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## *Working Paper No. 538*

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### *Efficient Frontiers and Fiscal Stability: An ex-ante and ex-post Application to the Irish Public Finances*

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*Abstract: Revenue from taxation has become more volatile after the global financial crisis. In this paper we provide a mean-variance analysis for key taxation components in the Irish fiscal accounts. This approach is a useful complement to the more standard measures of fiscal developments, which typically focus on aggregate public finance indicators. In an Irish context, the analysis reveals that for a given taxation return, sourcing an increased amount of revenue from direct as opposed to indirect sources of taxation post 2008 would have provided a more stable fiscal environment.*

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## 1. Introduction

The difficulties in the public finances of many countries due to the financial crisis of 2007/08 has prompted the adoption of measures seeking more sustainable public finances.<sup>1</sup> At a European level, a range of initiatives have been undertaken over the past number of years to consolidate the Stability and Growth pact with the emergence of more fiscal rules (with stricter caps on government spending and borrowing) and greater levels of macroeconomic and fiscal surveillance.<sup>2</sup> Central to these fiscal rules is the limiting of discretion amongst policy-makers via explicit quantitative limits on relevant fiscal aggregates being set. Another policy development within the EU, the establishment of independent fiscal institutions/councils,<sup>3</sup> also focuses on 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, that they are not, in themselves, as argued by Addison-Smyth and McQuinn (2016), fully sufficient to identify underlying fiscal vulnerabilities. For example, focusing on overall aggregate fiscal indicators may obfuscate trends in the composition of taxation receipts leading to greater fiscal fragility. Thus, as a complement to standard measures of assessing fiscal developments, we argue for more granular assessments aimed at understanding both the movements and co-movements of different taxation aggregates. Specifically, for a given rate of growth in the public finances of a particular country, can the composition of those taxation receipts be changed to reduce the underlying volatility of the exchequer position or alternatively, for a given level of uncertainty, can overall taxation receipts be increased?

To examine this, we apply a mean-variance analysis, popular in the finance literature, to Irish exchequer receipts over the period 1984 to 2015. The Irish fiscal position experienced particular volatility over the recent 10 year period. Notably, we estimate the efficient frontier based both on the ex ante forecasts of the taxation components and the

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<sup>1</sup>For a description on the fiscal framework within Europe, see European Commission (2013).

<sup>2</sup>In an Irish context, the Medium-Term Budgetary Framework (Department of Finance, (2014)) outlines the domestic operation of the European framework.

<sup>3</sup>For more on fiscal councils see Hagemann (2011).

ex post outcomes, where the former are provided in the “budget books” of the Irish Department of Finance. Our analysis reveals that a significant improvement of average total taxation revenue growth to its volatility could have been achieved if a greater proportion of taxation revenue came from direct as opposed to indirect sources.

## 2. Data and the Irish fiscal experience

Over the past 30 years Irish fiscal indicators have experienced a particularly turbulent nature. Figure 1 plots the Irish General Government Balance and Government debt over the period 1985 to 2016. In the mid 1980s, as Government expenditure significantly outpaced growth in the general economy, the Irish public finances deteriorated considerably. From 1985 to 2002, the public finances steadily improved as the economy grew - the latter half of which included the Celtic Tiger era. From 2003 to 2007, the fiscal position dramatically improved helped in part by the heightened level of activity in the Irish housing market (see McCarthy and McQuinn (2013) for more on this). However, 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 monitored from exchequer tax data. In Figure 2, we plot both total exchequer receipts as well as the shares of the main components: income tax, excise duty, corporation tax, value added tax (VAT) and other taxes. Exchequer tax receipts capture cash inflows into central government. 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.

Clearly, the different components of the exchequer receipts display differing returns and volatility. Consequently, a framework which illustrates the trade off between the risk and returns of these taxation items would provide useful information to policy makers in appraising the stability of the public finances.

### 3. Model

Crain (2003) is one of the first applications to examine whether the expected return and risk trade-off found in financial markets also applies in a fiscal context; in this case the relationship examined was that between a US state's economic growth, volatility and its tax revenues. Cornia and Nelson (2010) also conduct a similar assessment across US states. However, few if any applications in a European context, have examined the risk and return trade-off of individual taxation components.

The efficient frontier is the set of optimal combination of assets (portfolios) offering the highest expected return for a defined level of risk or the lowest risk for a given level of expected return. Portfolios that lie below the efficient frontier are sub-optimal, because they do not provide enough return for the level of risk. Portfolios that cluster to the right of the efficient frontier are also sub-optimal, because they have a higher level of risk for the defined rate of return. In this case, the efficient frontier is estimated over the main taxation aggregates in Figure 2 and is given by

$$\begin{aligned}
 & \max_{w_i} \quad \overline{\Delta T} \quad \text{subject to} \\
 & \sigma_{\Delta P} = \sqrt{\sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_{ij}} \\
 & \overline{\Delta T} = \sum_{i=1}^N w_i \overline{\Delta T}_i \\
 & \sum_{i=1}^N w_i = 1 \\
 & upper_i \geq w_i \geq lower_i \quad \forall i
 \end{aligned}$$

where  $\sigma_{ij}$  are the covariances of percent changes in tax revenue sources,  $w_i$  is a column vector of weights,  $\overline{\Delta T}$  is the average percentage change in total tax revenue,  $\overline{\Delta T}_i$  is the average percentage change in tax revenue sources.

The first constraint is the risk on a weighted mix of tax revenue sources (in percentage changes). The second constraint is the average percentage change in total tax revenue which is a weighted sum of percentage changes in tax revenue sources. The third constraint is that portfolio weights sum to unity. The fourth constraint places upper and lower bounds on the percentage weights on the different taxation components.

In this context the bounds may be thought of reflecting constraints on policy-makers from moving from one source of taxation to another possibly due to the underlying structure of the economy.<sup>4</sup>

## 4. Results

In the empirical application two sets of bounds are used; in the first set, the upper and lower bounds are based on the share of total tax revenue for each revenue source. In the second set as a control, the upper and lower bounds are 1 and 0. The efficient frontiers in mean and standard deviation space are estimated using three data periods, 2000-2007, 2008-2015 and 1985-2015. Separating the sample either side of 2007 is particularly appropriate owing to the disproportionate impact of the international financial crisis on the Irish economy. The frontiers are estimated using annual time series on both (a) the actual and then (b) the Budget Book forecasts of mean percentage change in each tax revenue source.

The results based on the actual mean percentage change are presented in Tables 1 to 3 and Figures 3 to 8. The efficient frontiers based on the actual share of the taxes are very short when compared with the (0,1) bounds i.e. if policy makers had complete discretion in sourcing taxation revenues, the potential trade-off in risk return possibilities would be greater. A red dot with a short label indicates the mean and standard deviation of a tax revenue source. For example, income tax is labeled IT. One green dot indicates

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<sup>4</sup>In a finance context, these bounds may be thought of as minimum and maximum holding requirements.

the mean and standard deviation of the percentage change for actual total revenue which is an inefficient mix of tax revenue sources in all time periods. It is south-east of the blue efficient frontier. The other green dot indicates risk and average percentage change for total revenue based on an efficient set of tax weights which gives a superior mean and standard deviation of the percentage change. In each case, the actual percentage change for total revenue is targeted and the risk attached to the efficient tax mix is then calculated. The reduction in risk can be either observed from the figures or calculated in any of the tables.

