural wages.
Capital Gains Tax	Nominal GNP.
Capital Acquisitions Tax	Nominal GNP.
Stamp Duties	Volume and price of new housing activity; Investment in non-residential construction.

and a consistency check is applied to ensure that total tax revenue grows broadly in line with nominal GDP. TFMRG (2008) stated that "over the 1996-2006 period, the implied aggregate tax-to-GDP elasticity was found to average 1.1".[10] Analysis by the ESRI (published in TFMRG, 2008) suggests that the Department of Finance's assumption of an aggregate tax elasticity of 1 is reasonable. It is also the case that elasticities vary over time, with aggregate annual measures sometimes deviating far from the long-run average, making this a worthy topic for further investigation.

In addition to the responsiveness of tax revenue to the macro driver captured by E, revenue forecasts also need to take account of the impact of policy changes, such as the effect of changes in tax rates on the appropriate macro driver. For example, while nominal personal consumption growth will impact VAT revenue (with E capturing this relationship) a change in the VAT rate will also affect the growth in nominal personal consumption. The tax forecasting equation does not specify this effect explicitly but attempts to capture it by taking account of the impact of tax rate changes in the forecast for the macro driver.

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[9] Pay as you earn (PAYE) is the largest component of income tax. Non-PAYE components of income tax are not considered in this paper due to data limitations.
[10] At the time of this study the Department of Finance confirmed that their estimate of the elasticity has not changed.

III SIZE AND DIRECTION OF FORECAST ERRORS

3.1 *Errors by Forecast Horizon*

We begin by measuring the size and direction of forecast errors for various tax categories by comparing tax forecasts published in the annual budgets with outcomes from end-year Exchequer statements. We consider forecast horizons of one, two and three years ahead over the period 1999-2014.[11,12] For example, tax outturns published in the end-year Exchequer statement for 2013 are compared with forecasts made one year earlier in *Budget 2013* (published in December 2012), two years earlier in *Budget 2012* (published in December 2011) and three years earlier in *Budget 2011* (published in December 2010). Six tax categories are examined: income tax; VAT; excise; corporation tax; capital taxes; and "other" (defined in Section 2.1).

A positive error indicates that the outturn was greater than the forecast and implies that the Department of Finance underestimated the actual outturn in a particular year. Negative errors imply that the Department of Finance overestimated actual outturns.

We calculate the Mean Error (ME) and Root Mean Square Error (RMSE) as given by Equations (2) and (3). The ME is a useful indicator of the average direction of the forecast errors and can be informative about possible bias in the forecasting process. The RMSE gives a better sense of the magnitude of the errors, as it is not differentially affected by positive and negative errors.

$$ME_t = \frac{1}{T} \sum_{t=1}^{T} e_t \tag{2}$$

$$RMSE_t = \left(\frac{1}{T} \sum_{t=1}^{T} e_t^2 \right)^{1/2} \tag{3}$$

Figure 3 shows the results of these calculations for total tax revenues for the period 1999-2014. Due to the scale of the forecast errors in 2008 and 2009, Figure 3 also shows both measures for the period excluding these years. The results show that the ME is quite different from the RMSE both in size and direction, indicating that positive and negative errors are offsetting one another. As expected, the RMSE rises as the forecast horizon increases. The fact that the ME is consistently negative may initially give the impression that forecasts

[11] We begin the analysis with forecasts published in December 1998 (Budget 1999) because forecasts beyond a one-year horizon were not provided in Budget 1997 (published in December 1996) or Budget 1998 (published in December 1997). The one-year-ahead sample contains 16 observations, the last of which reflects forecasts made in 2013 for 2014. There are 15 and 14 observations in the two and three-year-ahead samples respectively.

[12] In 2014, the Budget moved from December to October.

are biased towards an overestimation of tax revenues, in contrast with the IMF's (2005) view that between 1991 and 2003 "budget forecasts relied on a prudent assumption", i.e. tended to be biased in the direction of under-estimation. However, the ME excluding 2008-2009 shows a less clear-cut pattern. Indeed, upon closer examination, it appears that there are no clear signs of bias in the forecasts over the 1999-2014 period as a whole. For the 14-16 years for which forecasts across the various horizons are examined, there are close to equal numbers of positive and negative errors observed for total tax revenue.

Figure 3: *Forecast Error Summary (1999-2014)*
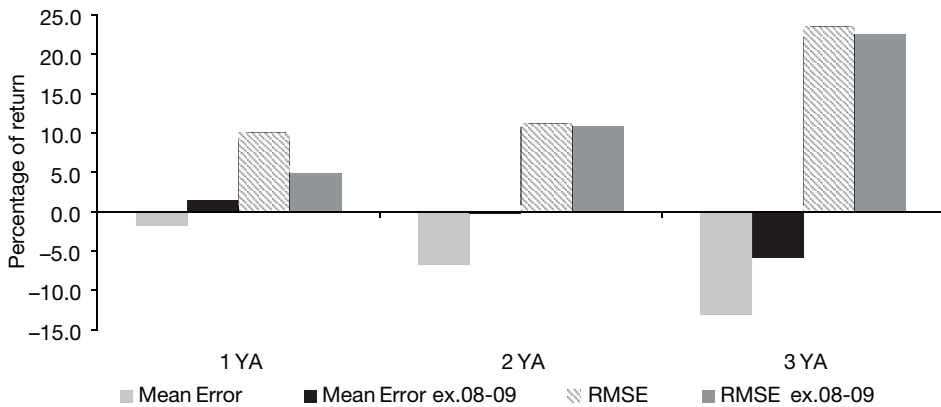
Sources: Department of Finance and author calculations.
Note: YA indicates Year(s) Ahead

Total taxes are generally forecast as the sum of each of the tax heads. Figures 4 to 7 show the ME and RMSE for each tax head. We also show the mean weighted error and the weighted RMSE, where the errors for each tax head are weighted by their forecast share in total tax revenue to reflect their relative importance. Due to the distortionary effects of the 2008-2009 years shown above, these observations are again excluded. Figure 4 shows that the errors for capital taxes and other taxes are the largest over all forecast horizons and Figure 5 shows that they remain important even after adjusting for their relatively small share in total taxes. This is not unexpected given the extraordinary influence of the boom in the housing sector on these tax heads over much of the period examined. Recall that stamp duties related to property conveyance are included in the "other taxes" category and that capital gains tax receipts relating to the property market are included under the capital taxes head. Addison-Smyth and McQuinn (2010) gives a good sense of the extent of

this housing-related impact, documenting that the share of residential construction-related taxes in the Exchequer returns more than doubled between 1999 and their peak in 2006. It is unsurprising, therefore, that the forecasting errors for the tax heads most directly influenced by this development were so dominant.

This is also borne out in Figures 6 and 7 where the magnitude of the errors is more clearly depicted. Even when weighted according to their forecasted share in total taxes, the RMSEs for capital taxes and other taxes remain as important (and in some cases more important) than errors in much larger tax heads such as income tax and VAT. It is also important to note that income tax includes USC from 2011 onwards. This could have affected errors in the period surrounding its introduction due to uncertainty surrounding the impact of the new tax. Interestingly, breaking down these averages to look at the direction of year-by-year errors does indicate that for many tax heads, revenues tended to be underestimated during periods of strong economic activity and overestimated when economic conditions were weak, including during the exceptional period of economic weakness in 2008-2009. In subsequent sections, a closer look is taken at the pattern of errors in specific sub-periods and the role of errors in the forecasts of the relevant macroeconomic drivers for tax revenue is examined.

