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The HERMES-13 macroeconomic model of the Irish economy

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Abstract: The HERMES macroeconomic model has been used extensively for over 25 years to carry out medium-term forecasting and scenario analysis of the Irish economy. Most recently the model has been used to generate the scenarios underpinning the 2013 edition of the ESRI's Medium-Term Review. In the long period over which the model has been used for policy analysis, the Irish economy has undergone substantial change and new approaches to modelling important economic relationships have been developed. This paper outlines the structure and behaviour of the most recent version of the HERMES model (HERMES-13). We describe the key mechanisms and the modelling innovations which have been introduced to deal with major changes in the economy. As the model draws on a range of research on the Irish economy, we describe how this work has been incorporated into the model to better capture key economic relationships. Finally, we examine the results of a series of shocks to key variables carried out using the model. This provides a benchmark against which to evaluate the long-run properties of the model as well as illustrating how the model can shed light on the key transmission channels in the economy. This paper, and the accompanying detailed model listing and estimation output, provides a basic reference manual that practitioners and interested parties can use to interpret model output and, it is hoped, make suggestions for further model development and improvement.

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1 Introduction: the evolution of HERMES-13

In this paper we present the latest version of the ESRI HERMES macroeconomic model of the Irish economy. HERMES is a large-scale supply-side model which has been used extensively over the past 25 years for macroeconomic forecasting and policy analysis. Over that period it has been modified, extended and adapted to reflect changes in the structure of the economy and also to reflect changing needs of model users. In this most recent version, the lessons of the recent economic crisis are reflected in a renewed focus on the linkages between debt levels and economic activity.

The HERMES model was first developed for Ireland in the 1980s. Its origins lie in an earlier Keynesian model developed in the Central Bank and the Department of Finance in the 1970s, (see Bradley et al., 1978 and Fitz Gerald and Keegan, 1981). The modeling project was originally part of an EU-wide system of macroeconomic models – HERMES – that were specifically designed to deal with supply-side issues.[1] The HERMES model structure was designed to answer problems arising from the oil price shocks of the 1970s, problems that earlier models could not hope to tackle. The Irish version of HERMES was modified to deal with the special circumstances of the Irish economy. It was described in detail in Bradley et al., 1993 and was used in the ESRI Medium-Term Reviews covering the periods 1987-92 and 1989-94.

The specification of the HERMES model is built on the assumption that firms are attempting to minimise their cost of production or maximise their profits and that households are attempting to maximise their utility. This optimising behaviour is built into the basic specification of the model. If necessary, goodness of fit to historical data is sacrificed to ensure that the model's specification conforms to economic theory on the behaviour of firms and consumers.

In order to model the effects of the EU Structural Funds and the results of the completion of the Single Market, the model was developed further in 1990-91, taking on some key aspects of its current structure. There was significant further elaboration of the supply side to deal with eleven sectors of the economy and the complexity of the processes driving these eleven sectors. Since then the model has evolved further.[2]

In the early years of the last decade it was further developed to model energy demand and supply and the resulting impact on carbon emissions (Bergin, FitzGerald and Kearney, 2004 and Hennessy and FitzGerald, 2011). Today, the impact of economic activity on the

[1] The Bureau du Plan in Belgium use the HERMES model for Belgium that was originally developed as part of the joint EU funded project.

[2] In the mid-1990s a smaller version of HERMES, HERMIN, was developed specifically to examine the impact of EU structural fund investment in cohesion countries (Bradley, 1995). Since it was first developed versions have been estimated and used for many EU economies. See http://www.herminonline.net/

environment is best handled by a specially developed model in the ESRI called ISUS[3]. This latter model can be linked to HERMES through feedbacks from the environment to the macro-economy. The growing concerns about the housing market over the course of the last decade also saw the inclusion in HERMES of a model of that sector in 2005 (Duffy, FitzGerald and Kearney, 2005).

Over the last fifteen years the nature of the Irish economy has changed in a number of ways. Whereas twenty years ago migration was generally outward, in more recent times it has involved large flows in both directions with the migrants including many foreigners as well as Irish people. Previous versions of the model had assumed a very elastic labour supply. However, the 2008 version of the model was modified to better capture the factors driving migration in Ireland today (FitzGerald et al., 2008, Chapter 2.)

In 1990 the vast bulk of Irish exports came from the manufactured sector whereas today a majority of Ireland's exports are services. Thus key parts of the market services sector are tradable and subject to direct competition from firms abroad. This new reality was recognised in modifications made to the 2008 version of the model. These modifications also involved an elaboration of the mechanism through which corporation tax affects the profitability of the traded sector of the economy (Conefrey and FitzGerald, 2011).

In this paper we describe the latest 2013 version of HERMES, *HERMES-13* for short. It builds on the 2008 version in a number of ways. Firstly the risk premium on government debt (and also, optionally, on borrowing from Irish banks) is now a function of the level of government borrowing and government indebtedness. This modification is important in understanding how the current government debt crisis impacts on the economy as a whole. A second modification involves the development of the consumption function to capture the fact that consumers are affected by their permanent income. To operationalise this, the new consumption function handles the situation where consumption is driven by the level of household wealth (both housing wealth and other financial wealth) and not just current income. This approach allows HERMES to handle the deleveraging process that the household sector is currently undergoing in a more appropriate manner.

This paper aims to provide a non-technical introduction to the present revised and extended version of the ESRI medium-term model. [4] In Section 2 we give an overview of the key mechanisms in the model. This covers more detailed descriptions of the main elements: output, including manufacturing and services; the labour market, including labour supply and wage formation; the expenditure (or absorption) side of the model including consumption and housing; the current account; and the government sector. Section 2.6 provides a description of the energy sub-model, which is embedded within the medium-term model, while Section 2.7 discusses how the model is closed. In Section 3 we explore the

3 http://esri.ie/research/research_areas/environment/isus/

4 An annotated listing of the latest version of the model, including the estimation results, is available on the ESRI website http://www.esri.ie/research/research_areas/macroeconomics/the-hermes-model/

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behaviour of the model, by looking at a range of exogenous and policy shocks and scenarios. Section 4 summarises the results of these shocks and multiplier estimates and Section 5 concludes.

2 An overview of the model

Economists have three different ways of looking at the behaviour of the macro-economy. They examine what is produced (for example, output from the industrial sector); what is spent (e.g., private consumption, investment, etc.); and the incomes earned by the factors of production (e.g., the industrial wage bill, profits, etc.).

Each approach (output, expenditure and income), should lead to an identical measure of gross domestic product (GDP), being the conventional aggregate measure of activity in the entire economy. Short-term forecasts (such as those published regularly in the ESRI's Quarterly Economic Commentary) focus more on expenditure-income relations. The ESRI Medium-Term Review adopts a time horizon of five or more years. With this medium-term orientation in mind, the HERMES model of the Irish economy focuses initially on the output (or production) relationships, and examines the downstream expenditure and income consequences. The key mechanisms within the model can be summarised as follows:

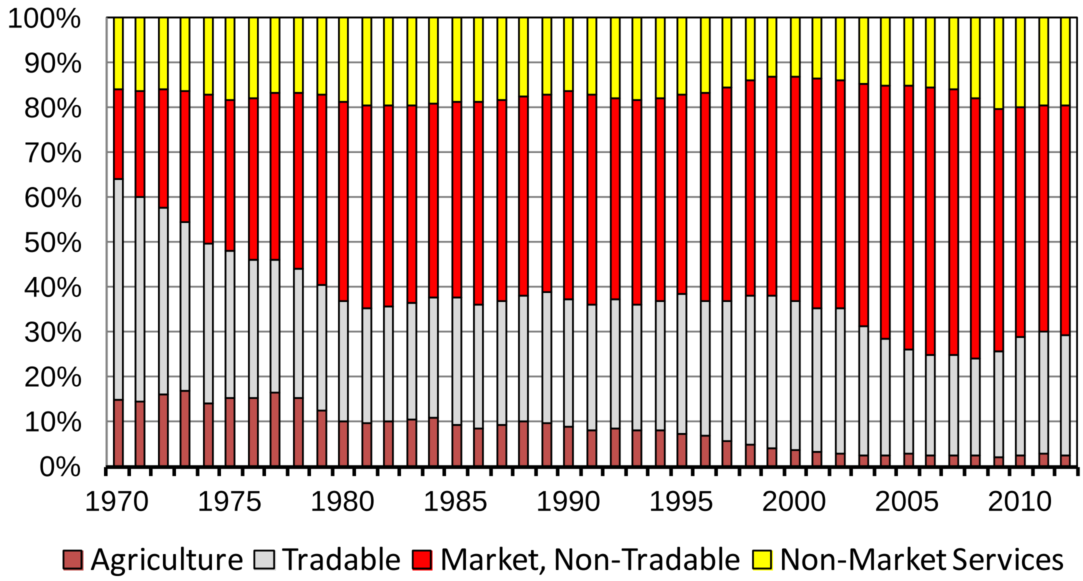
- The tradable sector is driven by world demand, elements of domestic demand, and cost competitiveness.
- The sheltered market sector (services and building) is driven by domestic demand.
- The public sector is policy-driven, and includes a detailed treatment of borrowing, debt accumulation.
- Wages are determined in a bargaining model, and influenced by the factors that affect the supply and demand for labour – e.g. prices, taxes, and unemployment.
- The labour market is open and influenced through migration by conditions in alternative labour markets, such as the UK labour market.
- The demand for housing is a function of income, price, demographics and the real cost of capital. Supply is determined by the profitability of building dwellings.
- Consumption is a function of "permanent income". Housing wealth and financial wealth both influence consumption. The actual level of consumption could be different from the "optimal" level[5].
- The risk premium on government bonds is a function of the level of debt and borrowing.

An initial distinction can be made between those sectors of the economy that are exposed to the competitive world trading environment (the internationally traded sector –

5 For example because of the effects of credit constraints on consumer behaviour.

henceforth referred to more simply as the traded sector) and those sectors that are sheltered from direct exposure to international competitive trade (referred to more simply as the non-traded sector). Broadly speaking, the traded sector consists of manufacturing, most of agriculture, and an element of market services (e.g., financial and business services, software, tourism, etc.). The non-traded sectors comprise the rest of the economy (i.e., utilities, building, most of market services and all public or non-market services). The relative sizes of these sectors, in terms of added value, are shown in Figure 1.

Figure 1: Share of Gross Domestic Product, by sector



Given the extreme openness of the Irish economy (exports exceeded 100 per cent of GNP in 2010), we give primacy to the traded sector as the main engine of sustainable growth in the Irish economy. In the case of manufacturing, there are two key determinants of growth: the state of world demand and the level of Irish cost competitiveness relative to its trading partners. Hence, the two external forces driving the Irish manufacturing sector's output are the rate of world growth (which is more-or-less-transmitted one-for-one to Ireland) and the level of world cost competitiveness, which Ireland must at least match in order to grow as fast as the world economy. Any gain in competitiveness results in an increase in market share and growth faster than the world economy. Any loss of competitiveness reverses this process.

Obviously, the decisions on the optimal level of output in Ireland are implemented through investment decisions by individual firms – either investing to build new plant or decisions to close existing plant. In the case of the high technology sector the bulk of the new investment comes from foreign firms and takes the form of foreign direct investment (FDI). Thus the level of foreign direct investment into Ireland is seen as ultimately a function of the world demand for the relevant product and the competitiveness of the Irish economy as a location from which to supply that world market.

Given the level of output in manufacturing, the manner in which it is produced is then determined in the model. Firstly, Irish manufacturing output prices are determined primarily in the world market place and cannot easily be altered to respond to Irish cost conditions. In other words, Irish firms trading internationally tend to be "price takers". The optimal mix of labour, capital and material inputs then depends on their relative prices. For example, if wage inflation outstrips rises in the cost of capital, there is some scope for substituting capital for labour in the production process in the medium term. In addition to relative price terms, there is also a systematic change in the use of inputs of goods and services due to "technical change". For example, in manufacturing there is a tendency towards "labour saving technical progress", i.e., less labour is needed each year to produce the same level of real output. The determinants of technical progress are a complex mixture of catch-up factors, human capital, physical infrastructure, business efficiency, and policies targeted at innovative firms.

Developing on the above outline, the ESRI model contains equations describing the determination of manufacturing output and factor inputs, in terms of external forces (world output and world competitiveness) and domestic forces (mainly Irish wage costs and the cost of capital, with some role for domestic demand and other domestic input costs). Since output prices and the prices of material inputs and capital[6] are largely determined externally, attention is focused on the determination of wage rates.

Wage rates are modelled as the outcome of bargaining between trade unions and employers, with the frequent intervention of the government indirectly through the tax and welfare systems. The factors driving employers in bargaining include the price they can get for their product or service, their competitiveness in their key markets, the taxes they pay, and the productivity of the individual firm. The price that employers obtain for their product clearly influences the price at which they can profitably purchase factor inputs, like labour. The price they are prepared to pay for labour in Ireland is also affected by the price they would have to pay for labour elsewhere.

Employees are assumed to bargain in terms of their real after tax wage. They bargain with employers and, when the rate of pay is agreed, employers are then assumed to choose their optimal employment level. Employees take home pay is clearly affected by consumer prices and the taxes that they pay on their earnings. As discussed later, migration is itself directly affected by labour market conditions in Ireland relative to other countries. This affects the wage bargaining process, directly through changing domestic labour supply, and indirectly through affecting the expectations of Irish employees.

An increasing share of the output of the business and financial sub-sector of market services is tradable, generating a significant share of Irish exports. This sector is now modelled as a function of domestic demand and exports of services. Exports of services are, in turn, modelled as a function of world output and of Irish competitiveness relative to its trading partners (Conefrey and FitzGerald, 2011). Output for the rest of the non-traded sector is driven mainly by domestic demand. So, for example, private consumption will contain a

[6] The cost of capital for many smaller domestic firms is determined in Ireland. Multinationals fund themselves wherever in the world is cheapest and are not affected by Irish financial conditions.

certain element of services sector output (transport and communication, recreation, professional services, etc.), and any change in consumption will impact on the demand for services sector output accordingly.

Services sector output is assumed to be produced by firms in a way that minimizes the costs of production. Hence the mix of capital and labour inputs is sensitive to the relative prices of the inputs, as in manufacturing. However, given the sector's insulation from world competition, prices in the services sector tend to be determined as a mark-up on input costs. Hence, if these services are required as inputs into manufacturing, a loss in industrial competitiveness can result if the price of Irish services rises excessively.

The HERMES model uses adaptive or extrapolative expectations mechanisms, which assume that agents believe that future performance of a particular variable is affected only by its past. A much more sophisticated approach, used in many models over the last quarter of a century, is to assume "rational" expectations mechanisms, which assume that people form their view of the future by taking account of all available information, including available economic model forecasts. This approach is particularly important when modelling the behaviour of interest rates and exchange rates and other financial sector variables. With membership of monetary union, the monetary and exchange rate section of the HERMES model was replaced by the NiGEM world model of the National Institute for Economic and Social Research in the UK. The NiGEM model builds in such forward-looking behaviour. In other areas it is possible that "rational expectations" could play a significant role. However, recent experience of the housing market suggested that adaptive expectations better reflected the behaviour of agents in that market. If market players had correctly forecast future events we would never have had a housing bubble.

Finally, this version of HERMES includes data for the balance sheets of the banking system and of the Central Bank. At present, these data solely provide "hooks" for incorporating a future model of the financial sector. As a result, the behaviour of the financial sector is not modelled in the present version of HERMES and, when using HERMES, it is very important to take this into account. Hopefully future models of the Irish economy will incorporate the insights from the latest research on the financial crisis of the last five years.

In this paper we report on the HERMES-13 version of the model. This was estimated over the period September-December 2012 using the most recent ESRI annual databank. The underlying data are based on *National Income and Expenditure,* 2010 (NIE10). This has proved necessary as a full set of consistent data based on NIE11 was not available when the model was being estimated in 2012. A full description of these data together with information on how to access the most recent version of the databank can be found in http://www.esri.ie/irish_economy/databank/ .