The results when the forecasted mean percentage change in each tax revenue source is used are presented in Tables 4 to 6 and Figures 9 to 14. These forecasts are 1 year ahead and compiled from the Irish Department of Finance's "Budget Book Forecasts". Consequently, the frontiers based on these forecasts can be interpreted as ex-ante measures of risk. The forecasts tend to over exaggerate the average rate of growth in revenue during the boom period (2000-2007) vis-à-vis what actually happened. In contrast, forecasts of average growth percentage changes in revenue are more pessimistic during the recession period (2008-2015). Overall, therefore, the forecasts tend to be more volatile. As a result, as can be seen from both the figures and tables, the reduction in risk tends to be lower when the forecasts are used.

Over the entire period (1985-2015), a larger weight on income tax would have reduced the standard deviation of the exchequer receipts for the same, given return. However, the biggest improvement in achieving a better mean and standard deviation of total revenue growth would have been in the 2008-2015 period if there was a larger weight on income tax and a smaller weight on VAT. One possible reason may be the exceptionally volatile nature of the Irish housing market over this period. As noted in previous research (Addison-Smyth and McQuinn (2010, 2016)), certain Irish taxation categories such as VAT became heavily linked to developments in the Irish property sector for the post 2000 period. From Figure 15, which charts the coefficient of variation<sup>5</sup> for GDP and house prices over this period, the relative volatility in house prices after 2008 is clearly evident.

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<sup>5</sup>The 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. In this case a rolling 5 year window is used.



Interestingly, the results found, in an Irish context, for income taxes and VAT contrasts with those of Cornia and Nelson (2010) in the case of US state revenues. Over the period 1994 - 2009, Cornia and Nelson (2010) find that, while a sales tax offers stability but at the cost of a lower growth rate, individual income tax offers growth but at the cost of increased volatility.

## 5. Concluding Comments

The application of mean-variance analysis in a fiscal policy context provides policy makers with an additional, well established rigorous tool in assessing the sustainability of the public finances. By applying the approach to different sources of taxation, it can be thought of as a useful, granular complement to measures which focus on overall fiscal indicators such as the General Government Balance and the Government debt to GDP ratio. As such it complements other granular assessments of the public finances such as those focusing on efficiency and equality considerations (see Callan, Colgan, Logue, Savage, Walsh (2015) for example).

In an Irish context, the analysis reveals that for a given return, sourcing an increased amount of revenue from direct as opposed to indirect sources of taxation post 2008 would have provided a more stable fiscal environment. Importantly, this would have happened at a time when the Irish public finances were under considerable strain. Overall, the relatively stabilising influence of income taxation has important fiscal policy implications, particularly, in the case of small open economy such as Ireland's where fiscal as well as other key macroeconomic indicators are especially vulnerable to international shocks.

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**Table 1:** Based on Actual Percentage Changes in Government Revenue: 2000 - 2007

Tax	Weights		Bounds		Weights		Bounds	
	Actual	Efficient	Upper	Lower	Actual	Efficient	Upper	Lower
Income tax	30.2	30.0	50.0	30.0	30.2	25.8	1.0	0.0
VAT	29.7	40.0	40.0	20.0	29.7	52.5	1.0	0.0
Excise duty	13.9	10.0	30.0	10.0	13.9	7.6	1.0	0.0
Corporation tax	14.9	15.9	30.0	10.0	14.9	13.9	1.0	0.0
Other tax	5.7	4.1	10.0	1.0	5.7	0.0	1.0	0.0
Risk	5.1	4.2			5.1	4.0		
Return	9.3	9.3			9.3	9.3		

**Table 2:** Based on Actual Percentage Changes in Government Revenue: 2008 - 2015

Tax	Weights		Bounds		Weights		Bounds	
	Actual	Efficient	Upper	Lower	Actual	Efficient	Upper	Lower
Income tax	38.6	50.0	50.0	30.0	38.6	22.1	1.0	0.0
VAT	29.2	20.0	40.0	20.0	29.2	0.0	1.0	0.0
Excise duty	13.2	14.4	20.0	10.0	13.2	78.8	1.0	0.0
Corporation tax	12.0	14.6	20.0	10.0	12.0	0.0	1.0	0.0
Other tax	3.5	1.0	10.0	1.0	3.5	0.0	1.0	0.0
Risk	11.2	9.7			11.2	6.6		
Return	0.1	2.0			0.1	0.1		

Table 3: Based on Actual Percentage Changes in Government Revenue: 1985 - 2015

Tax	Weights		Bounds		Weights		Bounds	
	Actual	Efficient	Upper	Lower	Actual	Efficient	Upper	Lower
Income tax	36.3	49.4	50.0	30.0	36.3	55.0	1.0	0.0
VAT	27.3	20.0	40.0	20.0	27.3	15.6	1.0	0.0
Excise duty	16.8	19.6	20.0	10.0	16.8	21.3	1.0	0.0
Corporation tax	10.7	10.0	20.0	10.0	10.7	21.3	1.0	0.0
Other tax	9.0	1.0	10.0	1.0	9.0	8.1	1.0	0.0
Risk	7.6	6.4			7.6	6.2		
Return	6.7	6.8			6.7	6.7		

**Table 4:** Based on Forecasted Percentage Changes in Government Revenue: 2000 - 2007

Tax	Weights		Bounds		Weights		Bounds	
	Actual	Efficient	Upper	Lower	Actual	Efficient	Upper	Lower
Income tax	30.2	30.0	50.0	30.0	30.2	0.0	1.0	0.0
VAT	29.7	36.5	40.0	20.0	29.7	38.7	1.0	0.0
Excise duty	13.9	10.0	30.0	10.0	13.9	22.1	1.0	0.0
Corporation tax	14.9	23.5	30.0	10.0	14.9	39.3	1.0	0.0
Risk	5.1	4.9			5.1	3.9		
Return	9.3	9.3			9.3	9.3		





Table 5: Based on Forecasted Percentage Changes in Government Revenue: 2008 - 2015

Tax	Weights		Bounds		Weights		Bounds	
	Actual	Efficient	Upper	Lower	Actual	Efficient	Upper	Lower
Income tax	38.6	59.5	90.0	30.0	38.6	28.5	1.0	0.0
VAT	29.2	20.0	40.0	20.0	29.2	0.0	1.0	0.0
Excise duty	13.2	10.2	20.0	10.0	13.2	71.5	1.0	0.0
Corporation tax	12.0	10.0	20.0	10.0	12.0	0.0	1.0	0.0
Risk	11.2	10.8			11.2	8.8		
Return	0.1	1.6			0.1	0.1		

**Table 6:** Based on Forecasted Percentage Changes in Government Revenue: 1985 - 2015

Tax	Weights		Bounds		Weights		Bounds	
	Actual	Efficient	Upper	Lower	Actual	Efficient	Upper	Lower
Income tax	36.3	50.0	50.0	30.0	36.3	77.1	1.0	0.0
VAT	27.3	21.0	40.0	20.0	27.3	12.5	1.0	0.0
Excise duty	16.8	19.0	20.0	10.0	16.8	8.9	1.0	0.0
Corporation tax	10.7	10.0	20.0	10.0	10.7	1.6	1.0	0.0
Risk	11.2	10.8			7.6	6.9		
Return	0.1	1.6			6.7	6.7		

