

# Financial Scrutiny Unit Briefing

## Understanding Corporation Tax Modelling

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Richard Marsh and Scherie Nicol

Given recent interest in the economic impact of a reduction in corporation tax on the Scottish economy, this paper analyses the modelling work that has been undertaken by the Scottish Government (Scottish Government, 2011) examining the economic impact of a reduction in corporation tax. It also considers how different scenarios may influence the modelling results.



Picture - Andrew Cowan/Scottish Parliament



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## EXECUTIVE SUMMARY

Since the mid-1980s almost all OECD countries have made major structural changes to their tax systems. Corporate tax reforms have generally resulted in reduced rates, the UK's main rate of corporation tax is currently 23% which is in the lower half of the range for OECD countries. The main rate of UK corporation tax will fall further to 21% in 2014 and 20% in 2015.

Allowances and exceptions can significantly reduce the average effective rate of tax relative to the headline rate. There is a substantial body of literature which finds a relationship between levels of foreign direct investment (FDI) and average effective corporate tax rates.

Corporation tax is one of many influences on inward investment including skills and infrastructure. Any modelling of the benefits of reducing corporation tax, as a means of attracting inward investment, must be viewed within this wider context.

In 2011 the Scottish Government published a report showing the results of using a Computable General Equilibrium (CGE) model to investigate the economic impact of reducing the rate of corporation tax. Such models are widely used in the appraisal of economic policies. These models are popular as they can describe outcomes for detailed industry sectors and include supply-side developments showing how markets such as housing, labour or investment adjust to policy changes.

CGE models have a number of strengths as practical tools to appraise policies. Given their basis in economic theory and the range of data used, CGE models can be considered as a numerical aid to analytical thought, as well as a means of quantifying the impact of policy changes.

Understanding how the modelled outcomes are arrived at is at least as important as understanding the modelled outcomes. For example, the main channels of effect from a 3% point reduction in corporation tax are interpreted by the Scottish Government as lowering the cost of capital, increasing inward investment and changing government spending in Scotland.

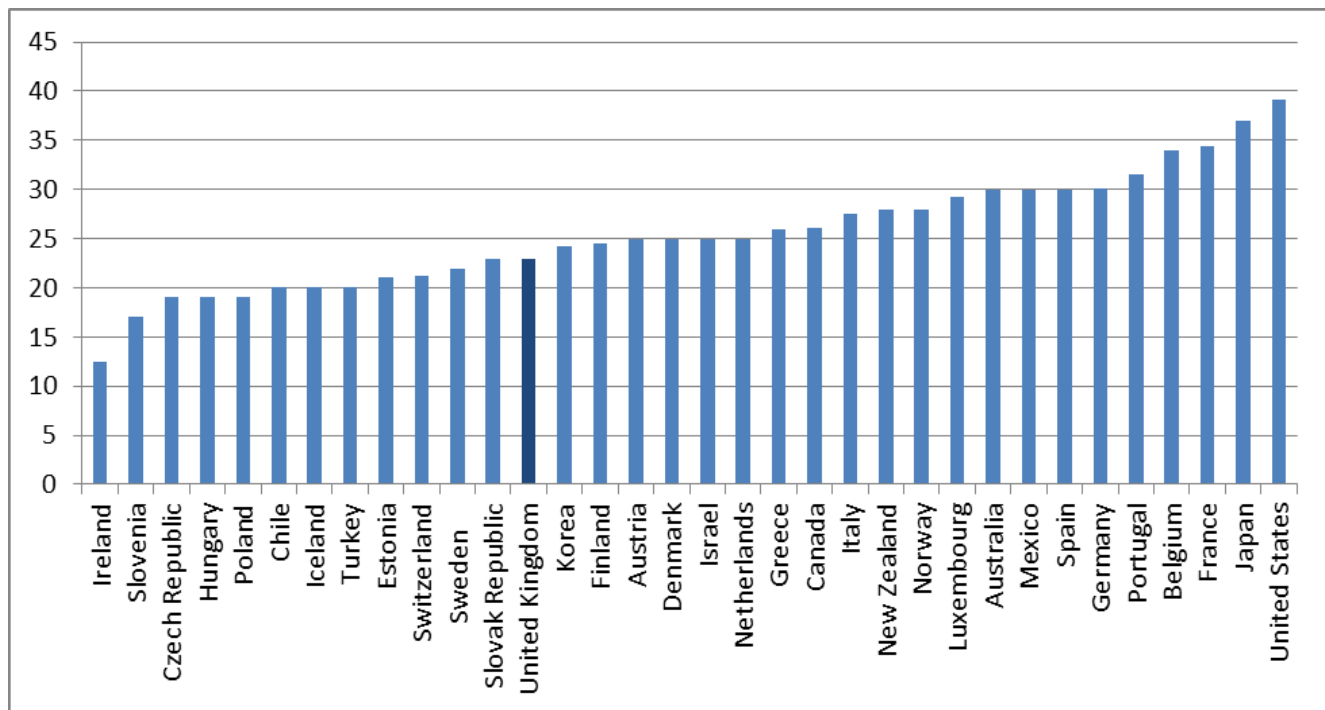
Modelled outcomes are sensitive to the scale of impact through each of these channels. The Scottish Government report presents a single central scenario, although a large number of alternative scenarios are both possible and plausible. Over 20 years the CGE model suggests GDP in Scotland will be 1.4% higher and there will be an additional 27,000 jobs compared to a scenario where corporation tax is unchanged. Most plausible scenarios resulting from a cut in corporation tax are likely to expand the economy, create jobs and increase investment.