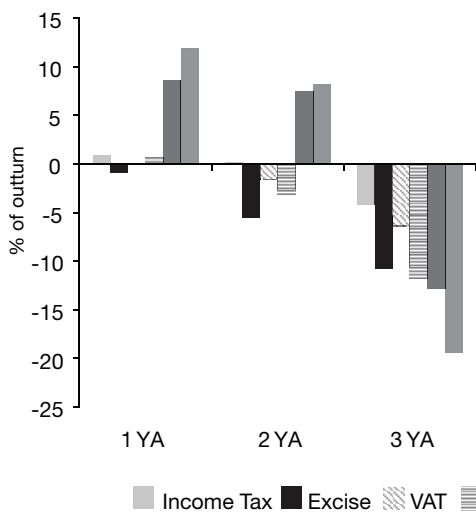Figure 4: *Mean Error (Excluding 2008-2009) By Tax Head*
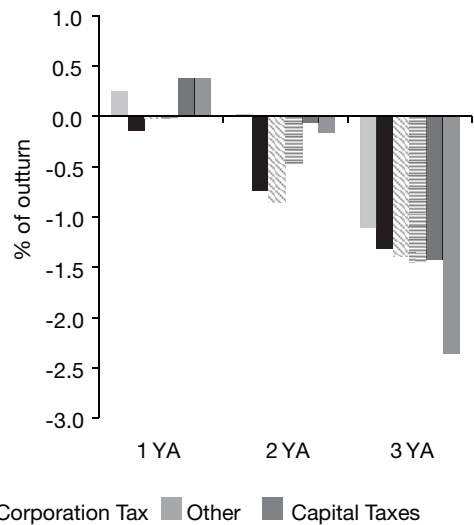
Figure 5: *Mean Weighted Error (Excluding 2008-2009)*

Income Tax Excise VAT Corporation Tax Other Capital Taxes
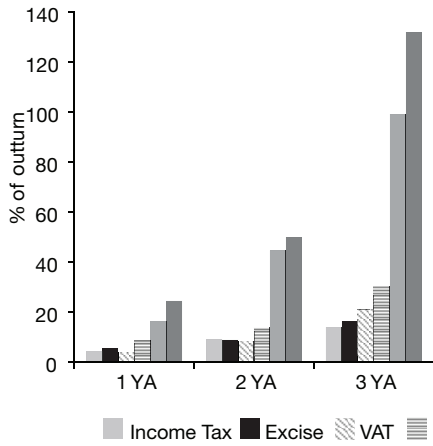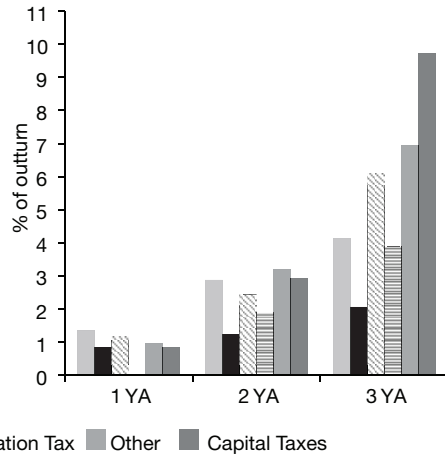
Figure 6: *RMSE Excluding 2008-2009*

Figure 7: *Weighted RMSE Excluding 2008-2009*

3.2 *One-Year-Ahead Errors Before, During and After the Crisis*[13]

Focussing on one-year-ahead forecasting errors, we next break the sample into three sub-periods to represent the periods before, during and after the crisis.[14] Table 2 shows that for the period as a whole, the ME for total tax revenue was slightly negative (–0.9 per cent). It is evident, however, that this average was influenced heavily by large negative errors in the 2008-2009 sub-period, as the Department of Finance (and forecasting agencies generally) failed to predict the sharp economic downturn. Over-predictions were mostly evident during periods of economic weakness, with errors also negative during the previous economic downturn in 2001 and 2002. In most of the remaining years in the sample, forecast errors for overall tax revenue were positive, peaking at 8.5 per cent in 2006 (Figure 9). Similarities are evident across the individual tax heads, with large over-predictions in each of the categories in the 2008-2009 sub-period and almost exclusively negative errors for both 2001 and 2002. Differences are also apparent, however, indicating that factors other than macroeconomic conditions were at play in determining the forecast errors.

It is noteworthy that during the period 2010-2014, the mean error for total taxes is less positive than during 1997-2007, meaning that taxes overshot their forecasts by less in the more recent period. This is particularly true for income tax and VAT, both of which underperformed relative to their forecast on average.

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[13] Much of the material in this section was previously presented in a box using data to 2012 in the April 2013 *Fiscal Assessment Report* (IFAC, 2013 pp. 30-31).

[14] We can use a slightly longer time period here: 1997-2014, as only the one-year forecast horizon is examined.

Table 2: *One-Year-Ahead Mean Errors by Tax Head*

ME	1997-2014	1997-2007	2008-2009	2010-2014
Income Tax	0.2	2.3	−8.6	−0.7
Excise	−2.1	−0.9	−16.0	0.8
Capital Taxes	−1.0	21.8	−128.8	0.0
VAT	−1.7	1.2	−20.7	−0.3
Corporation Tax	−3.0	0.6	−42.4	4.8
Other	1.8	7.9	−54.9	10.9
Total	−0.9	2.7	−24.7	0.9

Figure 8 shows that the largest RMSEs have been consistently in capital taxes and the "other" category, with the latter including stamp duties. As discussed above, the major influence of property market developments on these tax categories is reflected in the large positive MEs during the boom years, as revenues from this source were underestimated, followed by even larger negative errors (overestimates) during the subsequent correction.
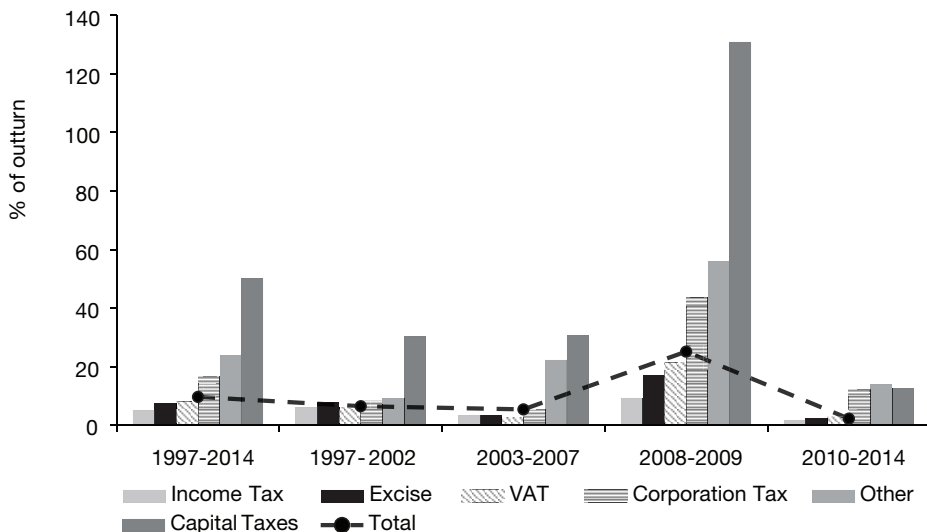
Figure 8: *One-Year-Ahead RMSE by Tax Head*

Figure 9 shows the contributions of each tax head towards overall errors. It has generally been the case that the largest tax categories have made the greatest contributions to forecasting errors over the 1997-2014 period. VAT accounted for the greatest proportion of the forecasting errors in both 2008 and 2009, due mainly to the unforeseen collapse in property related and

consumption expenditure.[15] A decomposition of the errors, presented in Section IV, suggests that effects of VAT policy changes[16] and one-off items were also overestimated in these years. Corporation tax made the second largest contribution to the error during this period, as yields fell by over 20 per cent in both 2008 and 2009 against the background of a broad deterioration in the international economic environment. Although capital and "other" taxes contribute only a small proportion of the total tax take, the contribution of these taxes toward the overall error became quite significant between 2003 and 2009. For example, in 2005, capital and "other" taxes contributed 13 per cent to total tax revenue but accounted for over two-thirds of the forecasting error. The contribution of income tax errors is particularly small in the post-2009 period as even during the introduction of the USC in 2011. Smaller errors feature across many of the other tax categories post-2009 where we can again see that the error for total tax revenue is less positive than it had been during most of pre-2008 period.