Figure 1: Irish Government Headline Fiscal Indicators: 1985-2016

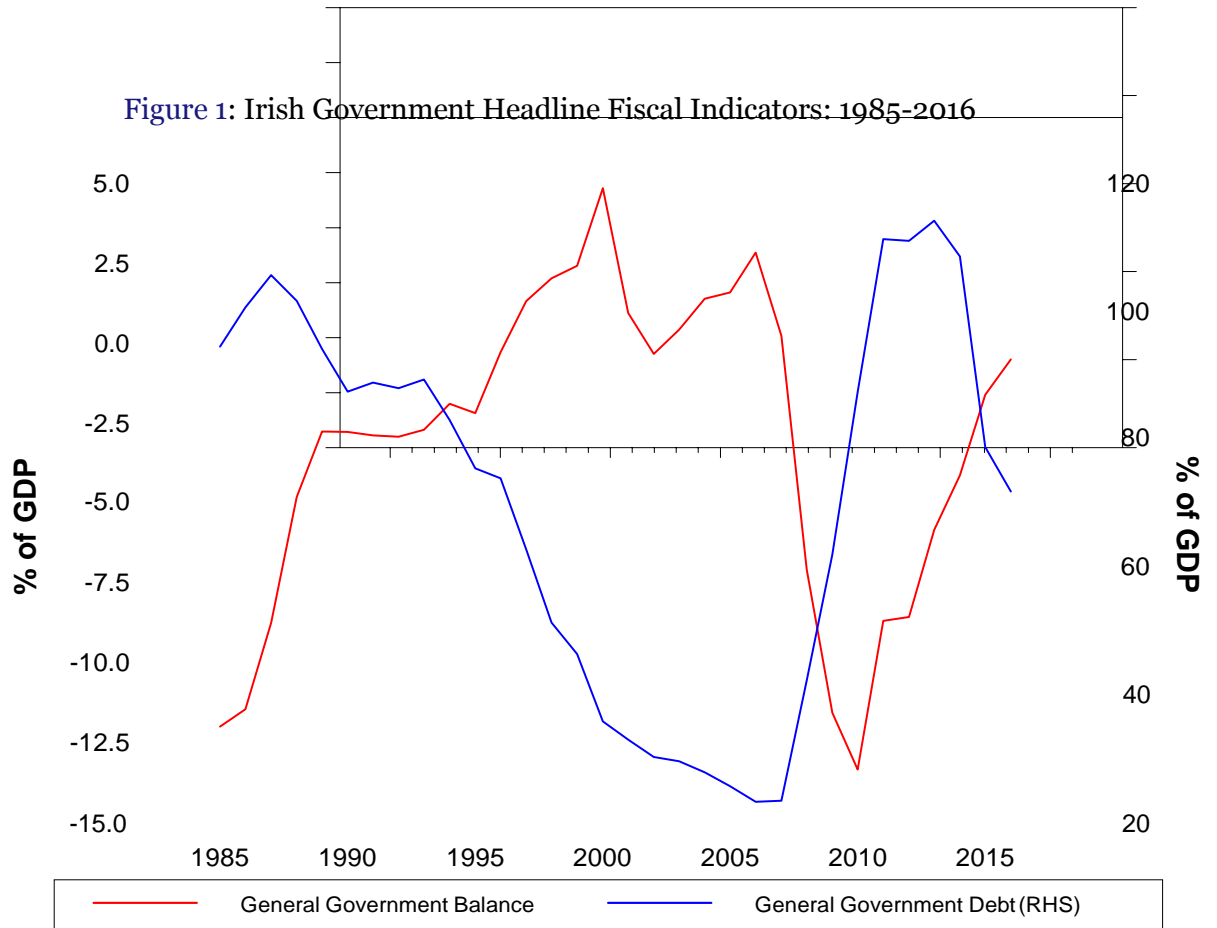


Figure 2: Irish Government Exchequer Returns: 1984-2015

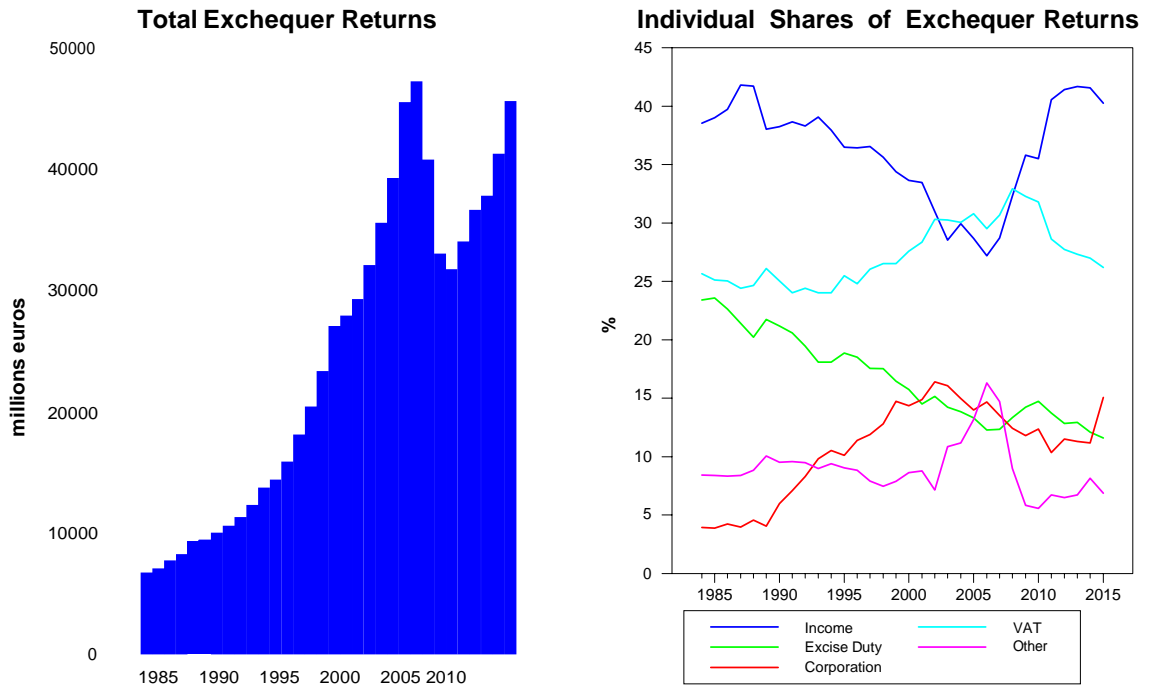


Figure 3: Actual Percentage Changes in Government Revenue (tight bounds): 2000-2007