The static change (immediate effect) in corporation tax revenues, as a result of the rate reduction, is estimated at minus £385 million. The model indicates this initial loss in revenues will be offset by dynamic gains through a broadening of the tax base and increased revenues from other taxes such as income tax. The Scottish Government report does not show how long it may take for dynamic tax revenue gains to offset any initial revenue losses from the policy (the payback period).

## OVERVIEW OF CORPORATION TAX

A previous [briefing](#) (2011) by the Scottish Parliament Information Centre (SPICe) describes corporation tax, how it is set and the link between taxation and economic performance. The main rate of UK corporation tax is currently 23%. This will be reduced to 21% in April 2014 and 20% in April 2015. This is in the lower half of the range for Organisation for Economic Co-operation and Development (OECD) countries in 2013:

**Figure 1 – main rate of corporation tax in OECD countries in 2013**



Source: OECD [2013](#)

Allowances and exemptions can significantly reduce the effective rate of tax. The effective rate will vary depending upon factors such as levels of capital expenditure, research and development costs and interest payments as well as industry specific initiatives.

The Scottish Government's [Corporation Tax Discussion Paper](#) (2011) points out that business decisions are more influenced by effective average and effective marginal tax rates than by headline rates. Although profits, and thus the tax base, have increased in recent years, corporation tax revenues have not increased to the same extent in Scotland and so the average effective rate of corporation tax has fallen.

## CORPORATION TAX AND ECONOMIC PERFORMANCE

A number of studies have examined the link between corporation tax and economic growth, in particular its influence on capital investment and attracting foreign direct investment. However, corporation tax is just one of many factors influencing the investment decisions of companies.

For example, Ernst & Young's latest UK Attractiveness Survey (Ernst & Young, 2013) found that foreign-based companies rated the UK's most attractive aspects as "*quality of life, diversity, cultural aspects and language*" followed by "*technology and telecommunications infrastructure*" and the "*stability and transparency of the political, legal and regulatory environment*".

Corporation tax was cited in thirteenth place in the survey. However, corporation tax had become a more attractive aspect for foreign investors in the UK (between 2011 and 2012).

## **CORPORATION TAX RATE AND REVENUE IMPLICATIONS**

The revenue implications of lowering the rate of corporation tax are not straight forward as illustrated by the "Laffer curve". Arthur Laffer argued that a tax rate of 0% or 100% will both result in zero tax revenues. At a rate of zero there are no revenues but as the tax rate increases (from zero) the yield will rise. However, there comes a point where the yield will fall as the taxed activity declines because the tax has removed the incentive. At a tax rate of 100% there is no activity, because there is no incentive. Conversely a reduction from a higher rate of tax may increase revenues as incentives for taxed activities improve.