Figure 9: *Contribution of Each Tax Head to the Overall Error*
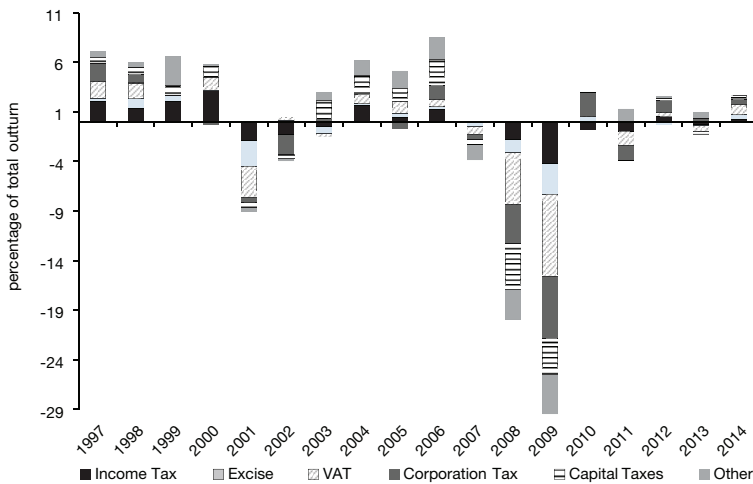
Sources: Department of Finance and author calculations.
Note: Forecast error = Outturn – forecast, where forecast includes adjustment for judgement.
*2009 contained a Supplementary Budget.

[15] Addison-Smyth and McQuinn (2010) report that VAT receipts relating to new housing accounted for almost a quarter of VAT receipts in 2007. The Department of Finance forecast that real consumption would grow by 3.8 per cent and 0.5 per cent in 2008 and 2009 respectively. Data from the CSO's National Income and Expenditure Accounts 2014 shows that the actual growth rates were 0.3 per cent in 2008 and -5.3 per cent in 2009.
[16] Changes in VAT charged on supplies in the construction sector were expected to yield €49 million in 2008. Also, the standard rate of VAT was increased from 21 to 21.5 per cent in December 2008. This measure was expected to yield €227 million in a full year.

IV ERROR DECOMPOSITION[17]

4.1 *Data and Methodology*

To gain further insight into the sources of the errors, we decompose one-year-ahead errors for four of the main tax heads (VAT, corporation tax, excise and the "pay as you earn" (PAYE) component of income tax). Three types of errors are identified: starting point errors, i.e. errors that are caused by using an incorrect estimate of the yield for a particular tax in the current year (Rev_t in Equation 1); macro driver errors, i.e. errors that are caused by using an incorrect projected growth rate in the macro driver (B_{t+1}^G in Equation 1); and other errors which are caused by using incorrect estimates of any other component of the forecast, i.e. one-off items in the current year and the next year (T_t and T_{t+1}), the static yield from any changes in policy for the coming year (M_{t+1}), the judgement factor for the coming year (J_{t+1}) and the elasticity, E, which the Department of Finance assumes is 1 for most tax heads (an exception is the PAYE component of income tax).[18]

First, the Department of Finance forecasts are replicated. This is done by collecting the data that were used at the time the forecast was made: in the case of VAT and corporation tax, data for Rev_t are taken from annual budget publications while the Department of Finance supplied these data for the PAYE component of income tax and for sub components of excise duty; data for M_{t+1} for each tax head are taken from Budget publications; information about B_{t+1}^G, T_t, T_{t+1} and E was provided to us by the Department of Finance for the years 2004-2014. We identify the judgement term, J_{t+1}, as the difference between the published forecast and the forecast that is generated using the information that was provided by the Department of Finance.

The forecast equations for VAT and corporation tax mirror Equation (1) presented earlier. The forecast for excise duty consists of two parts: the first part involves predicting the expected yield from Vehicle Registration Tax (VRT) (in which case the macro driver is the expected increase in sales of new cars multiplied by the expected increase in the price of new cars); the second part consists of forecasting excise duty minus VRT (in which case the macro driver is the projected growth rate in nominal personal consumption excluding cars and tourism spending).[19] In the case of PAYE, Equation (1) is adapted to include two macro drivers – the expected growth in non-agricultural wages and non-agricultural employment – each of which is multiplied by an elasticity factor

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[17] Some of the results in this section were presented in Analytical Note 3 as part of IFAC (2014).
[18] This approach ignores possible interactions between different sources of errors. It is likely that any interaction terms would be small and this approach greatly simplifies the analysis.
[19] In the case of excise, the measure of personal consumption expenditure is adjusted to include expenditure by Irish residents abroad and exclude expenditure of non-Irish residents in Ireland.

(see Section 2.2). The elasticities used to forecast PAYE are estimated by the Department of Finance and can vary over time. The employment elasticity has been close to one in recent years while the earnings elasticity has been between 2.1 and 2.2. In the case of other tax heads the elasticity, E, is assumed to be one.

Starting point errors can be identified by estimating Equation (1) using actual outturn data for Rev_t which is published in the end year Exchequer statement.[20] All other values in the equation are those that were used by the Department of Finance at the time the forecast was made. By comparing the number that is generated using this equation to the budget forecast we isolate the degree to which Rev_{t+1} is inaccurate due to the use of an incorrect estimate of the tax yield in the current year, that is at the start of the forecast period. For example, in the case of VAT, the total forecast error in 2012 was €176 million. This error falls to €166 million when the actual yield for 2011 (Rev_t) is used in place of the estimated yield. Thus, the starting point error in this case is €10 million. Similarly, we identify the macro driver error by estimating Equation (1) using the correct value for B_{t+1}^G, published in the National Income and Expenditure Accounts (NIE).[21] The "other" forecast error is calculated as a residual, i.e. the overall forecast error for a particular tax head minus the starting point error and the macro driver error. All errors are calculated in nominal values to facilitate aggregation and comparison. In the case of excise, the various types of errors are calculated for each subcomponent separately and are then combined in order to get the total excise starting point, macro driver and "other" errors.

The specific equations for each tax head are described in more detail in Appendix A. Due to data limitations, we cannot decompose the forecast errors for other components of income tax, capital taxes, customs duties or stamp duties, or for the period before 2004.

4.2 *Error Decomposition Results*

Because positive and negative errors from different sources can cancel each other out, we convert all errors to positive values and generate a "gross" error in absolute terms. We can then identify the contribution of each source of error to the overall error. Table 3 reports the average contribution made by each of the four tax heads to the gross error over the period 2004-2014. The

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[20] Outturn data for PAYE, VRT and excise excluding VRT are provided by the Department of Finance.

[21] In the case of a forecast made for the year 2011, outturn data for B_{t+1}^G are taken from the National Income and Expenditure Accounts (2014). Outturns for non-agricultural employment, which feeds into the PAYE forecast, are taken from the Quarterly National Household Survey (Q1 2015). In the case of VRT, outturn data for new car sales and prices were provided by the CSO.

peak contribution and the year in which it occurred are also shown. In Figures 10 to 13, the forecast error for each year is decomposed in nominal terms. Results show that both positive and negative errors were prevalent over the period.