The HERMES model is large and complex, including 180 behavioural equations. Together with aggregations, transformations and other identities the simulation model includes a total of 824 equations. These are listed in Appendix 1, with further details on estimation available at http://www.esri.ie/research/research_areas/macroeconomics/the-hermes-model/.

Table 1 shows the estimated Root Mean Square Percentage Error for GNP, GDP and total employment (LTOT) for 7 generations of the HERMES model.

Table 1: RMSE of successive versions of the HERMES model.

Database	begin	end	GNP	GDP	LTOT
NIE95	1975	1990	14.5	10.3	9.9
NIE97	1974	1996	8.8	2.8	3.7
NIE99	1975	1998	2.2	2.2	1.0
NIE01	1984	2000	2.1	3.0	1.2
NIE03	1984	2002	4.1	2.0	1.5
NIE06	1976	2005	2.1	1.8	1.2
NIE10	1977	2009	3.2	4.7	1.8

2.1 The output side of the model

In this section we give an overview of the HERMES-13 model of the manufacturing and services sectors. The three manufacturing sectors and three market services sectors form the core of the output side of the model and include a detailed theoretical specification.

In addition to these six sectors, the HERMES model also includes five other sectors, namely building and construction, utilities, agriculture, public administration and health and education. The treatment of these sectors in HERMES can be summarized as follows:

A factor demand sector is estimated for the building and construction sector using the same model as is used for manufacturing. However, it does not fit as well. Output of building and construction depends on the level of investment in building and construction which in turn, is determined by the factor demand equations in other sectors and also by the model of the housing sector.

Output in the utilities sector depends on the energy sub-model, described in Section 2.6.

Output in the non-market sectors and in agriculture is generally treated as exogenous.

In Section 2.1.3 we simulate the output side of the model, using both a shock to wage rates and a shock to world demand. The simulation results for the wage rate shock give an estimate of the overall elasticity of labour demand, and this feeds into the development of the labour market in Section 2.2.

2.1.1 The manufacturing sector

Manufacturing is divided into three sectors, high-tech, traditional and food processing. High-tech covers chemicals and pharmaceuticals with the traditional sector covering the rest of the sector. The same basic model is applied to each of the three sectors. It is outlined in Bradley and FitzGerald (1988) and Bradley, Fitz Gerald and Kearney (1993).

The choice of the location for production by the stylised world firm is made so as to minimise the world firm’s cost of production. The world firm can choose to locate some of the production process of a good in one country and then combine the components produced in one country with labour and capital in another location to produce a final good.

In the latter case, the production of the final good in a relevant country will be undertaken using domestic capital and labour, combined with materials for further production, which are produced in another location. Where final products consist of components from many countries, the cost of production in an individual country can influence domestic value added (GDP) in two ways. First the relative cost of production in one country compared to the rest of the world will affect the location where the final good will be produced, hence affecting domestic value added (GDP). The relative cost of production can also affect domestic value added by causing the world firm to produce more or less of that final good in the relevant country by varying the share of material inputs, many of which may be imported.

Thus this model encompasses behaviour such as outsourcing, modelling it as a function of the changes in the cost of domestic inputs relative to the cost of materials produced abroad. As a result, as discussed below, the effect of changes in the relative cost of domestic inputs on domestic value added must include both the substitution of gross output in Ireland for similar output elsewhere, and also the substitution of domestic inputs (labour and capital) by material inputs which are, in an Irish context, generally imported.

For this model to be a valid representation of the Irish manufacturing sector, a number of assumptions are necessary. Here we assume constant returns to scale. We also assume that the output in any country is weakly homothetically separable from output in all other countries. This latter assumption means that changes in relative prices of factors of production within one country, which do not affect the overall cost of production in that country, will not affect the mix of inputs used to produce a good in another country. This restriction is necessary for an aggregate “Irish output” to exist, allowing a model to be based on national output data. While this restriction may on the face of it seem realistic, in practise in a modern world economy, the restrictions may no longer be fully valid.

$$C_w = f(c_I, c_R, t) \quad (1)$$

$$\frac{Q_I}{Q_W} = f(\frac{c_I}{c_R}, t) \quad (2)$$

$$c_I = \frac{C_I}{Q_I} = f(p_l, p_m, K, t) \quad (3)$$

$$\frac{L}{Q_I} = f(\frac{p_m}{p_l}, K, t) \quad (4)$$

$$\frac{K^*}{Q^*} = f(\frac{p_l}{p_k}, \frac{p_e}{p_k}, t) \quad (5)$$

The model assumes that the production of goods on a worldwide scale can be characterised by a cost function (1) where the cost of world output of manufactured goods, C_w, is a function of the unit cost of production in Ireland c_I relative to the rest of the world, c_R, and technical progress, t. Then the share of world output that is located in Ireland (2) is also a function of the unit cost of production in Ireland c_I relative to the rest of the world, c_R, and technical progress, t. The output of each sector in Ireland is defined as Q_I and the relevant output in the rest of the world is Q_W. The unit cost of production in Ireland is defined in Equation (3) as a function of the cost of labour, p_l, the price of inputs of goods and services including energy, p_m, the capital stock K and technical progress, t. From this equation the share of each of the factors of production –labour, capital and materials – in domestic output is determined (labour, L, is shown in Equation (4)).[7] Finally, Equation (5) defines the optimal capital output ratio (optimal is denoted by "*").

The cost of capital is determined as a function of interest rates, the price of output, the price of investment goods and the tax and subsidy regime (Znuderl and Kearney, 2013). Generally firms' expectations are assumed to be backward looking when considering the profitability of investment.

A modified version of the Generalised Leontief functional form is used to estimate the model.[8] This system of equations can be solved to derive the optimal capital stock conditional on world output and the price of the factor inputs in Ireland. This system of long-term or equilibrium equations are estimated within an Error Correction Model (ECMs) framework, which allows for estimation of the adjustment path of each of the key variables. These are shown in the annotated model listing, available from the authors. There are sundry other identities and less important equations that constitute the model for each of the sub-sectors of manufacturing which are also shown in the model listing.

As an example of how the model works, Figure 2 shows the actual capital stock and the optimal stock for high tech. manufacturing, where the optimal stock is derived from the model described here. The difference between these two aggregates within the model drives investment. In the case of the high tech sector, the estimates suggest that up to 1994 the actual capital stock was a little above the optimal level, implying that the sector was close to an equilibrium. However, from the mid-1990s the optimal capital stock rose way above the actual, implying that firms desired to expand their capital stock. The dotcom burst of 2002 saw a temporary reduction in the optimal capital stock, implying a reduction in pressure to invest. However, with the recovery in the world economy from 2003 onwards it was again profitable to invest in Ireland. However, once the current recession began, the optimal capital stock actually fell below the actual and the consequence has been firm closures.

[7] A similar equation is derived for materials.

[8] See Bradley, Fitz Gerald and Kearney (1993) for the formal derivation which is based on Morrison (1988).