Any reduction in the rate of corporation tax will result in a "static" loss of revenues. However, if the tax cut causes the economy to grow then there is likely to be "dynamic" gain in tax revenues. If the gains offset the initial revenue losses over time, the end of the payback period of the policy is reached.

If corporation tax revenues were to increase as a result of a cut in rates, this may partly arise from a strategic response by companies locating profitable parts of their business to lower tax territories, while some of the supporting economic activities that are helping to generate those profits remain elsewhere. Additional inward investment resulting from a reduction in corporation tax rates may be associated with a loss of revenues for other economies. However in the simulations that the Scottish Government carried out there was assumed to be no tax shifting of this kind, so that the fiscal implications for Scotland were not based on this type of reaction to tax changes.

GDP and the tax base may increase as a result of additional inward investment but the repatriation of foreign profits may translate into a weaker impact on income received by Scottish residents as opposed to overseas owners of businesses. For example, the latest figures for Ireland, which has the lowest headline corporation tax rate of any OECD country, suggest that in 2011 Gross National Income (GNI) per capita of €28,611 was 19% lower than Gross Domestic Product (GDP) per capita at €35,455 ([Central Statistics Office](#), 2013).

Policy makers have also expressed concern that the practice of countries competing for foreign direct investment by lowering corporation tax rates will result in a "race to the bottom". This issue is explored in a previous SPICe [briefing](#) (2011).

## **WHAT IS A CGE MODEL?**

Computable General Equilibrium (CGE) modelling is widely used in the appraisal of economic policies including trade, investment and taxation. Users of CGE models include governments and international agencies such as the International Monetary Fund (IMF), World Bank and OECD.

CGE models are frequently used by UK government departments to investigate the implications of policy changes, including the tax system. For example, earlier this year the UK Department for Business, Innovation and Skills (BIS) commissioned CGE modelling research

to show the impact of a trade and investment agreement between the European Union and the United States (Centre for Economic Policy Research, 2013).

A review of Computable General Equilibrium (CGE) modelling, including strengths and weaknesses, is provided in a report commissioned by the Scottish Government (Allan et al, 2008) where a CGE model was used to investigate environmental impacts. A CGE model paints a picture of an economy in a state of 'general equilibrium' where supply and demand are in balance and there is no upward or downward pressure on prices.

A CGE model can be useful in describing this state for all parts of the economy at the same time. The calculations used in a CGE model to describe an economy are often too complex to be worked out manually. The models can take considerable time and effort to build but once assembled they can be used many times over to address a wide range of policy questions.

CGE models are usually able to model detailed demand and supply-side developments, showing how markets including housing, labour or investment adjust to shocks or policy changes. For example, a new inward investment project may raise real wages or lower unemployment in Scotland relative to the rest of the UK. In this case labour markets may adjust through inward migration placing downward pressure on real wages and upward pressure on unemployment until they return towards their base year or equilibrium level. By including both supply-side adjustments and demand, models aim to measure the net impacts as well as the gross impacts of policy changes.

The models are popular as they can describe modelled outcomes for specific impacts or policy changes across detailed industry sectors. Models are generally set to reflect the structure and behaviour of a particular economy and estimate not only the direction, but also the likely size of impacts. They can be especially good for looking at economic debates which can be described as 'on the one hand' and 'on the other', because they can show how much weight the rest of the economy places on each hand.

The detailed economic data needed to build economic models is often only available lagged by a number of years, or may not be available at all. This means the base year of a CGE model, as with other economic models, may not be representative of the current state of the economy. CGE models also require the value of key behavioural parameters such as price sensitivity, adjustment speeds, etc. Where current values for these parameters are not available, CGE models allows values to be borrowed from "... different countries and/or time periods" (Allan et al, 2008).

The report commissioned by the Scottish Government (Allan et al, 2008) highlights that CGE models generally assume that markets are competitive and work well with companies and households responding rationally to changes. These assumptions are not wholly consistent with empirical evidence. Given their basis in economic theory and the range of data used then "... CGE analysis can be considered a numerical aid to analytical thought."

Whilst some models are built to address specific questions or policy areas, CGE models are capable of tackling a wide range of issues. However, this means that "CGE modelling is an 'art' as well as a 'science'" (Wright, October 2011) and the main strength lies "... with their flexibility, in the sense that their 'general' nature means that they can be adapted to a variety of problems depending on the creativity and ingenuity of the researcher."