In the case of VAT, the error peaked in absolute terms in 2009 when the error relating to the macro driver estimate (i.e. expected levels of consumption expenditure) accounted for 70 per cent of the gross error. Generally, however, the contribution of the macro driver error to the gross VAT error was much lower, accounting for approximately one-third of the total. The starting point errors were negative (the outturns were overestimated) in most years considered and accounted for the smallest proportion of the gross VAT forecasting error on average. The size and direction of the "other" error has fluctuated over time. It peaked in absolute terms in 2008. We cannot tell the extent to which the "other" error is influenced by mis-estimation of the cost of new policy measures (M_{t+1}), the level of judgement imposed on the forecast (i.e. the J_{t+1} component) or the effect of one-off items (T_{t+1}) being overstated. It is also possible that part of the other error pre-2008 is due to the fact that a portion of VAT receipts were related to the property market rather than ordinary consumption. Since 2009, the absolute size of VAT forecast errors has generally decreased. However, in some years (e.g. 2010) it has been the case that substantial positive and negative errors from different sources have offset each other, resulting in an overall forecast error that appears small.

Table 3: *Gross Errors 2004-2014*

|	% of Gross Error					
	Macro		*Starting Point*		*Other*	
	Avg.	*Peak (Yr. of Peak)*	*Avg.*	*Peak (Yr. of Peak)*	*Avg.*	*Peak (Yr. of Peak)*
VAT	30%	70% (2009)	8%	23% (2004)	62%	85% (2013)
PAYE	40%	89% (2009)	11%	38% (2011)	49%	85% (2012)
Corporation Tax	18%	51% (2014)	23%	73% (2013)	59%	89% (2006)
Excise	42%	83% (2006)	18%	60% (2014)	41%	83% (2007)

Figure 10: *VAT*
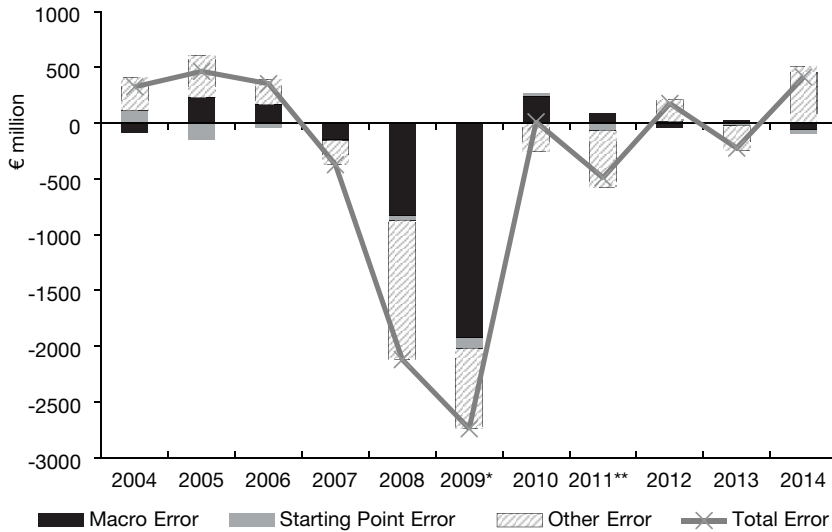
Sources: Department of Finance and author calculations.
Note: Forecast error = Outturn − forecast, where forecast includes adjustment for judgement.
* 2009 Contained a Supplementary Budget.
**The Jobs Initiative 2011 levied a reduced 9 per cent VAT rate on the tourism sector.
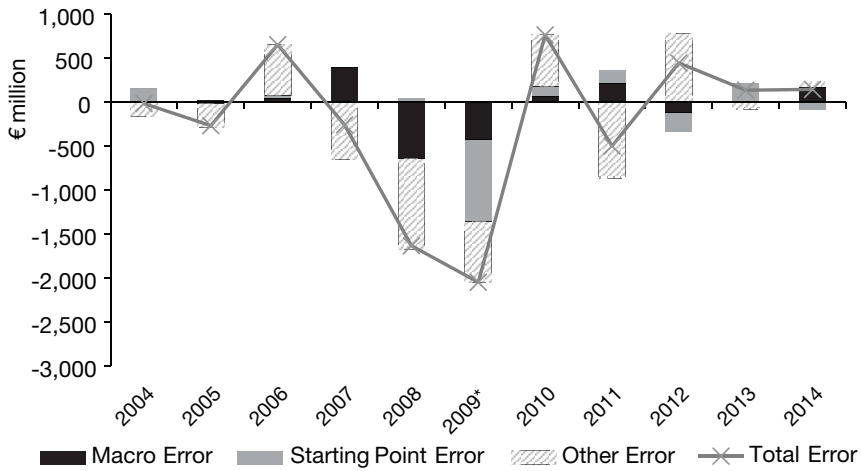
Figure 11: *PAYE*
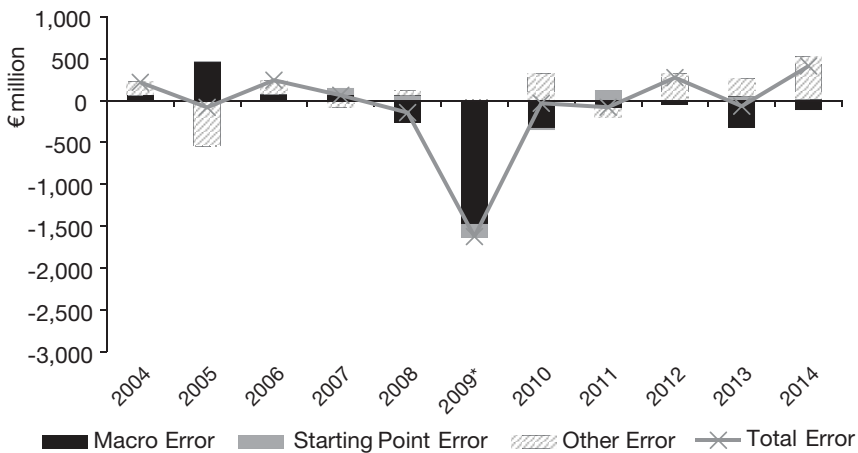
Sources: Department of Finance and author calculations.
Note: Forecast error = Outturn − forecast, where forecast includes adjustment for judgement.
*2009 contained a Supplementary Budget.
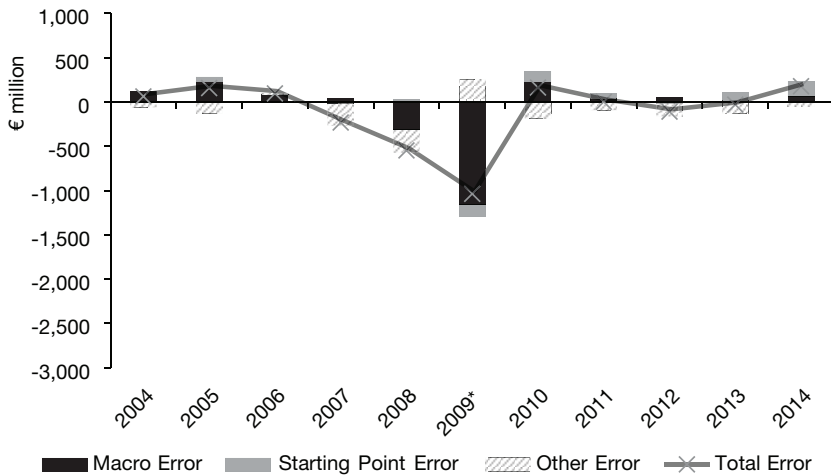
Figure 12: *Corporation Tax*

Sources: Department of Finance and author calculations.
Note: Forecast error = Outturn – forecast, where forecast includes adjustment for judgement.
*2009 contained a Supplementary Budget.

Figure 13: *Excise*

Sources: Department of Finance and author calculations.
Note: Forecast error = Outturn – forecast, where forecast includes adjustment for judgement.
*2009 contained a Supplementary Budget.