Figure 2: Optimal and Actual Capital Stock, High Tech. Manufacturing

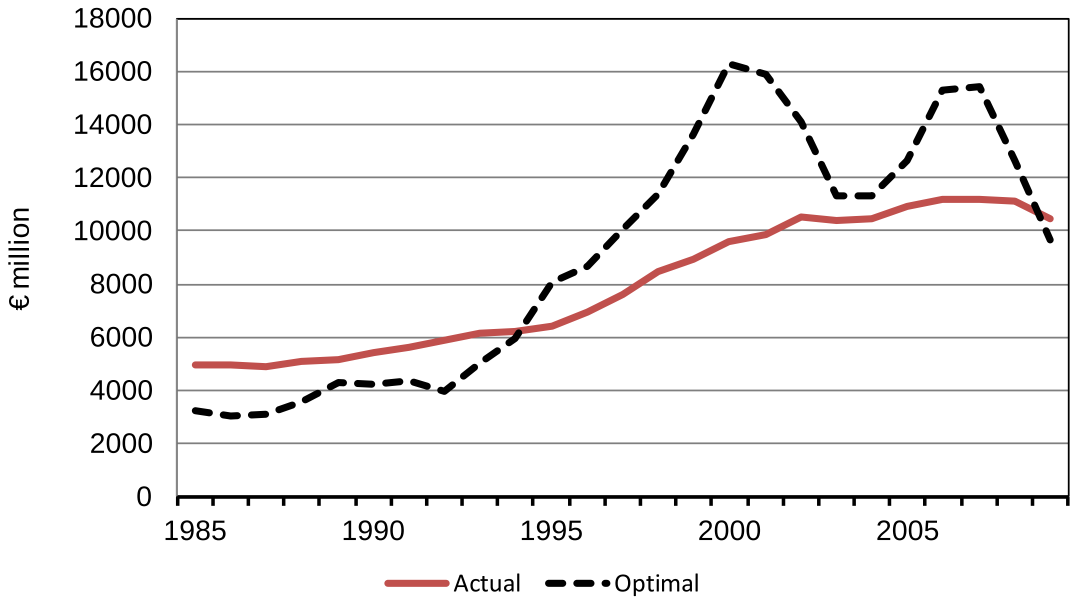


Table 2: Manufacturing Sectors, Price Elasticities of Demand, Long Run

	Labour	Materials	Capital
High Tech Manufacturing			
Labour	-0.86	1.32	-0.46
Materials	0.13	-0.39	0.26
Capital	-0.15	0.88	-0.73
Traditional Manufacturing			
Labour	-0.92	0.99	-0.07
Materials	0.23	-0.26	0.03
Capital	-0.11	0.21	-0.10
Food Processing Manufacturing			
Labour	-0.40	0.74	-0.34
Materials	0.07	-0.27	0.21
Capital	-0.14	0.94	-0.80

Table 2 shows the long run elasticities of demand for the three factors in the three manufacturing sub-sectors for 2009. In every case the own elasticity of demand is negative. Also capital and labour are complements for each other and substitutes for material inputs in all three sub-sectors. This means that value added is a substitute for inputs of materials and services. If either the cost of capital increases or the price of labour increases the effect will be a fall in value added. As much of the inputs of materials (including services) are imported, this means that, whatever the source of an increase in domestic costs, the result is a substitution for domestic value added of predominantly imported inputs. The importance of this finding is discussed later in Section 2.1.3.

The optimal output in each subsector is modelled as a function of foreign GDP and the cost of production relative to the rest of the world, where the domestic cost of production is defined by equation (3) above. The adjustment of output to its long-run level is estimated in an ECM.

The price of output in the manufacturing sector is generally externally determined – firms are price takers on the world market. This is not surprising given the heavy preponderance of foreign firms producing for a global market (Callan and FitzGerald, 1989 and Fitz Gerald, Keeney and Scott, 2009). As a result, the price of gross output in manufacturing is modelled as a function of foreign output prices. We impose homogeneity in foreign prices (and the exchange rate).

The price of material inputs used in the sector is made up of the price of energy inputs and the price of other raw materials inputs, including services. The weight of the two price series is estimated. The price series for material inputs uses data from the 1998s input output table (McCarthy, 2007) to weight the price of imported inputs and the price of inputs from other sectors of the domestic economy.

Wage rates in manufacturing sub-sectors are assumed to follow wage rates in the non-agricultural sector: an elasticity of unity is imposed with respect to non-agricultural wage rates.

In the most recent estimation, the statistical results suggested that

the model of the manufacturing sector in HERMES-13 fits better than in the previous versions of HERMES. This is probably because of the more coherent definitions used for the three manufacturing sub-sectors.

Whereas in the previous versions of the model time or technical progress played a big role in year to year changes, its role is now more attenuated. Much more of the change in the economy is explained by the other exogenous variables.

The effect of changes in competitiveness on gross output, and hence exports, is low. However, its effects on net output or value added are much greater. This highlights the importance of modelling the manufacturing sector using three factors of production which allow for substitution of value added (domestic factors of production) by material inputs (which are generally imported, McCarthy, 2008). Modelling exports (a proxy for gross output) as a function of competitiveness will greatly underestimate the effects of this variable on the real economy.

2.1.2 The market services sector

In the current version of HERMES the market services sector is split three-ways: distribution (wholesale and retail), transport and communications, and other business services (professional, financial, personal). In the case of the first two subsectors it is assumed that they are largely non-tradable so that the scale of output is determined in the model by a suitably weighted measure of final demand (e.g., the weights determining, say, distribution output reflect the distribution content of consumption, etc.). However, over the last twenty years the Business and Financial sub-sector of market services has increasingly become part of the tradable sector. As a result, a new model of that sector was introduced in the 2008 version of HERMES (Conefrey and FitzGerald, 2011).

In the latest version of the HERMES model the exports of services (excluding tourism), X_s, are a function of world activity Q_w (proxied by EU GDP), Irish wage rates, W_i, relative to those in the UK, W_u, and the rate of corporation tax, T, equation (6).

$$X_s = f(Q_w, \frac{W_i}{W_u}, T) \qquad (6)$$

The estimated elasticity of services exports with respect to world activity in recent years is very high at over 5. The elasticity with respect to domestic wage rates is -0.7.

Output in the business and financial sector, Q_i, is a function of exports of services, domestic demand weighted by input output coefficients, D, and the price of output of the sector P_i relative to wage rates in the UK (7).

$$Q_i = f(X_s, D, {P_i}/{W_u}) \qquad (7)$$

The equation allows for the importance of exports as a market for the output of the sector. The estimation results suggest that, at the margin, one third of the output of the sub-sector is exported (determined by the ratio of the coefficients on the two demand variables)[9].

The long run capital stock in the sector is a function of output and profitability in the sector. The demand for labour is a function of the real wage rate, output in the sector and the capital stock.

In the other two marker services sectors, distribution and the transport and communications sub-sectors, output is a function of weighted final demand. In the case of the distribution sector tourism exports have a significantly higher weighting than implied by the input-output table. In turn, tourism exports are affected by Ireland's international competitiveness, making the output of this sector responsive, to a limited degree, to competitiveness.

The factor demands in the distribution sector (for capital and labour) are estimated as a factor demand system using a translog specification.

The special nature of the transport and communications sector is recognised in the model. Up to the late 1980s it was predominantly state-owned and the enterprises did not appear to act like normal competitive firms. They were neither minimising costs nor maximising profits. However, since the late 1980s the sector has been transformed. As a result we estimate the factor demand equations using a shorter data sample than is the case for the other sectors (from 1990 to 2010). Employment in this sub-sector is now determined as a function of output, the real wage rate and the capital stock.

9 These coefficients were relatively stable even when the equation was estimated over a much shorter period.

The output deflators for the sub-sectors of market services are determined as a mark-up on domestic costs. However, because much of the output of the business and financial sub-sector is tradable, the output price of that sector is also affected by prices in the UK – the sector is, partially, a price taker. This reflects the fact that some of the exporting firms in the sector are themselves price-takers on the world market. (See Section 2.7 for a discussion of model closure for an explanation of an alternative measure of the deflator in the business and financial services sector.)

2.1.3 Simulating the output side of the model

A good way of understanding the results for the output side of the model is to simulate "shocks" to that sub-model within HERMES. Here the model is solved for its long-term equilibrium. The dynamics are not considered here (speed of adjustment). This is done by substituting the long run equilibrium capital stock for the actual capital stock, so that in the face of shocks the economy switches immediately to its long-term equilibrium.

In these simulations, the output sector is considered on its own, with all the other parts of the model exogenous: the expenditure side, the labour market, prices, the public sector, etc.

This means that the normal multiplier effects, where the incomes of the agents are spent causing more demand, are not modelled. This affects, in particular, the results of a shock to world output. The full multiplier effects of such a shock would be significantly higher if the multiplier effects were taken into account. However, this partial simulation gives a clearer view of the workings of the output side. It shows the properties of the supply curve for Irish output. It also allows an estimate to be made of the elasticity of labour demand in the model. This is important in developing the labour market of the model.

In the first simulation we raise wage rates in the economy by 1 per cent. Tables 3 and 4 show the effects on key variables. Because of the assumptions we have made, simulating the output side of the model on its own, the effects exclude any feedback from demand or prices. In this simulation it is assumed that the value of public expenditure is fixed so that the rise in wage rates of 1 per cent results in a fall in employment in the public sector of a similar amount.