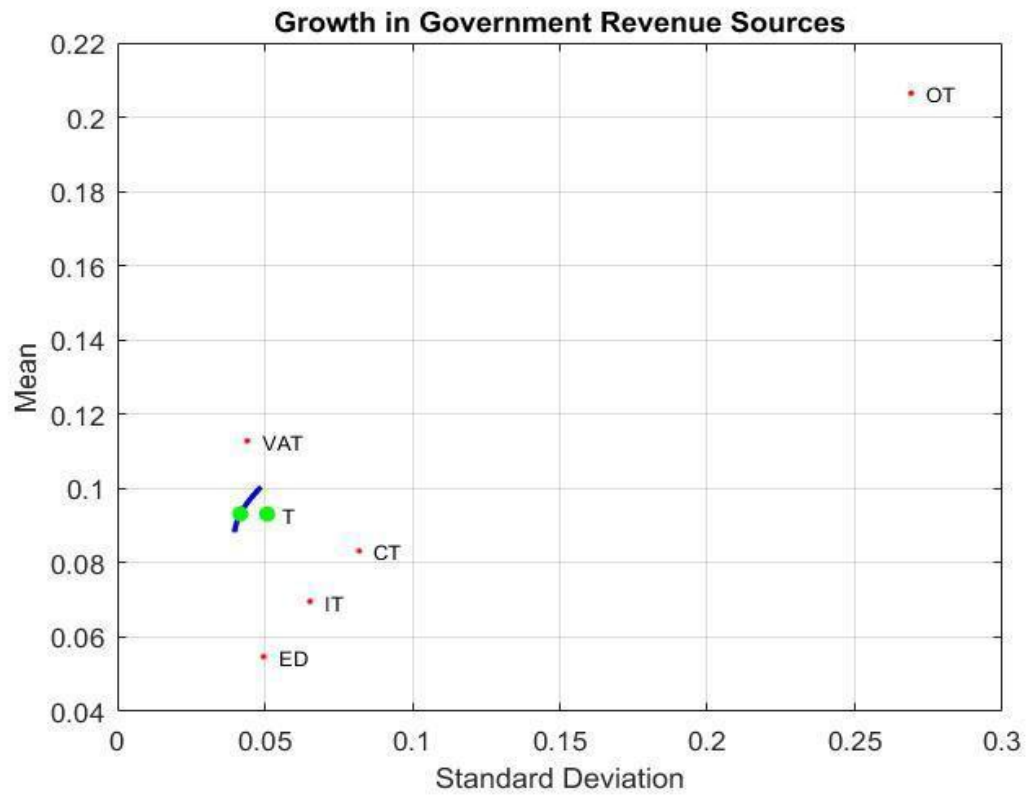


Figure 4: Actual Percentage Changes in Government Revenue (0,1 bounds): 2000-2007

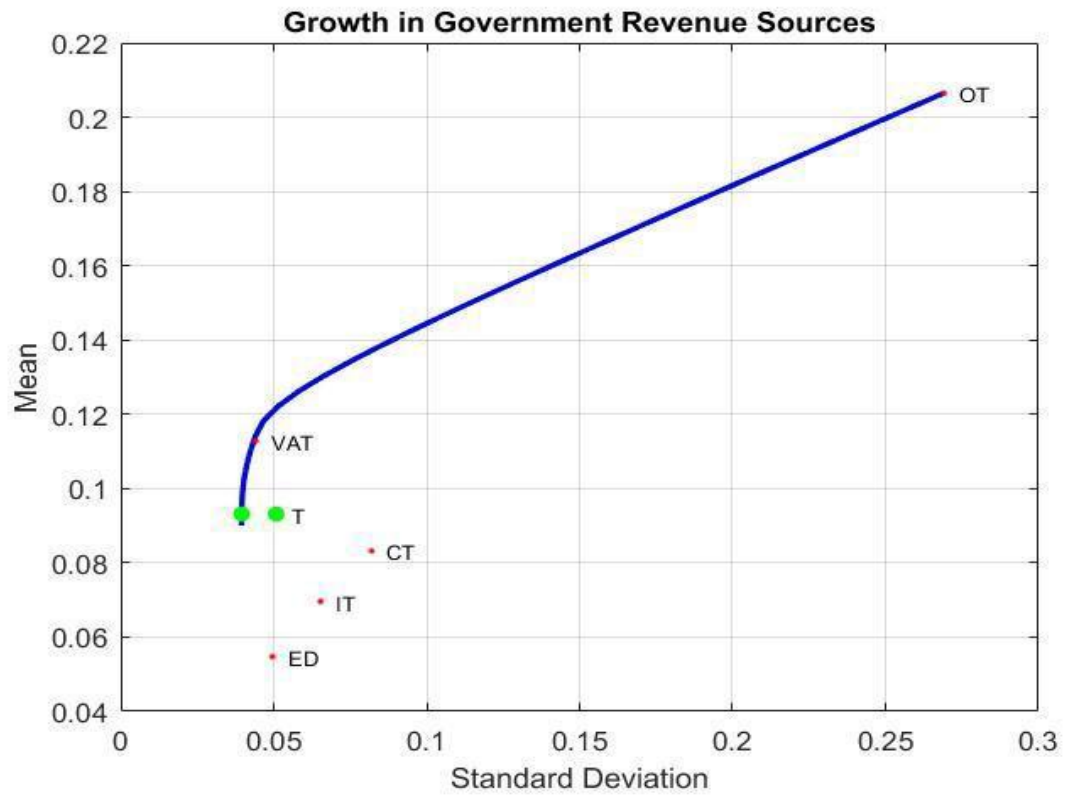


Figure 5: Actual Percentage Changes in Government Revenue (tight bounds): 2008-2015

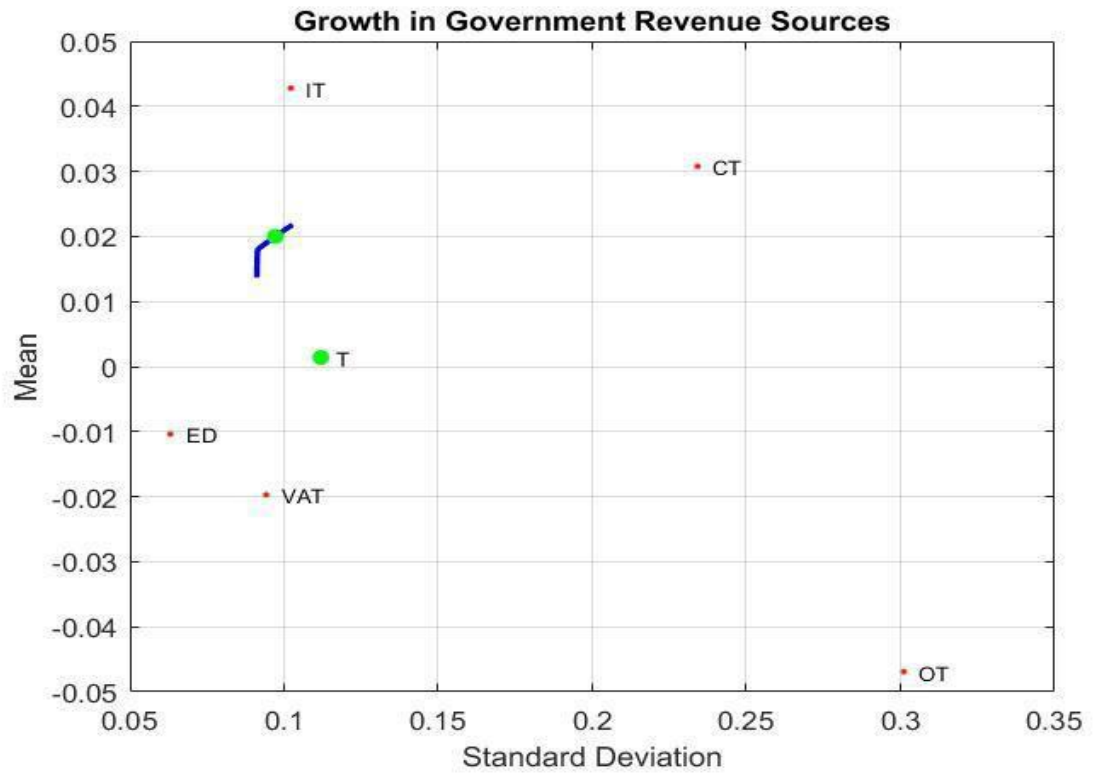


Figure 6: Actual Percentage Changes in Government Revenue (0,1 bounds): 2008-2015