The total PAYE error peaked in 2009, having been overestimated by some €1.6 billion (19 per cent of the outturn for that year). The macro driver accounted for 89 per cent of the gross error that year. On average, however, "other" errors made the largest contributions (49 per cent) towards the gross PAYE forecasting error over the 2004-2014 period. PAYE errors are small compared to the other tax heads with the only large error coming in 2009 due to the size of the macro error. The contribution of starting point errors to the gross error has been small (11 per cent on average) due to the fact that PAYE receipts do not fluctuate much from month to month.

Corporation tax forecasts errors have also been well distributed above and below zero since 2004. Figure 12 shows that they peaked in 2009, with contributions from all three types of error. The biggest contributor was the starting point error (45 per cent of the gross error), reflecting, in part, the unexpected decline in company profits in 2008. In most years considered, however, the "other" errors accounted for the greatest proportion of the forecasting error (59 per cent of the gross error on average) reflecting the difficulty in predicting the effects of Irish policy changes[22] and the external environment on already volatile levels of corporation tax revenue.[23] Until 2008, the macro driver used for corporation tax was the predicted change in the level of nominal GDP. In an effort to improve forecasting performance following the TFMRG 2008 report, the macro driver has been Gross Operating Surplus (GOS) (i.e. GDP less taxes and compensation of employees, plus subsidies) since 2009. An analysis of the forecast errors for both of these variables indicates that on average the move to GOS had only a small positive effect on the accuracy of the forecasts.[24] Starting point errors have been most significant for corporation tax, reflecting the somewhat lumpy nature of corporate tax revenues often received towards the end of the year.

In the case of excise, errors in the macro driver and starting point contribute almost evenly to the gross error. Macro driver errors accounted for approximately 42 per cent of the error on average over the relevant period and made the largest contribution on six of the eleven occasions considered. Separate decompositions of the forecasts for excise excluding VRT and VRT itself are shown in Appendix B. Results indicate that the large excise duty

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[22] Although the rate of corporation tax has not changed since 2003, various policy changes have been introduced, for example, incentives for expenditure on research and development, changes in liability depending on accounting periods, or alternative thresholds for start-up/small companies.
[23] As noted above, corporation tax receipts are highly concentrated among several large corporations in the external sector.
[24] Over the four year period (2009-2013 inclusive), the RMSE for nominal GDP was 25 per cent whereas for GOS it was 21 per cent. Nominal GDP forecasts performed better than GOS forecasts in 2011 and 2012 whereas GOS performed better in all other years.

errors in 2008-2009 were driven by poorer than expected levels of VRT.[25] Appendix B also shows that VRT errors are driven by macro errors while starting point errors tend to be particularly small. As very few cars are sold in the month of December, it may be easier to predict Rev_t for VRT than is the case for other tax heads.

In general, these decompositions suggest that the relative contribution of different error sources towards the overall error varies over time and by tax head. The exercise reveals that, on occasion, relatively small overall forecast errors mask larger offsetting component errors. A brief analysis of the correlations between the errors from the various sources did not reveal any discernible pattern, however. The IMF (2005) stated that "revenue forecast errors can be largely explained by errors in the outlook for growth" for the 1991-2003 period. The analysis presented here indicates that, while macro driver errors accounted for substantial portions of the errors in many cases, the "other" component had at least an equal if not more significant impact on forecasting accuracy over the 2004-2014 period. This finding was consistent across the four key tax heads. Thus, it is clear that tax revenue errors are not simply reflecting errors in the macro forecasts.

V ADJUSTMENTS TO THE FORECASTS

In some cases forecasters may seek to make adjustments to the forecast beyond those made to account for one-offs or policy changes. This may be due to the forecasting procedure persistently over- or underestimating the tax yield in the past, or due to a belief that some part of agents' behaviour with regard to the tax may change in a way that cannot accurately be picked up by the macro driver.[26] In this section, we take a more in-depth look at this judgement term, given the obvious potential for bias to enter into the forecasting process through this avenue. Specifically, we estimate the degree to which one-year-ahead forecasts for VAT, corporation tax, excise and PAYE were subjected to discretionary upward or downward adjustments by the Department of Finance. We do this by estimating the forecast equations described in Section 2.2 (and Appendix B) for the years 2004-2014 using the same data as was used by the Department of Finance at the time the forecast was made. The judgement term

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[25] According to the Department of Finance (2010), car sales declined by 19 per cent in 2008 and by 63 per cent in 2009. These declines, combined with an increase in car price competition, and the tendency towards buying cheaper and cleaner cars (where the VRT rates are lower), significantly reduced the VRT yield.

[26] For example, the Department of Finance may believe that growth in consumption could be more tax rich in future years and wish to adjust for that.

J_{t+1} is omitted from the estimation (we refer to these forecasts as "unadjusted" forecasts). We then compare the resulting values to the forecasts that are published in the annual budgets (we refer to these forecasts as "adjusted" forecasts because they are altered by the judgement term J_{t+1}). We also analyse the effect of such adjustments on overall forecast errors.

Figures 14 to 17 show the size and direction of adjustments (i.e. the size of J_{t+1} as a percentage of the overall forecast) that were applied to VAT, PAYE, corporation tax, and excise forecasts respectively between 2004 and 2014. The absolute size of the adjustments as well as the size of the adjustment as a percentage of the yield for the relevant tax head is shown in Appendix D. As a percentage of overall forecasts, adjustments appear relatively small: the biggest adjustments were applied to corporation tax (the absolute value of the adjustment amounted to 7.7 per cent of the forecast on average), followed by PAYE (6.2 per cent of the forecast on average). The average adjustments applied to excise and VAT forecasts were much smaller (1.6 per cent and 1.4 per cent respectively). In the case of corporation tax, the biggest adjustment was applied in 2010 where forecasts were adjusted downwards by over €800 million (26 per cent of the forecast for that year). The biggest excise adjustment occurred in 2009 when the forecast was adjusted downwards by €196 million (3.4 per cent of the forecast).[27] The largest adjustment to the VAT forecast occurred in 2009 – a downward adjustment of almost €800 million (5.8 per cent of the forecast for that year) – despite an increase of 0.5 per cent in the standard VAT rate that year.[28] The biggest adjustments to PAYE forecasts occurred before the crisis where forecasts were adjusted upwards by 12 per cent in 2004, 2005 and 2006. (This followed three years of income tax underestimations of 6, 4 and 2 per cent respectively).

For VAT, corporation tax and PAYE, the majority of adjustments were in an upward direction. In the case of excise, however, downward adjustments were consistently applied between 2004 and 2011. This pattern was reversed in 2012 when a small upward adjustment (less than 1 per cent of the excise forecast) was imposed. Although forecasts are routinely adjusted by the Department of Finance, in general, the adjustments are relatively small.[29]

Also shown in Figures 14 to 17 are the forecast errors that resulted after adjustments had been applied to the forecasts (i.e. the difference between the

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[27] This adjustment coincided with a measure to reduce excise on alcohol which was expected to cost approximately €90 million in 2010. This measure, however, should be captured in the term M_{t+1} rather than J_{t+1}.

[28] The standard rate was increased from 21 per cent to 21.5 per cent and was expected to yield €208 million in 2009.

[29] An exception is the VRT component of excise duty. Between 2004 and 2012, the VRT forecast was adjusted on only one occasion: a downward adjustment of €67 million in 2010.

actual outturn and the forecast published by the Department of Finance). Where the adjustment and the error are in the same direction, it indicates that the judgement improved the forecast accuracy. For example, in the case of a positive forecast error, the actual outturn was underestimated. If this forecast included a positive adjustment, this use of judgement to bring up the forecast resulted in the underestimation being smaller than it would otherwise have been.