Table 3: Simulating a 1 percent increase in wage rates: effect on output and employment

	1990	2000	2009
Effects on output, percentage change			
Manufacturing	-0.21	-0.23	-0.30
Industry	-0.17	-0.21	-0.25
Market Services	-0.11	-0.13	-0.17
Non-Market Services	-0.99	-0.99	-0.99
GDP factor cost	-0.28	-0.26	-0.33
GDP	-0.25	-0.24	-0.29
GNP	-0.23	-0.18	-0.29
Effects on employment, percentage change			
Manufacturing	-0.37	-0.54	-0.84
Industry	-0.55	-0.61	-0.71
Market Services	-0.45	-0.45	-0.47
Non-Market Services	-0.99	-0.99	-0.99
Total	**-0.48**	**-0.55**	**-0.61**

Table 3 shows the long-run effects of the rise in wage rates for three individual years. In the manufacturing sector output in 2009 would fall by 0.3 per cent. Output would also fall in the market services sector by 0.17 per cent, reflecting the fact that a significant part of the sector is now tradable. The share of the sector that is tradable has risen over time and this is illustrated by the fact that the effects in 1990 are much lower than in 2009. Overall, a one per cent rise in wage rates would reduce GNP by almost 0.3 percentage points in 2009.

The effects on employment are also shown in Table 3. The long run own elasticities of demand for labour in the three sub-sectors of manufacturing are shown above in Table 2. Here the effects take account of both the substitution of other inputs for labour as well as the substitution of foreign output for Irish output as a result of the loss of competitiveness. As can be seen from Table 3, in manufacturing in 2009 a 1 per cent increase in wage rates would have reduced employment by 0.84 per cent. In the market services sector, which is more insulated from foreign competition, the fall in employment would have been 0.47 per cent.[10]

For the economy as a whole, the fall in employment would have been 0.6 per cent in 2009 under these assumptions. However, if employment in the public sector were assumed to be fixed (so that the wage bill increased with higher wage rates) then the effect of the rise in wage rates would have been to reduce employment in the economy by 0.4 per cent. It is this latter elasticity of -0.4 that is used in calibrating the labour market model that determines wage rates.

[10] Because of the assumptions, the fall in employment in non-market services exactly matches the rise in wages.

Table 4: Simulating a 1 percent increase in wage rates: Effects on Manufacturing Sector

	1990	2000	2009
Gross Output	-0.06	-0.09	-0.06
Net Output	-0.21	-0.23	-0.30
Employment	-0.37	-0.54	-0.84
Materials	-0.01	0.05	0.07
Capital Stock	-0.11	-0.22	-0.17

Table 4 shows the effects of the increase in wage rates on the manufacturing sector. Because domestic capital and labour are complements, and both of them are substitutes for materials, an increase in wage rates of 1 per cent would have resulted in a 0.3 per cent fall in domestic value added (domestic labour and capital) and a 0.07 per cent rise in inputs of goods and services (inputs of goods and services accounted for 70 per cent of gross output in manufacturing in 2009). As much of the material inputs are imported, this would suggest that the reaction to an increase in domestic costs, here wages, would be to reduce the share of domestic value added in total output.

The negative effect on gross output is quite low at -0.06 per cent. Because most of gross output is exported, this means that modelling the direct effects of competitiveness changes using exports is likely to mask what is really going on. Gross output, and hence exports, are not very sensitive to competitiveness but value added, and hence GDP and GNP, are much more sensitive. This highlights the importance of modelling output in Ireland rather than exports as the key external driver of the economy. In the HERMES model we model gross output with three factors which captures this effect. An alternative approach, which also properly captures this competitiveness effect, is to model value added in the sector directly (Bradley and Untiedt, 2012).

In the second simulation we increased the world output variables (e.g. GDP in the US, the UK and the EU) by 1 per cent and examined how this affected output in the economy. Once again we held domestic demand and prices constant in this scenario.

Table 5: Simulating a 1 per cent increase in world demand, effects on output, Per cent

	1990	2000	2009
Manufacturing	0.22	1.32	0.93
Industry	0.18	1.17	0.77
Market Services	0.63	1.11	1.42
Non-Market Services	0.00	0.00	0.00
GDP factor cost	0.37	1.00	0.93
GDP	0.33	0.89	0.83
GNP	0.49	0.71	0.79

Table 5 shows the effect of this world output shock on doemstic output without any multiplier feedbacks. Output in the manufatcuring sector in 2009 would have risen by almost the same precentage as world output. However, the growing tradability of the market services sector is reflected in the rise over time in its responsiveness to changes in world ouptut. By 2009 market services' output would have risen by 1.4 per cebt, a considerably greater increase than in the case of manufacturing. The impact on GNP would be to raise it by 0.8 per cent.

Further testing shows that by 2009 over 70 per cent of the impact of a rise in world output was transmitted to the Irish economy through the tradable secrvies sector and under one third through the manufacturing sector. By contrast, in 1990 about 60 per cent of the impact of rising world demand came through manufacturing.

Section 3.3 shows the effects of such a shock using the full *HERMES* model, with demand and prices also adjusting. In that case the output effects are substantially greater than shown here.

These results suggest that the cost of capital matters to the Irish economy and that it affects the output side of the economy directly, as well as through its impact on the public finances. The importance of this channel in the current crisis needs further research. While the country specific risk premium was not fully passed on to business in the current crisis, this probably reflected the importance of the multi-national sector and also a degree of credit rationing.

2.2 The labour market

As discussed in Section 2.1.3 the equations determining employment by sector, when taken together, imply a long run own elasticity of demand for labour of -0.4. Section 2.2.1 shows that the system of equations determining labour force participation and migration produce a long-run elasticity of labour supply of at least +1.0. These parameters are embedded in the equation determining long-run or optimal wage rates as discussed in Section 2.2.2.

The implication of the elasticities of demand and supply is that the incidence of taxes on labour will fall predominantly on the employer rather than on employees in the long run. This is consistent with previous work modelling wage determination (Bradley *et al.,* 1993, Curtis and FitzGerald, 1996 and FitzGerald, 1999). The most recent estimates of the wage equation suggest that wage rates in 2009 were 8 per cent above their long-run level.

2.2.1 The supply of labour

The supply of labour consists of a series of relationships determining population of working age, participation in full-time education, participation in the labour force, and migration. Because of the different pattern of labour market participation for males and females, the supplies of female and male labour are modelled separately. In addition, we distinguish between labour force participation of those aged 15 to 24 and those aged 25 to 64.

The basic model of labour supply for age group x is as follows:

LABOUR SUPPLY: The supply of labour for a given age group in any given time period (LS_t^x) is determined by the labour force participation rate $(LFPR_t^x)$ and the population in that age group (N_t^x):

$$LS_t^x = LFPR_t^x \times N_t^x \qquad (8)$$

PARTICIPATION**:** The labour force participation rate is modelled as a function of real wages $\left(\left(\frac{w}{pc}\right)_t\right)$ a time trend and total employment (LTOT).

$$LFPR_t^x = f\left(\left(\frac{w}{pc}\right)_t, time, LTOT_t\right) \tag{9}$$

Estimating equation (9) directly using time series data proved unsatisfactory. Instead we calibrate this equation using the results of microeconomic studies. In the previous version of the model the elasticity with respect to the real wage was imposed from microeconomic estimates of labour supply elasticities (Doris, 2001). For the current version of HERMES-13, Bergin, 2013, using data from the CSO SILC, estimated probit models for a series of years covering much of the last decade. The results of this estimation have been used to calibrate these equations in HERMES.

In Bergin (2013), the wage variable used was the predicted log hourly gross wage rate. Wages were predicted using linear regression for men and using a Heckman model for women, to control for the problem of sample selection. Variables for the number of children and for whether a woman had a child under the age of four were used as identifying variables in the participation equation.

Elasticities with respect to wage effects are reported in Table 6. Participation equations for men typically show relatively low sensitivity to wage rates, and here is no exception. Also, the unqualified male participation elasticity is only included for 2004 (as it is they only year it is significant).