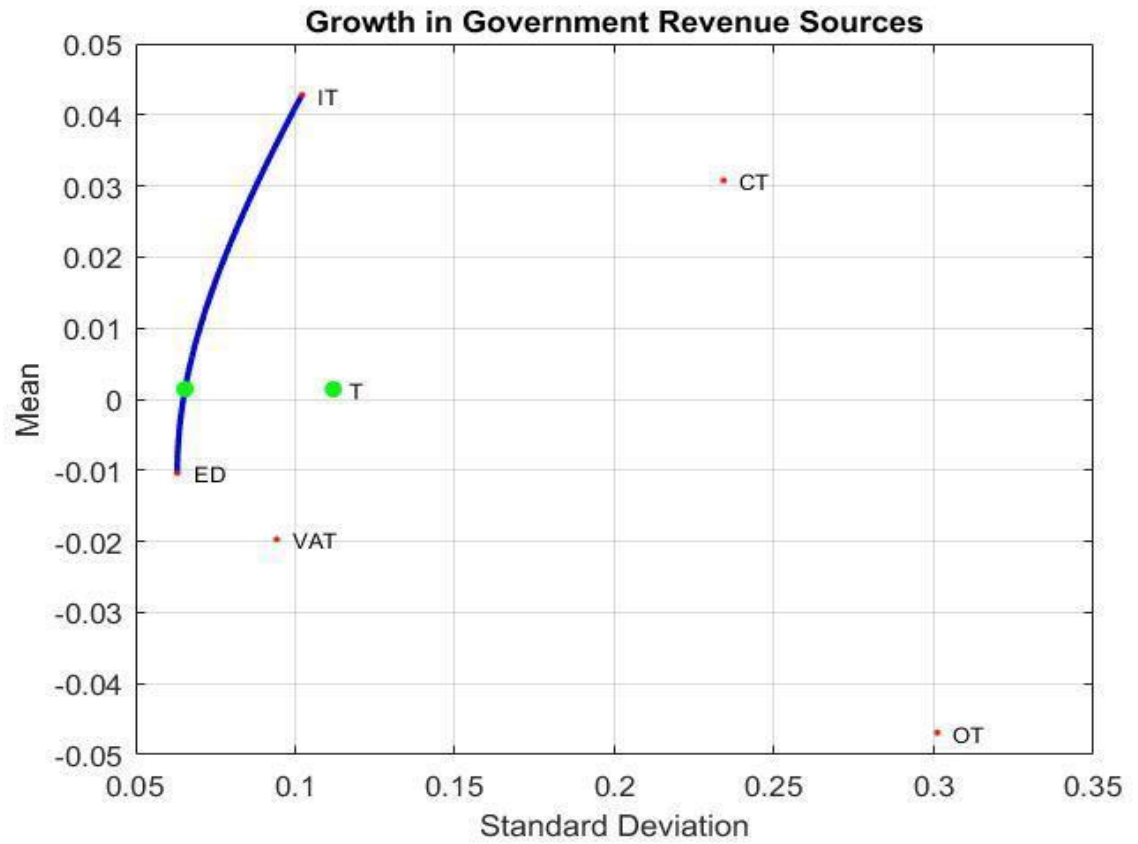




Figure 7: Actual Percentage Changes in Government Revenue (tight bounds): 1985-2015

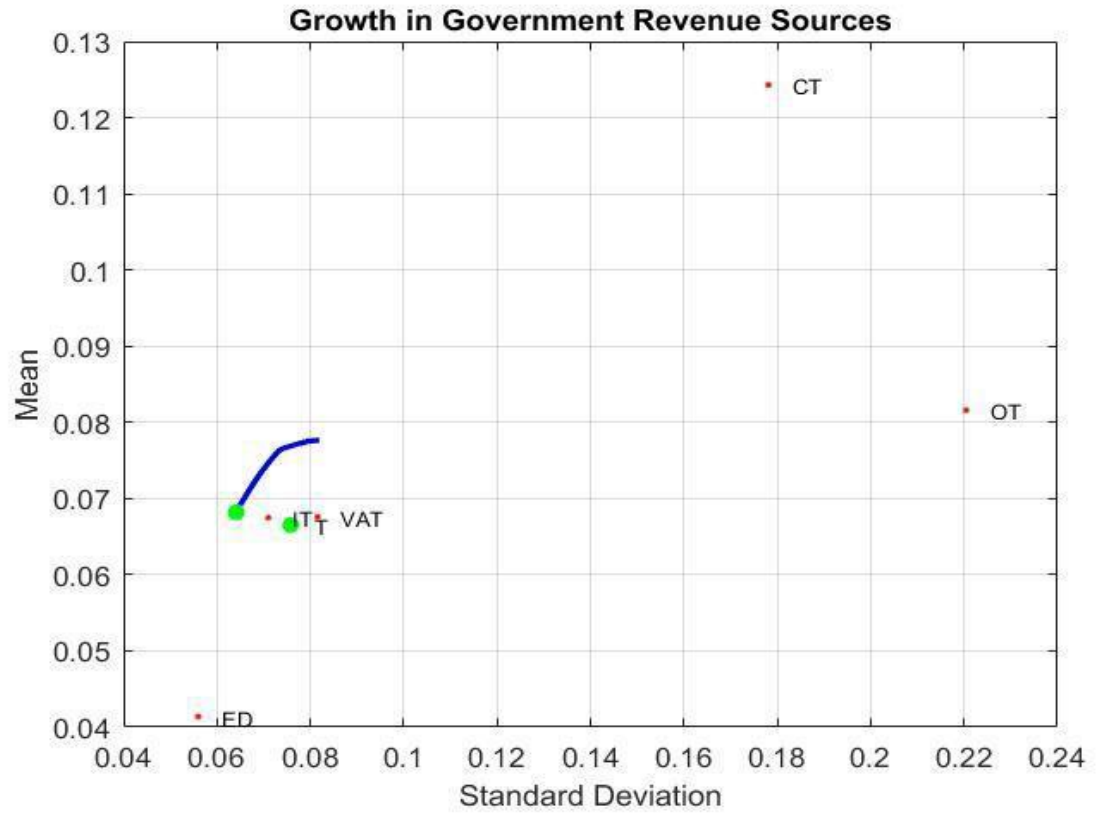


Figure 8: Actual Percentage Changes in Government Revenue (0,1 bounds): 1985-2015