Adjustments made by the Department of Finance improved the accuracy of the VAT forecasts in six of the eleven years considered. With regard to corporation tax and excise, adjusted forecasts exhibited smaller forecast errors than non-adjusted forecasts on four and six occasions respectively. With regard to PAYE, adjustments improved the accuracy of the forecasts in all years considered and by a significant amount in each year.

Figure 14: *Adjustments to VAT Forecasts and the Forecast Error*
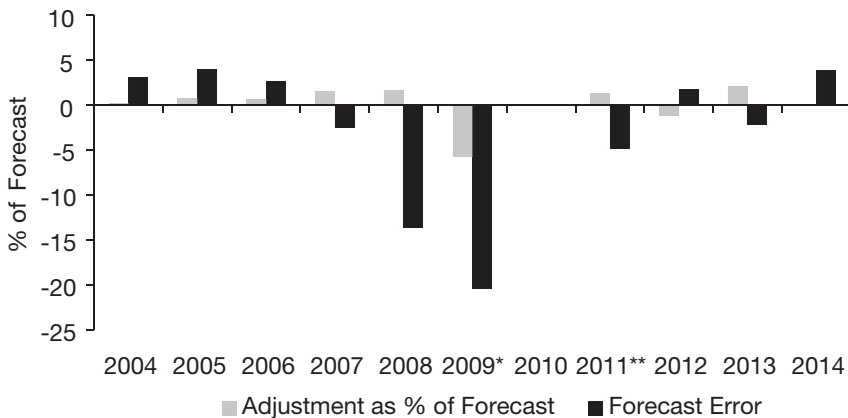
Sources: Department of Finance and author calculations.
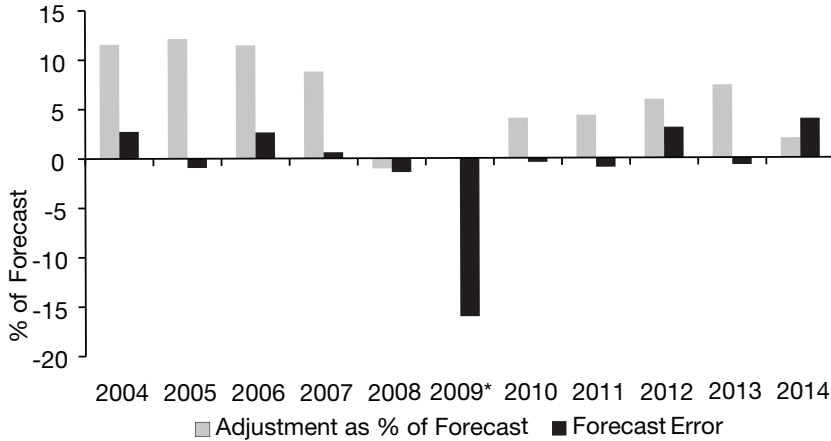*Note:* Forecast error = Outturn – forecast, where forecast includes adjustment for judgement.
* 2009 Contained a Supplementary Budget.
**The Jobs Initiative 2011 contained some small VAT policy changes.

The ME and RMSE for forecasts with and without adjustments are shown in Tables 4 and 5. For each tax head, the RMSE and ME are calculated over the period 2004-2014 and for three sub periods: 2004-2007; 2008-2009; 2010-2014. Results confirm that, on average, the errors for adjusted forecasts were smaller than those for unadjusted forecasts. In the case of PAYE, adjustments greatly reduced the MEs and RMSEs in all sub-periods considered. VAT and excise adjusted forecasts performed better than non-adjusted forecasts in all periods with the exception of 2010-2014 (as measured by the RMSE). The

adjustments to corporation tax reduced the ME and RMSE in the 2004-2007 period only.

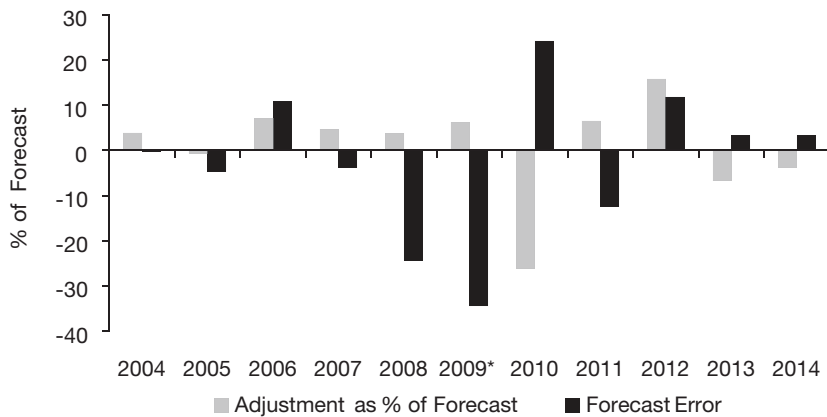Figure 15: *Adjustments to PAYE Forecasts and the Forecast Error*

Sources: Department of Finance and author calculations.
Note: Forecast error = outturn – forecast, where forecast includes adjustment for judgement.
*2009 contained a Supplementary Budget.

Figure 16: *Adjustments to Corporation Tax Forecasts and the Forecast Error*

Sources: Department of Finance and author calculations.
Note: Forecast error = outturn – forecast, where forecast includes adjustment for judgement.
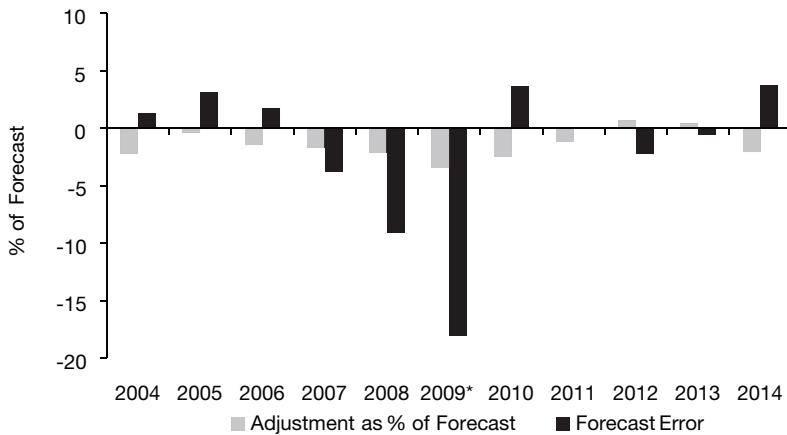*2009 contained a Supplementary Budget.

Figure 17: *Adjustments to Excise Forecasts and the Forecast Error*

Sources: Department of Finance and author calculations.
Note: Forecast error = outturn – forecast, where forecast includes adjustment for judgement.
*2009 contained a Supplementary Budget.

As can be seen in Tables 4 and 5, the application of judgement to the outcome of the forecasting equation to form the final tax forecasts has improved the forecasts in most cases. The fact that the adjustments have mostly had the effect of reducing RMSEs across tax heads suggests that they reflect an attempt to improve the accuracy of the forecasts, rather than an attempt to unjustifiably move the forecasts to what is considered a "better" outcome based on bias.

Table 4: *Mean Error for Unadjusted [30] and Adjusted Forecasts*

Mean Error	2004-2014		2004-2007		2008-2009		2010-2014	
	Unadd	Adjusted	Unadd	Adjusted	Unadd	Adjusted	Unadd	Adjusted
VAT	−4	−4	2.5	1.7	−23.4	−20.7	0.2	−0.3
Corporation Tax	−4.2	−6.5	3.7	0.1	−35.2	−42.4	2.5	4.4
Excise	−4.8	−3.2	−0.9	0.5	−19.3	−16	0	0.9
PAYE	4.9	−1.5	12.1	1.2	−10.8	−10.3	5.7	0.9

[30] We refer to unadjusted forecasts as forecasts that do not include the judgement term J_{t+1}. The adjusted forecast is that which includes the judgement term and was published in the annual Budget.