Table 6: Summary of Participation Elasticities for Men and Women

	2004	2005	2006	2007	2008	2009	2010
Males							
All	0.09	0.12	0.11	0.10	0.09	0.09	
Unqualified	0.31						
Qualified	0.07	0.13	0.12	0.11	0.10	0.10	
Females							
All	0.45	0.48	0.50	0.45	0.46	0.56	0.54
Unqualified	1.25	1.06	1.31	1.17	1.05	1.81	1.03
Qualified	0.42	0.46	0.47	0.42	0.41	0.52	0.52

The analysis here uses similar model specifications to Doris, 2001. Doris used Living in Ireland data and her estimates of the elasticities of participation for males (in 1998) were 0.19 for all males, 0.06 for qualified males and 0.68 for unqualified males. These are broadly consistent with the results shown here. Using a different specification (and dataset) Doris estimated the participation elasticity for all females to be 0.93 in 1998. Her estimates for unqualified and qualified females are 2.8 and 0.58 respectively. The estimates here for qualified females are very similar; however the estimates for unqualified females are lower.

These elasticities, derived from micro-economic data, were calibrated in equation (9).

A key factor affecting labour supply in Ireland over the last century has been migration. Ireland is unusual in the importance of this channel. Because of this propensity of Irish people to migrate, Irish labour supply has always been very sensitive to changing economic conditions. More recently, immigration into Ireland by returning emigrants and by foreigners has played a very important role. The growing numbers of non-Irish citizens in the migration flows means that past behaviour may be a less reliable guide to future population movements than it was over the 1990s. In addition, issues, such as the cost of housing and relative congestion levels, may also have affected choices on migration, even though they are not currently captured in the model (Duffy, FitzGerald and Kearney, 2005).

Many studies of Irish migration have been carried out using a model originally developed by Harris and Todaro, 1970. Studies for Ireland using this model include Walsh, 1968, and Honohan, 1992. In this approach net emigration (N) is modelled directly as a function of the difference between Irish wage rates (w_I) and UK wage rates (w_U) or unemployment rates in Ireland U_I and in the receiving UK labour market (U_U):

$$N = f(\frac{w_I}{w_U}, \frac{U_I}{U_U}) \tag{10}$$

$$N = a + b\log(\frac{w_I}{w_U}) \tag{11}$$

If we simplify by making net migration a simple linear function of the log of the relative wage rates as in equation (11), then for migration to be zero the following must be true:

$$0 = a + b\log(w_I) - b\log(w_U) \tag{12}$$

$$\log(w_I) = \log(w_U) - \frac{a}{b} \tag{13}$$

This specification implies that Irish wage rates must be set as a constant mark up on UK wage rates (13). Holding wage rates constant, this would imply an infinitely elastic supply of labour in the long run: migration will continue indefinitely once the relative wage rates depart from their equilibrium level.

While equation (10) provided a good approximation to the underlying true labour market behaviour for many decades, the data suggest that it is no longer appropriate. Instead, in the 2008 version of HERMES, the long-term stock of net migrants[11], rather than the flow, is modelled as a function of the factors affecting the relative attractiveness of the Irish and UK labour markets as shown below:

$$N^* = a_1 + a_2\frac{1-U_i}{1-U_u} + a_3\frac{w_i}{w_u} \tag{14}$$

This estimated equation models the stock of migrants in Ireland (including returned emigrants) as a function of differences in the unemployment rate between Ireland and the

[11] This is approximated by cumulating the flow of past migrants over the last 40 years.

UK and differences in the real after tax wage rates in the two labour markets. Migration in any given year is determined by the difference between the optimal stock of migrants and the actual stock. A dummy is included for the last decade to cover the effects of EU enlargement. The dummy reverts to zero at the end of the last decade, reflecting the fact that enlargement involved a once-off adjustment to a new population equilibrium, both for the new members states and for the rest of the EU.

When this system of equations determining labour supply – labour force participation and migration – is simulated, holding other variables constant, the result is an elasticity of labour supply in the long-run of unity.

Underlying the medium-term model specification is a much more detailed demographic model developed by the ESRI (Byrne, FitzGerald, and Znuderl, 2012). This model is used to estimate the likely natural increase in the underlying population of working age. Also it provides a cross-check on the modeling of demographics in *HERMES.* In the demographic model, because of the different pattern of labour market participation for males and females, the supplies of female and male labour are modelled separately. The model is driven by the educational attainment of the population. The final educational attainment of each cohort is assumed to be determined at age 20. Then the numbers with each of the four levels of education in each cohort are determined by ageing, by deaths and by migration. In turn, female participation rates are determined by the educational attainment of the cohort.

In using HERMES, the demographic model is used as a check on the results when undertaking complicated scenarios (as in the *Medium-Term Review)*. The approach taken in developing the scenarios is to first determine migration within HERMES and then to plug that result into the demographic model and let it determine the labour force. A short iteration between the two models can be used to reach a solution that incorporates some of the additional insights available from the demographic model. When considering "shocks" to the model, as in Section 3, the calibration of the sensitivity of labour force participation to changes in wage rates is particularly valuable.

2.2.2 Wage determination

The basic model of wage determination used in HERMES reflects the openness of the Irish economy. It is consistent with the modelling of the supply and demand for labour in the rest of HERMES. Long-run or "equilibrium" labour demand and labour supply are determined in separate systems of equations in the model, as described above. Together these equations determine the long-run "market clearing" wage rate.

In this section of the model we calibrate a simple wage equation that captures some of the key characteristics of these separate equations. This is done by imposing directly the elasticities of labour demand and supply in a reduced-form wage equation and then estimating the remaining parameters. This determines the long-run market clearing wage. The wage rate in the short term is then determined in an ECM. This approach ensures consistency within the model and it also means that when the model is shocked, starting from an equilibrium of full employment, the economy will eventually return to that full-employment equilibrium.

The derivation of the wage rate equation is straightforward. We assume a log-linear form for the aggregate labour supply and aggregate labour demand equations for the economy. These can be solved for the "equilibrium" wage rate w*[12].

Summarising the system of equations for each sector in the HERMES model, the demand for labour (15) is a function of world output, q_w, and the cost of labour in Ireland relative to the rest of the world, where w_i is the wage rate in Ireland, and w_u are the prices of wages in the UK.

$$l_i^d - q_w = d_0 + d_1(w_i - ew_u) \qquad (15)$$

In the case of labour supply, the set of equations describing the HERMES model of labour supply, set out above, can be summarised in nested form as equation (16):

$$l_i^s = b_1 + b_2(w_i - z_i + t_i) + b_3(w_u - z_u + t_u) + b_4(U_i - U_u) + b_5 R_i \qquad (16)$$

where:

l_i^s = labour supply in Ireland, (log of employment)
w_i = is the log of the wage rate in Ireland
z_i = is the log of the consumer price deflator for Ireland
t_i = is the tax rate in Ireland
U_i = is the unemployment rate in Ireland
R_i = is the log of the benefit level in Ireland

This system of equations can then be solved for the equilibrium wage rate. A simplified version of this reduced form model was then estimated with the imposed elasticities of demand (-0.4) and supply (+1.0) of labour. The wage rate then adjusts to this long-run equilibrium value as determined in an ECM.

[12] A formal derivation is given in Fitz Gerald (1999).