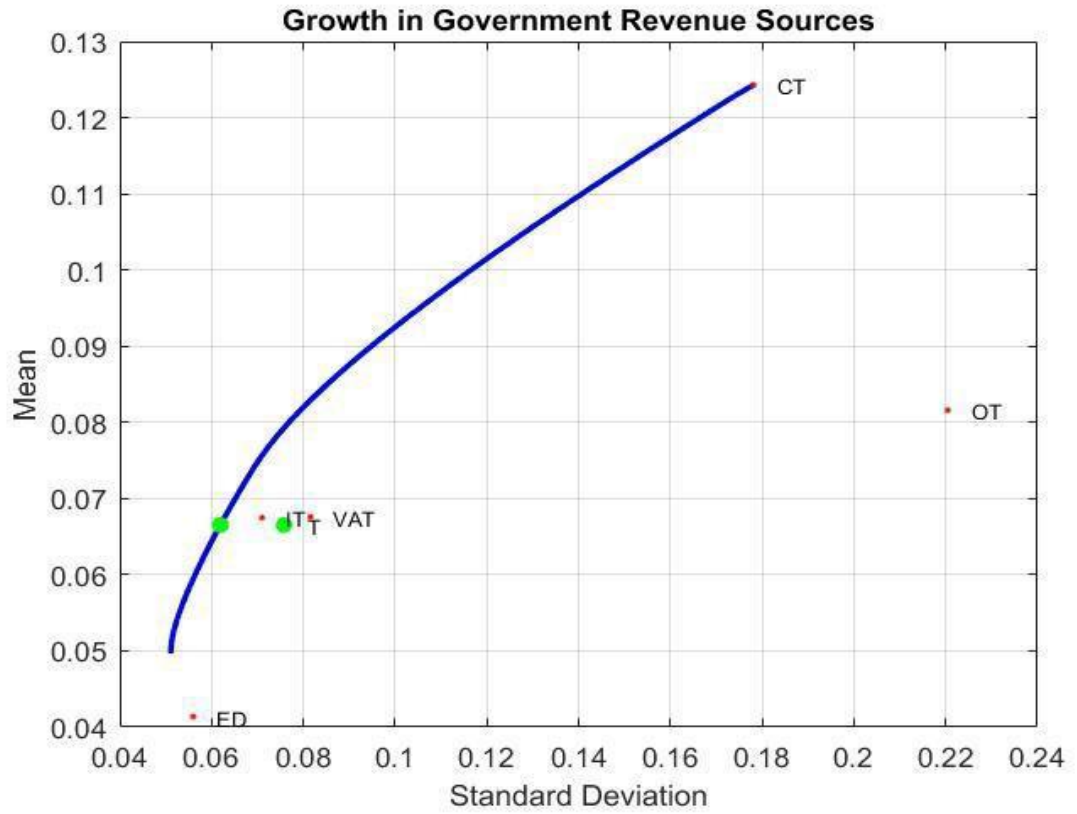


Figure 9: Forecasted Percentage Changes in Government Revenue (tight bounds): 2000-2007

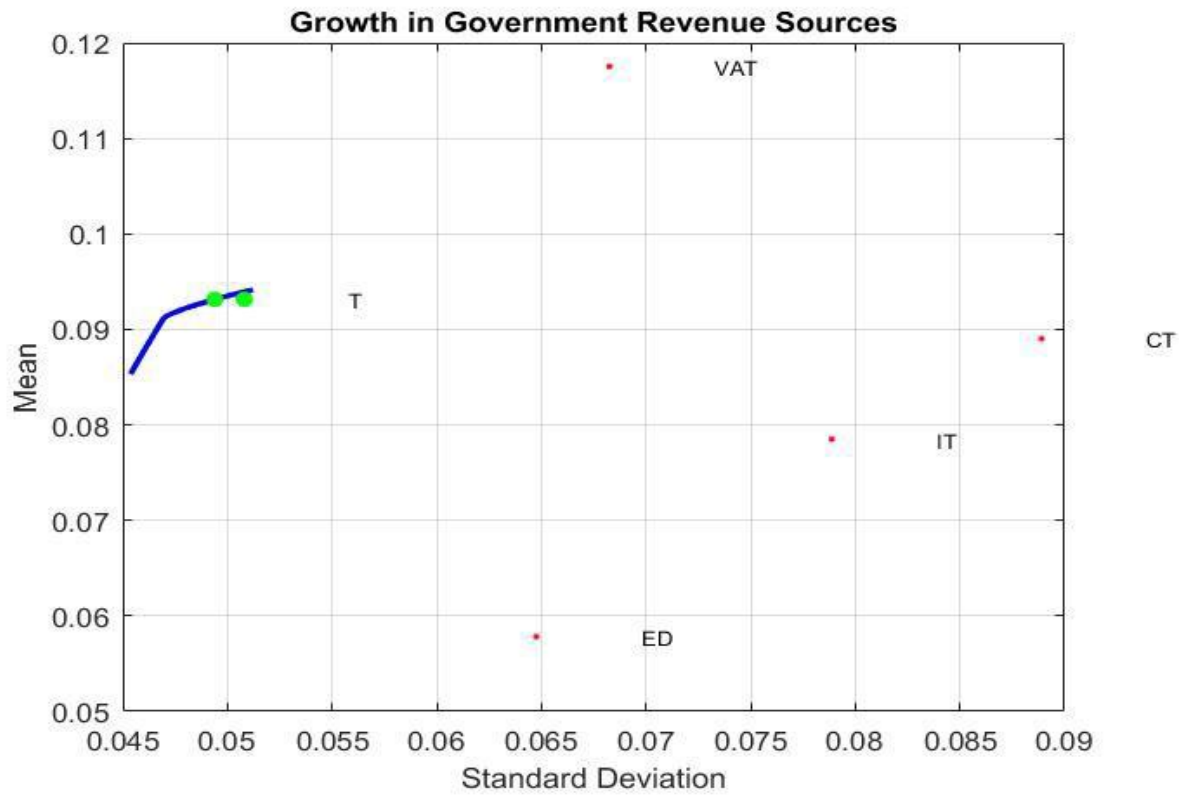


Figure 10: Forecasted Percentage Changes in Government Revenue (0,1 bounds): 2000-2007

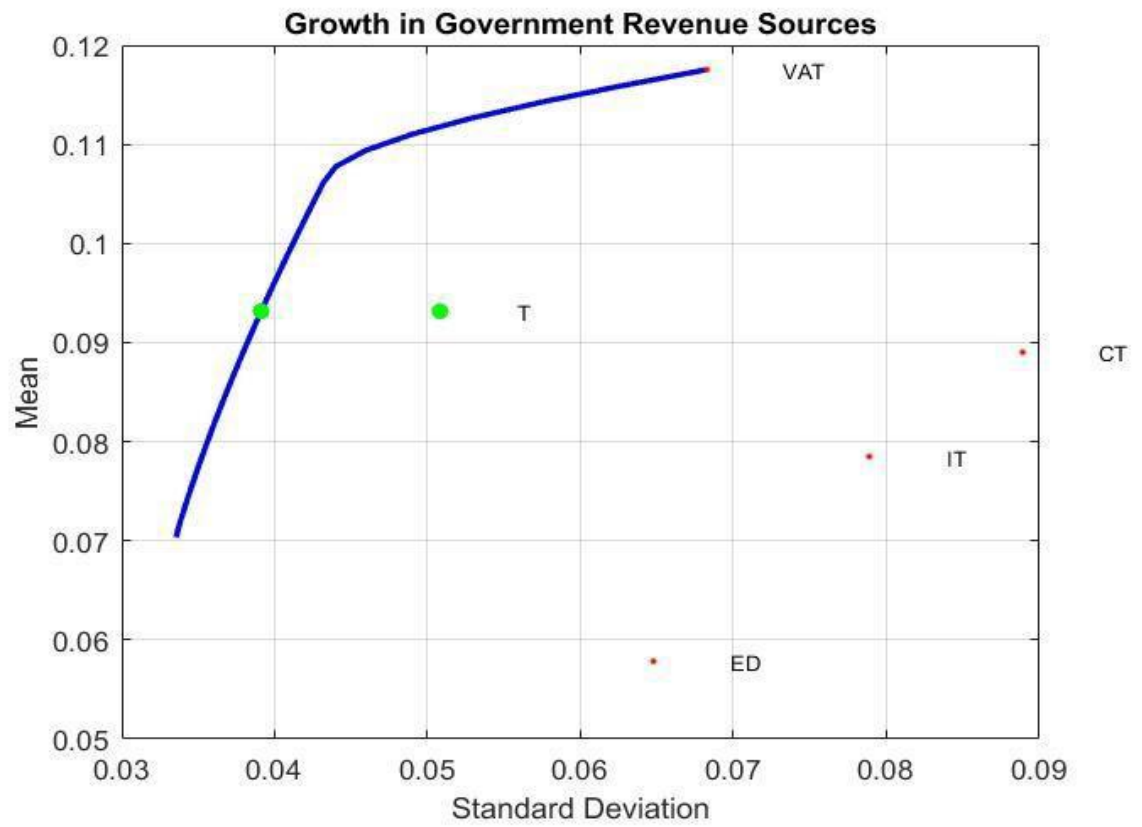


Figure 11: Forecasted Percentage Changes in Government Revenue (tight bounds): 2008-2015