Table 5: *RMSE for Unadjusted and Adjusted Forecasts*

RMSE	2004-2014		2004-2007		2008-2009		2010-2014	
	Unadd	Adjusted	Unadd	Adjusted	Unadd	Adjusted	Unadd	Adjusted
VAT	11.5	9.9	3.2	3.1	25.3	21.3	2.4	3.1
Corporation Tax	18.9	21.5	8.7	5.8	36.1	43.6	11.6	11.9
Excise	9.4	8	3.2	2.7	20.5	17.1	1.2	2.5
PAYE	10.6	6.3	12.2	1.9	13.7	13.5	6	2.2

VI: CONCLUSIONS

From the analysis conducted in this paper, we conclude that Department of Finance's forecasting errors are relatively large by international standards. With regard to bias, while judgement is routinely applied to the outcome of the tax forecasting equations, the adjustments usually improved the accuracy of the forecast and we find no evidence that this judgement is exercised in a systematic way with a view to biasing the forecasts in a particular direction.

It has generally been the case that the largest tax categories have made the greatest contributions to forecasting errors over the 1997-2014 period. As this incorporated the recent economic crisis, however, there were unusually large errors observed in certain years, leading to significant contributions from some of the smaller tax heads to the forecast errors for overall tax revenue. A decomposition of the overall errors into errors arising from macro driver errors, starting point errors and "other" sources, reveals an important contribution from errors associated with the macro driver for the tax head in question. This is partly in line with the finding on the role of macroeconomic forecast errors in IMF (2005) for an earlier time period. However, we also find that the "other" category routinely accounts for a very significant portion of the errors. This residual category by definition is a "catch-all" and includes errors arising from estimates of the static impact of policy changes, of one-off items, of elasticities and an element of judgement applied by the Department of Finance.

The dominant role played by this "other" source of forecasting error suggests that the relatively weak forecasting record for Ireland is not simply an inevitable consequence of the macroeconomic uncertainty associated with a small open economy and that careful review of the forecasting process may yield improvement. The smaller errors noted in Section 3.2 post-2009 are consistent with a positive impact from the implementation of some of the recommendations of the TFMRG (2008) report, underpinning the potential value of engaging again in this type of exercise, where the choice of macro drivers and elasticity assumptions were reviewed. The report also recommended incorporating

additional information sources in the forecasting process. The difficult fiscal period experienced in Ireland and other countries recently has spurred new research on identifying windfall revenues, for example, that could provide guidance on how to augment current procedures for forecasting and monitoring tax revenues. (In addition to Addison-Smyth and McQuinn (2010) referred to earlier, see, for example, Morris *et al*. (2009) for a multi-country analysis).

It appears, however, that no formal review of the tax forecasting methodology has been undertaken since the 2008 TFMRG study. While internal reviews may occur periodically within the Department of Finance, the additional benefits of a more formal and public review, with inputs from a broader group of experts and users, would suggest another review is overdue. Indeed, a more regular analysis of the tax forecasting performance was a key recommendation of the 2008 review. In addition, the periodic publication of more detailed information, such as on the role of judgement, on how the static impact of tax changes are calculated, on the impact of one-off factors and the evolution of elasticities over time, for example, would facilitate greater understanding of the forecasts generally and allow for more detailed investigations by outside analysts. It is noteworthy that much of the data used to conduct the decompositions in this paper were not publicly available. A greater level of transparency would likely bolster confidence in the official forecasts, as it would enable more rigorous independent and regular assessment of the size and source of forecast errors, and whether the forecasts suffer from bias.

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APPENDIX A

Summary of the Tax Forecasting Methodology Review Group recommendations

Table A1: *TFMRG Recommendations*

Recommendation	Implemented?
Maintain aggregate tax-to-GDP elasticity of 1.0 as a "top-down" check on the "bottom-up" forecasting approach.	Yes
Complement VAT forecasting with approach which projects VAT receipts from new housing separately.	No published evidence (but reportedly used internally by the Department to inform judgement)
Forecast corporation tax using Gross Operating Surplus in conjunction with nominal GDP.	Yes
Continue using new housing output and prices to project stamp duty from residential property while using investment in building and construction for stamp duty from non-residential property.	Yes
Continue the cautious approach to forecasting property related tax revenue.	Yes
Investigate the possibility of providing a more detailed breakdown of VAT.	No published evidence
Undertake more regular analysis of the tax forecasting performance.	No major subsequent review published.

Source: TFMRG (2008).

APPENDIX B

The following equation can be used to summarise the VAT forecasting process:

$$VAT_{t+1} = (VAT_t - T_t)((1 + (dPCN_{t+1})E) + T_{t+1} + M_{t+1} + J_{t+1}$$

where VAT_{t+1} is the forecast for VAT in the coming year, VAT_t is an estimate of the yield in the current year, T_t are one-off items affecting the yield in the current year and $dPCN_{t+1}$ is the projected growth rate in nominal personal consumption expenditure adjusted for tourism spending for the coming year, E is the elasticity between VAT revenue and the tax base, assumed to be 1, T_{t+1} are one-off items affecting the yield in the coming year, M_{t+1} is the estimated static yield from any changes in policy and J_{t+1} is a judgement factor applied by the Department of Finance.

The procedure for forecasting corporation tax can be summarised using the following equation:

$$Cor_{t+1} = (Cor_t - T_t)((1 + (dGDP_{t+1})E) + T_{t+1} + M_{t+1} + J_{t+1}$$

where Cor_{t+1} is the forecast for corporation tax in the coming year, Cor_t is an estimate of the yield in the current year and $dGDP_{t+1}$ is the projected growth rate in nominal GDP for the coming year. Nominal GDP was used as the macro driver until 2008. From 2009 onwards, gross operating surplus was used. T_t, E, T_{t+1}, M_{t+1}, and J_{t+1} are defined above.

The forecasting procedure for excise involves two strands, the first of which is to estimate excise that is collected from Vehicle Registration Tax (VRT). The second strand forecasts excise that is collected from all other sources.[31] The procedure can be summarised using the following equations:

$$VRT_{t+1} = VRT_t((1 + dPNC_{t+1})(1 + dVNC_{t+1})) + T_{t+1} + M_{t+1} + J_{t+1}$$

VRT_{t+1} is the forecast for Vehicle Registration Tax in the coming year, VRT_t is an estimate of the VRT yield in current year, $dPNC_{t+1}$ is the projected increase in the price of new cars while $dVNC_{t+1}$ is the projected increase in the volume of new car sales. All other variables are defined above. The second equation can be summarised as follows:

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[31] There are three main categories of excisable products: mineral oils; alcohol and alcoholic beverages; and manufactured tobacco. Excise duties are also chargeable on certain premises and activities (e.g. on betting and licenses for retailing of liquor). In Ireland, carbon tax, VRT and air travel tax are also collected as part of excise duty. The rates that apply to each excisable item can be found at http://www.revenue.ie/en/tax/excise/duties/excise-duty-rates.html.

$$Exc_{t+1} = (Exc_t - T_t)((1 + (dPCA_{t+1})E) + T_{t+1} + M_{t+1} + J_{t+1}$$

Exc_{t+1} is the forecast for excise excluding VRT in the coming year, Exc_t is an estimate of the excise excluding VRT yield in current year, and $dPCA_{t+1}$ is the projected growth rate in nominal personal consumption adjusted for tourism and excluding cars.

PAYE accounted for approximately 73 per cent of total income tax revenue in 2012. The PAYE forecasting process can be summarised as follows:

$$PAYE_{t+1} = (PAYE_t - T)_t((1 + (dY_{t+1})E^Y_{t+1})(1 + (dM_{t+1})E^M_{t+1})) + T_{t+1} + M_{t+1} + J_{t+1}$$

where $PAYE_{t+1}$ is the forecast for PAYE in the coming year and $PAYE_t$ is an estimate of the yield in the current year. dY_{t+1}, the projected growth in non-agricultural wages, is multiplied by an earnings elasticity E^Y_{t+1} and dM_{t+1}, the projected growth in non-agricultural employment, is multiplied by an employment elasticity E^M_{t+1}. All other variables are defined above.