# SCOTTISH GOVERNMENT CORPORATION TAX MODELLING

CGE modelling in Scotland has been used to address a diverse range of subjects including a Scottish variable rate of income tax (Lecca et al, 2010), the impact of foot and mouth disease (Fraser of Allander Institute, 2003a) the impact of reducing greenhouse gas emissions (Allan et al, 2008) and the impact of Scottish Enterprise (Fraser of Allander Institute, 2003b).

The above projects were undertaken using a CGE model for Scotland developed by staff based at the Fraser of Allander Institute of the University of Strathclyde (Harrigan et al, 1991). The model is called “A Macro-Micro Model of Scotland” (AMOS). The AMOS model offers a highly sophisticated framework for modelling policy impacts and captures the dynamics in a way that is consistent with sound economic theory. Elsewhere most CGE models are formulated and solved using General Equilibrium Modelling PACKage ([GEMPACK](#)) or the General Algebraic Modelling System ([GAMS](#)) software, often in conjunction with World Bank and other international agencies.

The Scottish Government has now purchased a variant of the AMOS model. It also has developed capacity to use, extend and update this model independently to investigate a range of economic policy issues. The Scottish Government used AMOS, with technical support from the University of Strathclyde, to model the impact of a reduction in the rate of corporation tax in Scotland (Scottish Government, 2011).

A series of assumptions often need to be made in order to operationalize questions asked of CGE models. These assumptions specify how different parts of the model will be changed, in this case to reflect a reduction in the corporation tax rate. This can be because the model does not always have the parameters necessary to directly model specific scenarios.

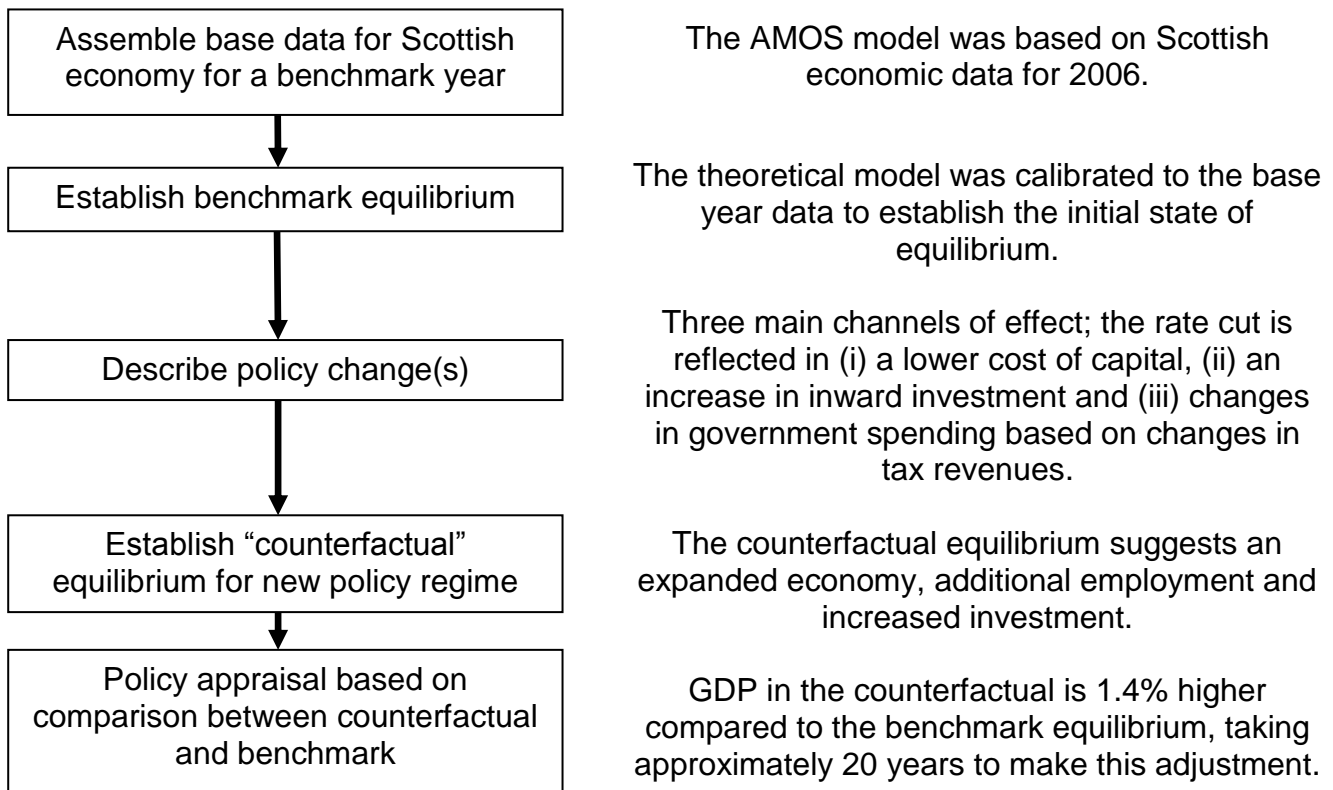
The model simulates how the economy may react to different policy scenarios, given certain changes. Therefore understanding how the modelled outcomes are arrived at is at least as important as understanding the modelled outcomes.