Figure 3: Ratio of Actual to Long-Run Non-Agricultural Wage Rates

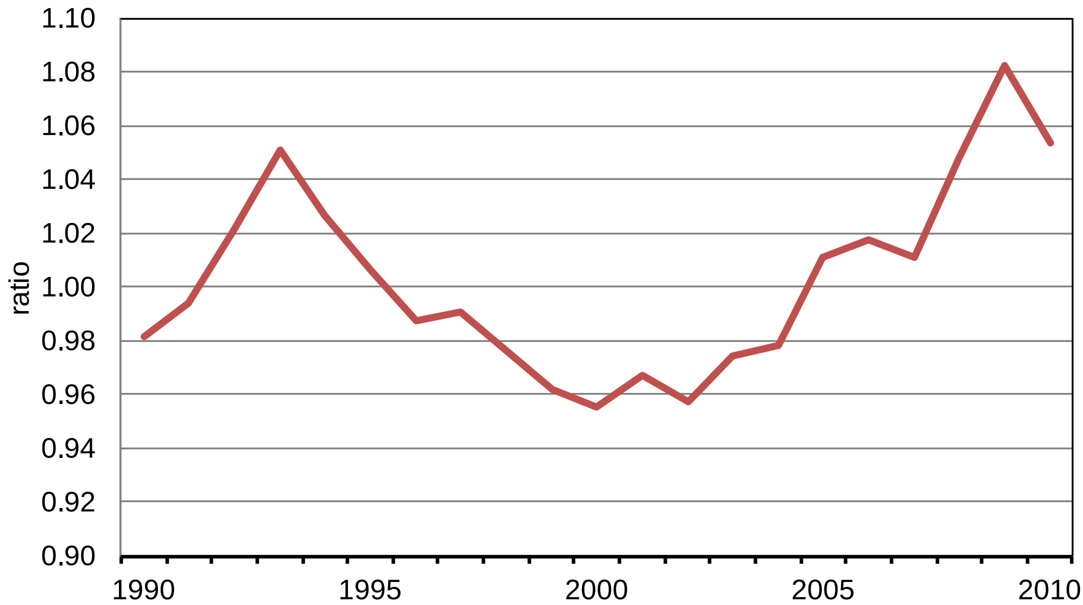


Figure 3 shows the ratio of the actual wage rate (average earnings) to the long-run or market clearing wage rate. This indicates that wage rates were significantly above their equilibrium level in the early 1990s, a time of very high unemployment. They fell well below their equilibrium level by 2000, making the economy very competitive. That level of competitiveness was unsustainable – wages had to rise more rapidly between 1999 and 2003 to restore long-term equilibrium to the labour market. However, they massively over-shot, so that by 2009 wage rates were 8 per cent above their market clearing level.

2.3 National expenditure

The expenditure side of the national accounts consists of private and public consumption and investment, stock changes, exports and imports.

The quest for a stable and robust model of private consumption behaviour has taxed, and continues to tax, the brains of economic modellers both in Ireland and abroad. Over the past decade our approach was to use the very simplest Keynesian model. This implied that consumption is determined by current personal disposable income, excluding any wealth effects. To address this, in the current version of the model we also include housing wealth and financial wealth variables in the consumption function, which proved significant when the data for the 1990s were included in estimation. This implies that when real housing wealth rises, for example because real house prices rise, there is a positive effect on consumption. International evidence also supports the existence of a "wealth effect", see for example Case, Quigley and Schiller, 2001.

Private investment is determined on the supply side of the model, described above, as a derived factor demand into the long-run production process. So, investment is determined initially by sector, and the aggregate sectoral investment is split between its two main components: machinery and equipment, and building and construction. The public elements of consumption and investment are used as policy instruments in the model. The exception is investment in housing, which is discussed below.

Industrial exports are determined in a supply function driven by manufacturing output, where the marginal propensities to export the output of each sector are estimated, and corrected by a time-trend, permitting the export share of output to rise over time.

Because of the importance of foreign direct investment in Ireland, we model separately profit repatriations by foreign multinationals. The level of repatriations by these firms is a function of their profitability operating in the Irish economy. Increasingly these repatriated profits are generated within the business and financial sector. This equation plays an important role in the model. It is a key determinant of the wedge between GDP and GNP.

Finally, there is no conventional behavioural equation for imports in our model. Rather, we determine all the separate sectoral components of output, and all the elements of final demand. Imports are then determined as a residual, i.e. the difference between output and final demand.

2.3.1 A new consumption function

The theoretical framework underpinning the consumption function in this version of HERMES is the life-cycle hypothesis of consumption and saving (Ando & Modigliani, 1963). This framework states that "consumers accumulate assets during working life so as to live on the surplus during retirement" (Davis, 2010). Therefore, planned consumption $C1_t^*$, is a function of total wealth, consisting of human wealth H_t and previous period's non-human wealth W_{t-1}:

$$C1_t^* = m(H_t + W_{t-1}) \tag{17}$$

where m is the marginal propensity to consume (MPC) out of total wealth. Human wealth H_t is unobservable but can be proxied by current labour income Y_t. Non-human wealth W_t consists of financial wealth and housing wealth.

Consumers need to be able to save and borrow in order to achieve inter-temporally optimal consumption. However, if consumers face uninsurable risks to their income, or credit constraints, their ability to smooth consumption is limited.

Davis (2010) suggests that an indicator of credit constraints can be constructed from the relative size of coefficients on income and wealth in the consumption function. In particular, the MPC out of income will be higher compared to the MPC out of wealth when credit constraints exist, as consumption smoothing through saving and borrowing is limited, and consumption is constrained to income. In the extreme case where all consumers are credit constrained, the planned consumption is reduced to a simple Keynesian function where consumption is determined by income only:

$$C2_t^* = kH_t \approx \hat{k}Y_t \tag{18}$$

The most recent version HERMES-13 includes options to use either the consumption function which accounts for effects related to saving and wealth (equation (17)) or the

Keynesian-type consumption function affected by income but not wealth (variant of Eqn. 18).

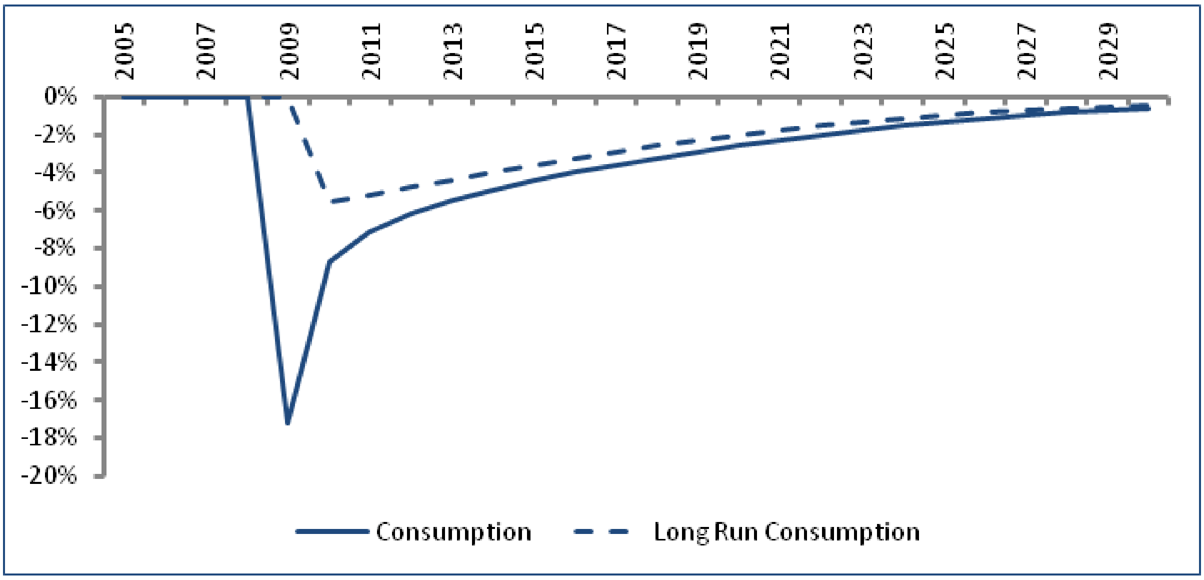
$$C^* = a_1 + a_2 Y + a_3 D_{-1} + a_4 F_{-1} \qquad (19)$$

Equation 19 shows the specification used to estimate the long-run consumption function with wealth effects. C* is long-run consumption per head. It is a function of, Y, real personal disposable income per capita, and lagged value of two types of wealth, real housing wealth per head (D) and real net financial wealth per head (F). This equation was estimated over the period 1990 to 2009.

The main components of financial wealth of households are currency and deposits, insurance and pension fund assets, and shares and other equity. Loans, including mortgage liabilities, are subtracted from financial wealth to arrive at net financial wealth. This is converted to real terms using the personal consumption deflator. Consumption adjusts to its long-run equilibrium using an ECM representation.