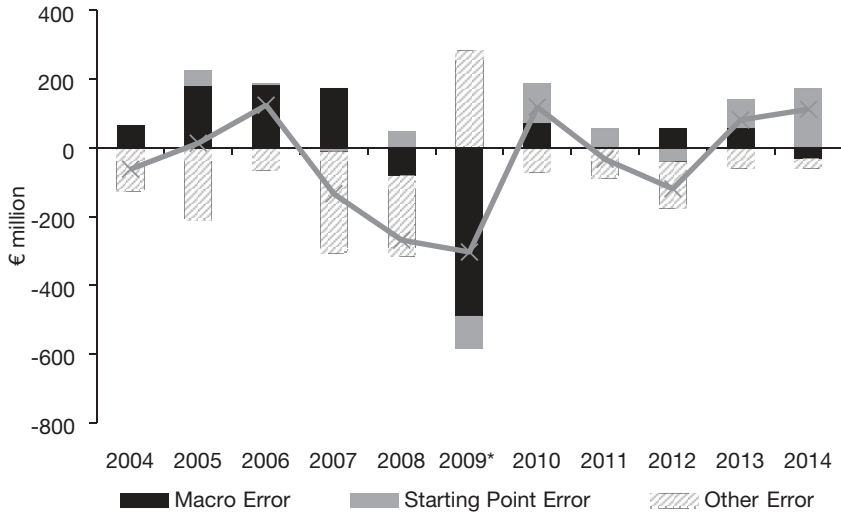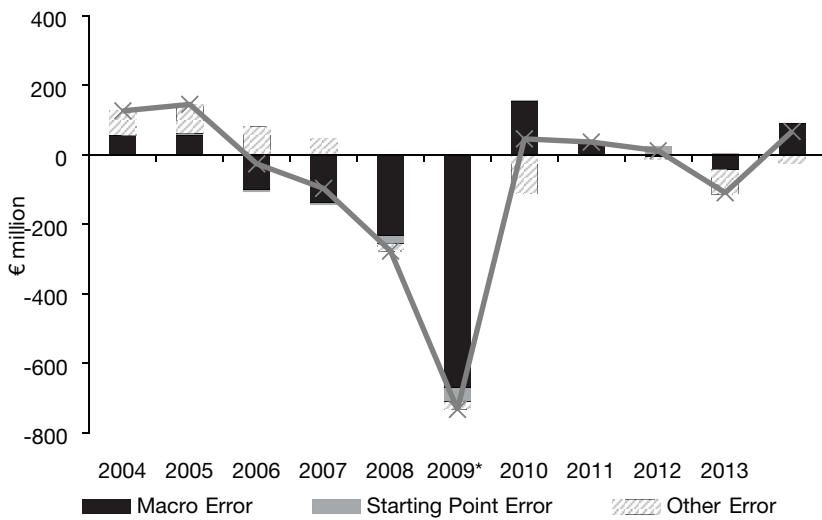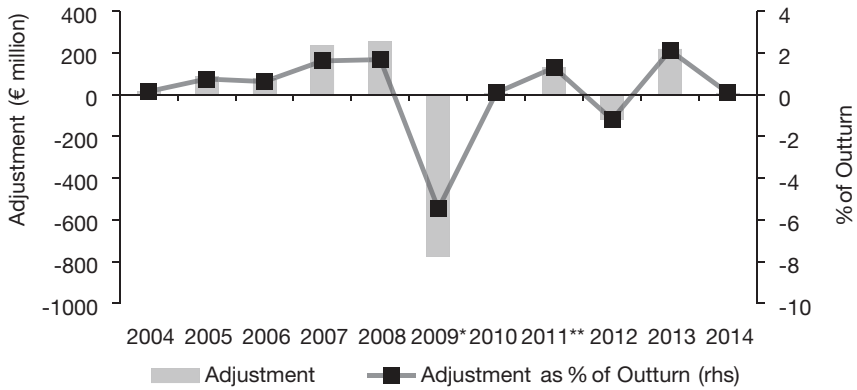APPENDIX C

Figure C1: *Excise excluding VRT*

Figure C2: *VRT*

APPENDIX D

Figure D1: *Adjustment to VAT Forecasts*

Note: The size of the adjustment is shown on the left axis whereas the adjustment as a percentage of the outturn is shown on the right axis.

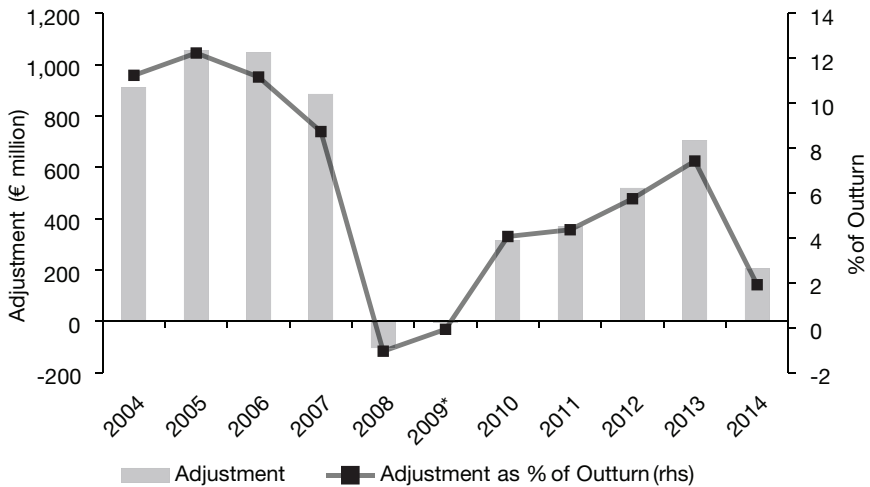### Figure D2: *Adjustment to PAYE*
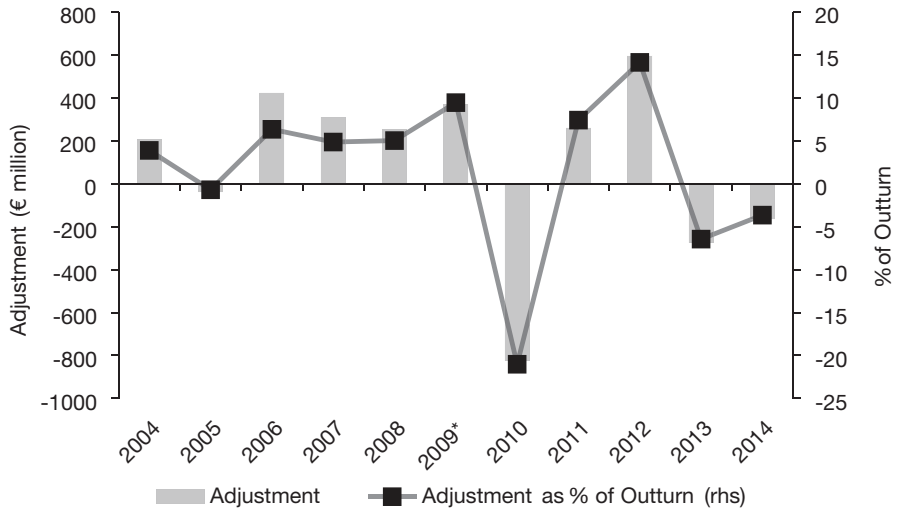
Figure D3: *Adjustment to Corporation Tax Forecasts*

Figure D4: *Adjustment to Excise Forecasts*