## MODELLING ISSUES

The burden of both corporation tax and other taxes should be considered within the wide range of factors that influence inward investment decisions, as highlighted earlier. The Scottish Government report should be viewed within this wider context.

The flow chart (Figure 2) summarises the approach of CGE modelling (based on Greenaway et al, 1993). Additional comments are provided to show the data, main channels of effect and outcomes from the Scottish Government modelling of a reduction the corporation tax rate. The AMOS model used was built on a snapshot of Scotland’s economy in 2006, the most recent year for which data was available. A benchmark equilibrium position was developed from the base year data where the theoretical model is calibrated to fit the base year data.

**Figure 2 – approach to CGE modelling of corporation tax**



(Greenaway et al, 1993, adapted by SPICe)

### **The relationship between the cost of capital and investment**

In the Scottish Government’s analysis, the reduction in corporation tax is used to estimate the likely reduction in the average effective tax rate, from 10.3% to 9.1%<sup>1</sup>. The fall in the effective rate gives rise to a reduction in the “cost of capital”<sup>2</sup> for the Scottish operations of companies. A reduction in the cost of capital provides an incentive for additional investment.

The CGE model does not model the detailed application of corporation tax as the average effective rate is the average rate of corporation tax across all industrial sectors. In reality, the average effective rate of corporation tax in different industrial sectors may be higher or lower due to allowances against research, capital investment or other expenditure items. Clearly, different types of firms will be affected in different ways; this would require further detailed analysis.

<sup>1</sup> The effective rate shows how much corporation tax is paid relative to profits on which corporation tax may be levied. Effective rates are often lower than headline rates due to allowances including capital investment and R&D spending (see page 4).

<sup>2</sup> The cost incurred in owning or borrowing capital, including interest payments and dividend obligations (Source: [Financial Times](#))



## Corporation tax and inward investment

The Scottish Government report assumes every percentage point decrease in corporation tax will increase the number of FDI jobs by 6%. Based on this assumption the 3% point reduction in corporation tax yields an 18% increase in the FDI jobs gained by Scotland.

Following trend figures of an additional 4,000 FDI jobs per annum, the 18% increase suggests an additional 720 FDI jobs per year, as stated in the report (page 19). These calculations are undertaken exogenously (outside of the CGE model).

## Other modelling issues

A number of assumptions are made by the Scottish Government and the model which influence the changes in output, job creation, inward investment and exports. For example, the model assumes 75% of the additional output resulting from the inflow of FDI is exported.