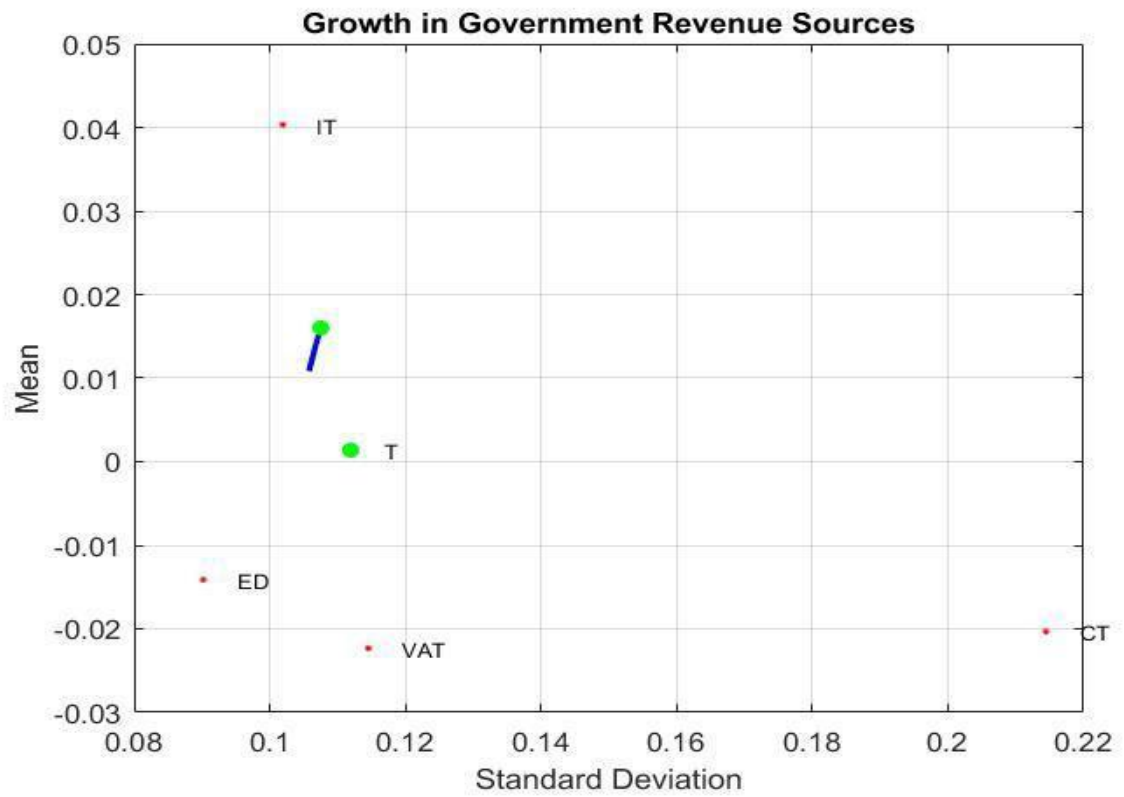


Figure 12: Forecasted Percentage Changes in Government Revenue (0,1 bounds): 2008-2015

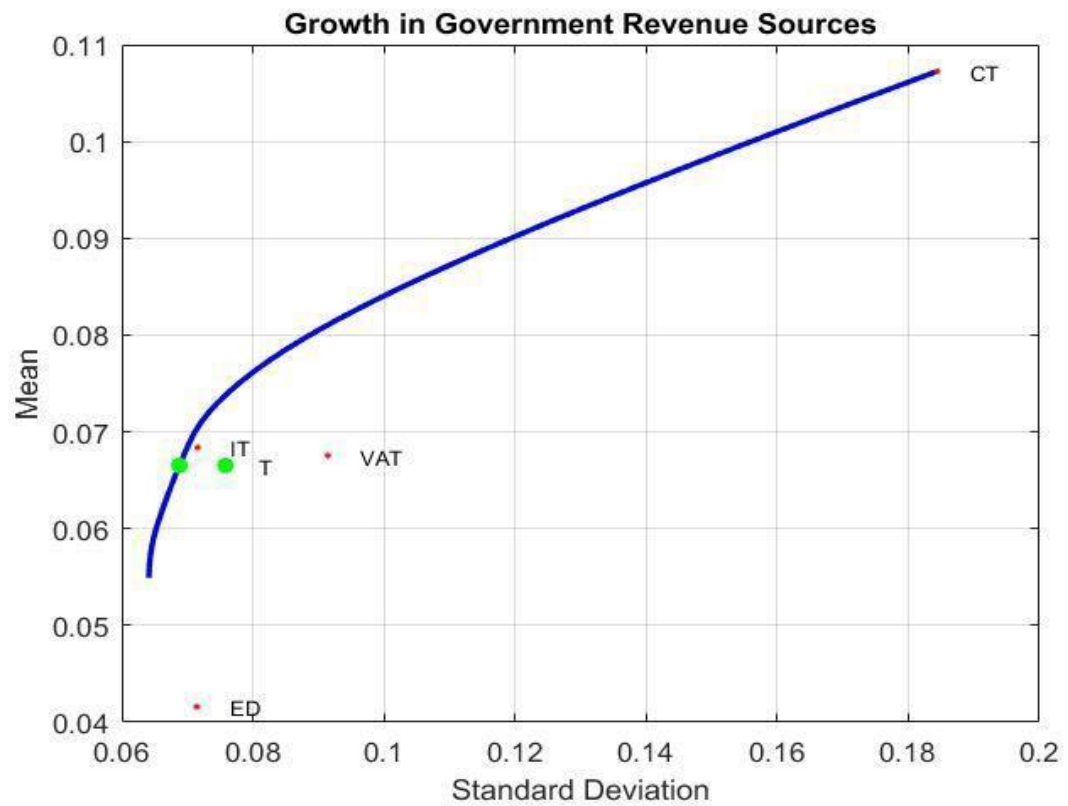


Figure 13: Forecasted Percentage Changes in Government Revenue (tight bounds): 1985-2015