Other important points to note about the modelling approach:

- The modelled outcomes are partly driven by assumptions made outside of the model, these assumptions are based on empirical evidence and judgement of the model user.
- The model as used by the Scottish Government does not account for potential responses from other territories or consider the impact of the policy on other territories.
- The report presents a single central scenario, but a large number of alternative scenarios are both possible and plausible.
- The model excludes North Sea corporation tax as this is effectively a different tax
- The model shows how Scotland's economy adjusts from one steady-state to another. This adjustment may take around 20 years but the economy may adjust more slowly or quickly implying a longer or shorter timeframe.
- There is a timeframe as results are generated for each time period (year). The report does not give the payback period, though increasing the tax take is not necessarily the intended outcome of the policy (the economy may be stimulated and GDP increase even where total tax take falls with corporation tax).
- Other modelling approaches, such as Input-Output modelling, also produce static outcomes but do not offer any timeframe (an important strength of CGE modelling).
- The initial static fall of £385m is used only in the modelling process to help estimate the fall in the average effective rate of corporation tax (and thus the cost of capital), in year 20 government expenditure has risen so that total tax take has risen by that point.
- The stock of FDI depreciates in the same way as other investment types, this stops the stock of FDI from growing indefinitely and instead allows it to stabilise at a higher level.

# SENSITIVITY ANALYSIS

## Corporation tax and FDI jobs

As outlined above the report presents a single central scenario, but any number of alternative scenarios are both possible and plausible. Varying the assumptions made outside of the model, or parameters inside the model, would produce a different set of modelled outcomes allowing analysis of how the modelled outcomes are sensitive to different policies, situations or different views of economic mechanisms.

For example, assumptions related to how much additional inward investment may arise were based on academic studies and empirical evidence. The Scottish Government report states that a reduction of -1% point in the corporation tax rate will result in a +6% increase in FDI (a semi-elasticity of -6.0).

The Scottish Government report references an OECD review on the effects of tax on FDI (OECD, 2007) and a HM Treasury report suggesting a semi-elasticity of -5.9 (HM Treasury, 2011). The Scottish Government report suggests the assumption of a semi-elasticity of -6.0 "... is also broadly consistent with HM Treasury analysis which uses a semi-elasticity for changes to the effective average tax rate of 5.9%".

The OECD review (including a meta-sample of 427 tax elasticities) found a median (mid-point) semi-elasticity of -2.9 and "... finds a majority of semi-elasticities in the range of -5 and 0." but semi-elasticities of up to -10 were not uncommon. The median figure suggests that a 1% reduction in corporation tax may result in a 2.9% increase in FDI.

Regional (sub-national) elasticities from the OECD review are higher. However, these have been calculated from studies relating to US states and the OECD review cautions that "... state statutory rates are evaluated at very low tax rates, so that a one percentage point change in the tax rate translates into a relatively large percentage change."<sup>3</sup>

There is no clear and definitive way open to the modellers to select the appropriate tax rate (headline or effective rates) or the level of FDI response (semi-elasticities). However, the empirical literature strongly suggests the FDI response to tax cuts varies considerably country to country. Using the median semi-elasticity from the OECD review would reduce the number of FDI jobs by around 50%.

The OECD review also found that some empirical studies applied the semi-elasticity to the change in the Average Effective Tax Rate (AETR), rather than headline tax rate, these have higher semi-elasticities (in order to produce a similar effect). The Scottish Government report refers to a reduction in the headline rate from of 23% and 20% which is equivalent to a reduction from 30% to 26.1% in the AMOS model<sup>4</sup>.

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<sup>3</sup> The OECD review covers a meta-analysis by Mooij and Ederveen which includes US state studies; a link to a full version of this study is given in the reference section of this report (Mooij and Ederveen, 2006). This study cautions that studies that use state statutory tax rates "... are substantially smaller than for other studies. Indeed, whereas most mean rates are in the order of 30%, state statutory rates are around 6% on average." Mooij and Ederveen further suggest "... the evaluation of elasticities at the state statutory rate is somewhat misleading as it differs considerably from other studies." and a more comparable measure should include federal and state taxes.

<sup>4</sup> The ratios of -3% to 23% and -3.9% to 30% are the same (-13%).

The Scottish Government calculated that the headline corporation tax rates of 30% and 26.1% were equivalent to AETRs of 10.3% and 9.1% respectively<sup>5</sup>. The initial corporation tax rate of 30% was referenced as the AMOS model was partly based on 2006 data for Scotland's economy when corporation tax was set at this higher rate.