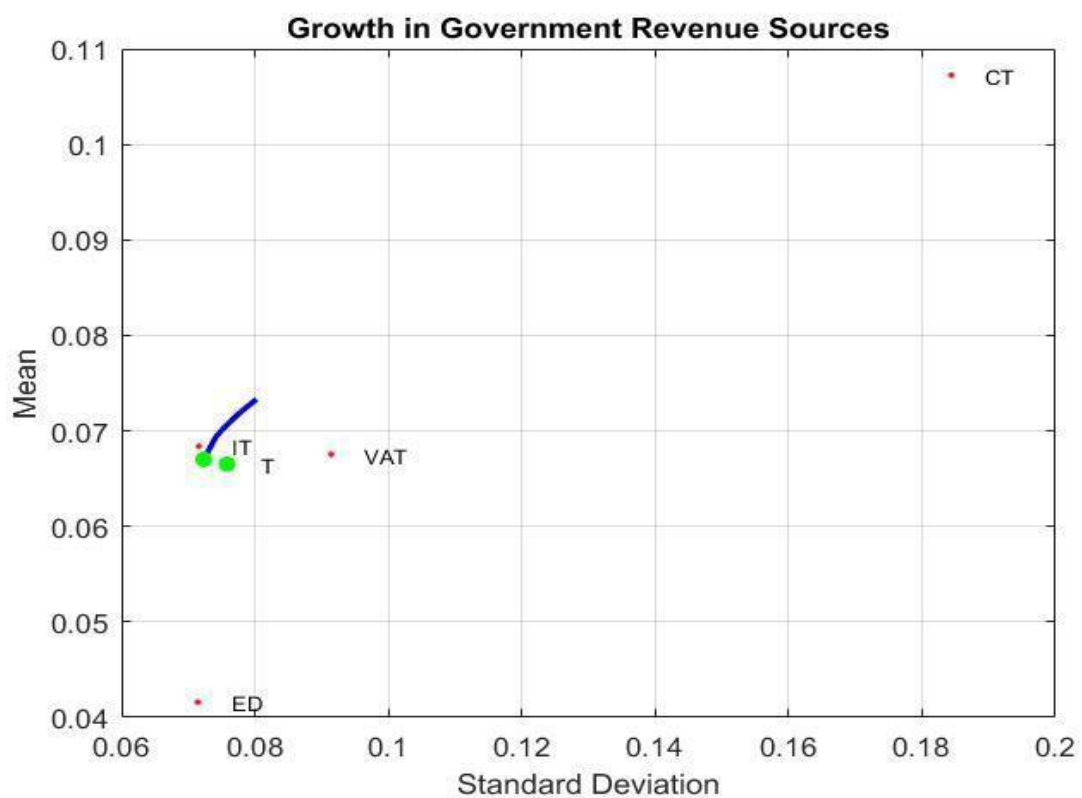


Figure 14: Forecasted Percentage Changes in Government Revenue (0,1 bounds): 1985-2015

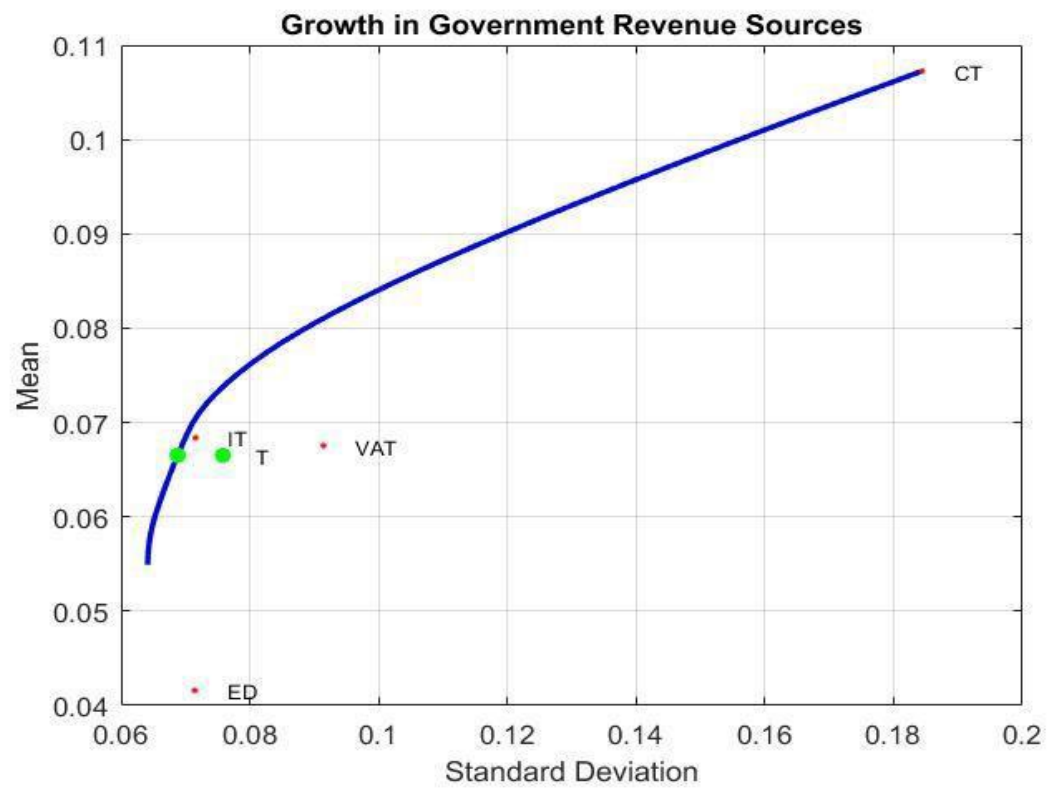
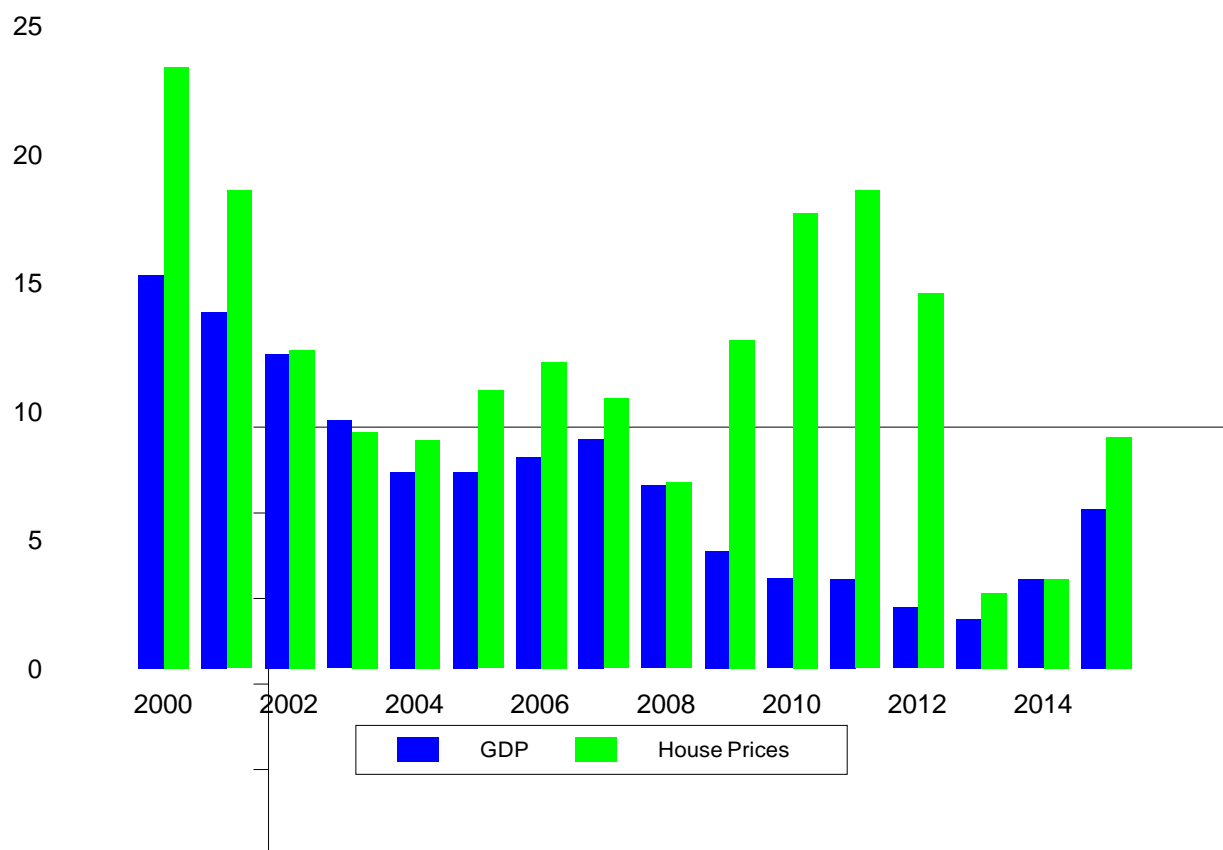




Figure 15: Coefficient of Variation (%) for Irish GDP and Real House Prices: 2000-2015



Year	Number	Title/Author(s) ESRI Authors/Affiliates <i>Italicised</i>
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