If the AETR change (-1.2%) was used instead of the change in the headline rate (-3%) then the number of additional FDI jobs would be 60% fewer. The HM Treasury figure (-5.9) is based on changes in the AETR and so may not be wholly consistent with the Scottish Government figure (-6.0) which is based on changes to the headline rate. If the Scottish Government applied the elasticity to changes in the AETR rather than the headline rate, this would result in around 60% fewer jobs.

The latest Ernst & Young reports on international investment (Ernst & Young, 2012 & 2013) showed Scotland gained nearly 6,000 FDI jobs during 2011 and nearly 5,000 jobs during 2012. The Scottish Government model assumes an additional 4,000 FDI jobs per annum, using the more recent figures could increase the FDI employment impact by up to 50%. Table 1 (appended) illustrates these potential changes.

The above calculations illustrate that outcomes could increase or decrease depending on the parameters chosen by the model user. Jobs are used as an example, but the same would be true of most variables in the model. Further scenarios supplementing the central scenario of the Scottish Government report would address this issue. Most plausible scenarios resulting from a cut in corporation tax are likely to expand the economy, create jobs and increase investment.

The Scottish Government report (2011) does not separate out the impacts of the different elements of the corporation tax change such as cost of capital, FDI and government expenditure. The main stimulus comes through increased endogenous investment and exports. FDI is modelled as primarily stimulating exports, page 10 of the Scottish Government report shows the main stimulus comes from increased competitiveness from the fall in the cost of capital. Changing the assumptions about FDI changes the absolute size of the impact but even with no FDI effect there would still be a stimulus to the economy.

## WHAT THE SCOTTISH GOVERNMENT MODELLING TELLS US

The Scottish Government modelling suggests a 3% point reduction in the corporation tax rate will expand the economy in total by 1.4% and add 27,000 jobs, 20 years after the reduction. The timeframe is "approximate" and a large part of the expansion takes place in the earlier years of the policy.

It is reasonable to suggest that in most plausible scenarios a 3% cut in corporation tax will expand the economy, create jobs and increase investment. Exports would also be expected to rise in absolute terms and as a share of Scotland's economy.

Policy costs are not presented in the Scottish Government report but in an [answer](#) to the Scottish Parliament (12/6/2013) the Finance Minister stated that £385 million "... is an estimate of a direct static change in corporation tax revenues and does not take into account the indirect impacts of the policy such as the broadening of the tax base."

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<sup>5</sup> Following the Scottish Government method, the latest figures available for 2011-12 suggest the average effective rate of corporation tax in Scotland will have fallen further from the 10.3% cited (based on [GERS](#) for tax receipts and [SNAP](#) for gross operating surplus) this excludes North Sea revenues.

When “dynamic” effects are taken into account, any reduction in corporation tax receipts may be offset partly or fully. This is as a result of any increased economic activity that the rate cut may stimulate. The 1.4% expansion of GDP over 20 years is likely to increase the amount of other taxes collected such as income tax. This can be inferred from the 0.1% increase in government consumption over 20 years, shown in Table 1 of the Scottish Government report (2011).

The published modelling work undertaken for Scotland does not provide evidence to attempt to estimate the payback period (the time taken for any initial loss in corporation tax revenues to be fully offset by additional taxes). Until the payback period is reached this policy will have negative implications for public finances. However, the modelling is done on a balanced budget basis and so the economic impacts of any lower government expenditure are captured.

A recent report for Northern Ireland outlining the case for a reduction in the corporation tax rate from 23% to 12.5% (The Economic Advisory Group, 2011) estimated that initial losses in annual corporation tax revenues will be matched after six years<sup>6</sup> (breakeven) by increased tax revenues from other areas and corporation tax from new FDI, and that the payback period will be longer.

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<sup>6</sup> The breakeven point includes losses borne by the rest of the UK as companies relocate to Northern Ireland.

## Appendix

**Table 1 –FDI jobs under different scenarios**

Scenario	Annual FDI Jobs	Difference from Scottish Government Report
SG elasticity is applied to headline tax rate	+720 jobs	-
SG elasticity is applied to average effective tax rate	+290 jobs	-60%
OECD median elasticity is used	+350 jobs	-50%
More recent FDI trends (Ernst & Young)	+1,080 jobs	+50%

Note: Figures rounded to the nearest 10 jobs, all above figures relate to FDI jobs only

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