When applied to the recent crisis this model captures the slow adjustment and deleveraging by households that has actually occurred. We have modelled here the effects of a permanent collapse in housing wealth of 50% in 2009. (When considering this simulation, it is important to note that consumers' real personal disposable income is kept constant.) The effect is to initially produce a dramatic fall in consumption and a corresponding rise in the savings rate. With a higher savings rate net financial wealth is gradually built up. Taking the consumption function and the savings identity determining net financial wealth, we can trace out how long it would take for net financial wealth to rise (through the addition of new savings) to offset the loss of financial wealth. The resulting path for consumption is shown in Figure 4.

Figure 4: The response of short-run and long-run consumption to the collapse in housing wealth in 2009



The dynamics corresponds to a Buffer Stock type model of consumption where consumers are offsetting the decline in their housing wealth through saving/accumulation of financial assets. Overall, this simulation suggests a prolonged deleveraging process, which continues throughout the current decade.

Consumption of energy by households is modelled in the energy block of the model with the rest of consumption being residually determined. The price of energy for households is also determined in the energy block. However, the price deflator for the vast bulk of consumption (excluding energy) is determined by a separate equation. This price deflator is a function of a weighted average of net of tax input costs, VAT rates and the rate of excise taxes. Thus the model handles appropriately the impact of indirect taxes on consumption.

By using a weighted average of input costs the model does not allow for differing behaviour in the face of different cost drivers (other than indirect taxes). This may mean that the model will tend to underestimate the impact of UK consumer prices and the bilateral exchange rate with sterling on Irish prices. Because much of the retail sector is dominated by UK based firms, traditionally the influence of developments in the UK on consumer prices has been significant (Bradley, 1977 and FitzGerald and Shortall, 1998). However, the advent of EMU rather changed this pattern (FitzGerald, 2001), though developments in the UK are still important today for consumer prices.

2.3.2 The Housing Market

The model of housing demand is based on work by Murphy and Brereton, 2001. In the model demographic factors, income, and the real cost of housing (including interest rates) all affect housing demand. Housing supply is affected by the profitability of house building, proxied by the price of houses relative to the cost of producing them. A similar model was used in McQuinn and O'Reilly, 2008. An overview of the housing section of the ESRI macro-model is given in Duffy, FitzGerald and Kearney,2005.

The demand for housing uses an inverted demand function specification. Real Irish new house prices are positively related to the level of real disposable income per capita (Y) and the percentage of the population aged 25-34 years (POP_{2534}), and is negatively related to the per capita housing stock (HSTOCK) and the real cost of capital for housing (rr).[13] In the model expectations are generally assumed to be backward looking. This appeared to fit the experience of the last fifteen years better than any alternative. However, there is an option in the model to modify expectations and how they affect the cost of capital for housing. A dummy variable is also included for 2003.[14] This equation determines the long-run equilibrium demand for housing.

$$\log P_h = a + b_1\log(Y) - b_2(HSTOCK) + b_3(POP_{2534}) - b_4(rr) + b_5(D_{2003}) \quad (20)$$

[13] The user cost of housing (proxied by the nominal mortgage interest rate less the change in house prices).

[14] This is in keeping with the approach of Murphy (2005). Murphy includes dummy variables for 1997 and 2003 that "…pick-up the combined effects of financial liberalisation, policy interventions since 1998 and speculative frenzy effects."

The housing supply equation, which estimates the number of house completions (H_s), is modelled as a function of the profitability of new house building. Thus, it is driven by new house prices (P_h) and the cost of building (cc), represented by wage costs, input costs and the cost of capital. The unit cost of production for building is derived from the estimation of a factor demand system for the building sector.

$$\log H_s = A + B_1 \log(P_h/cc). \quad (21)$$

Finally, the model includes an equation for the housing stock (HSTOCK) based on the housing stock in the previous period, housing completions (HCOMP) in the current period, and assuming depreciation of 0.5 per cent a year:

$$HSTOCK_t = 0.995 * HSTOCK_{t-1} + HCOMP_t \quad (22)$$

While the housing model defines the equilibrium demand for housing there is no equation determining equilibrium supply. The housing completions is a flow equation. It is only if the flow is zero (or equal to the dwellings that disappear through obsolescence- depreciation) that the model will return to an equilibrium when shocked. However, tests suggest that when the model is perturbed, over time the profitability of building houses will tend to return a level that would see a fairly stable supply of housing.

2.4 The Public Finances

In the model there are two options for handling the public finances. In the first option they are put on "auto-pilot" with rules for each item of public expenditure and revenue that will combine to produce what we define as a neutral fiscal stance. This means that the government is neither stimulating the economy nor taking action to deflate it. These rules are referred to as indexation rules. They are described in Section 2.4.1 and set out in detail in Appendix 2.

These indexation rules are optional. In practise, when modelling past behaviour or scenarios for the future, the indexation rules are switched off and the path of the individual government variables may be specified to match government budgetary choices. In such a case the choice of values for the government variables determines the nature of the fiscal stance, stimulatory or contractionary.

In addition to the indexation rules there is also an optional rule where the path of the General Government Deficit (or surplus), the GGD, is specified as a percentage of GDP. Then the model will ensure that that target GGD path is reached each year. The model uses a specified fiscal instrument to ensure that the target is met.

The output of the public sector is essentially determined by public employment inputs, and appears in the model on the expenditure side of the national accounts as public consumption. Wage rates in the public sector, the deflator for public consumption, are assumed to follow wage rates in the private sector unless otherwise specified.

Transfer payments, including pensions and unemployment benefits, are indexed. The rates of benefit can be indexed to either wage rates or consumer prices (or zero-indexed). The base for pension and other similar transfers is the population in the dependent age groups and expenditure is indexed to changes in that population. In the case of unemployment benefit payments, the rate, as indicated already, can be indexed to wage rates or prices while the base is the actual numbers unemployed. In each case expenditure is the product of the rate and the base.

Subsidies are determined as the product of a rate of subsidy multiplied by a suitable base.

National debt interest is a function of current and past interest rates and the amount of debt outstanding. Interest payments on government bonds in any year are equal to the payments in the previous year less the payments that would have been made on bonds that are repaid plus interest payments on new bonds issued. The current interest rate only directly affects the payments on new bonds issued. A similar approach is taken to modelling interest payments on small savings, promissory notes, and borrowing from the Troika. The proportion of interest payments paid abroad is an exogenous variable, reflecting the ownership of the debt. For example, all interest on borrowing from the Troika is paid abroad.

Government capital expenditure is either exogenous or indexed to a relevant price deflator. The one exception is capital grants to households and companies, where the rate of grant is exogenous and it is multiplied by a suitable base.

The main tax revenues are determined as the product of an average tax "rate" multiplied by the appropriate tax "base" (e.g., VAT receipts are determined as the product of an average VAT rate – a policy instrument – by the VAT base, being essentially the value of consumption expenditure and investment in housing. In the case of income tax, social insurance contributions and the universal social charge an average tax rate is applied to a suitable measure of taxable income. The approach to modelling revenue from corporation tax was developed in Conefrey and FitzGerald, 2011 and this is now implemented in the current version of the HERMES model. The same basic approach is applied to the other main tax heads.

Government debt is a function of the debt outstanding at the beginning of the year, the GGD for the year and the effects of any debt refinancing undertaken or any off-balance sheet transactions.

2.4.1 Fiscal rules: estimating the fiscal stance

Our method of estimating fiscal stance is to use the model to simulate the effects of an indexed budget, where indexation is based on assuming no policy change relative the previous year's budget. The difference between the indexed budget balance and the actual budget balance is then a measure of fiscal stance. A positive (negative) difference indicates a loosening (tightening) of fiscal policy. This is based on an incremental approach and so can be cumulated over time. Using a macroeconomic model for estimation allows for the implementation of detailed indexation rules for different items of revenue and expenditure.

Effectively, the indexed budget is intended to simulate a "what if there were no policy changes" budget relative to the previous year. In practice average tax rates and average expenditure rates are held unchanged relative to the previous year, where detailed indexation rules are used for individual tax and expenditure items. Appendix 2 give details on the indexation rules employed. We then compare this "indexed" outcome with the actual outturn in each year. The difference between the indexed and actual outcome provides an estimate of the fiscal stance.

The full indexed budget is computed assuming no change in average tax and expenditure rates from the previous year, and applying the actual growth rate to the revenue and expenditure base. The use of average tax and expenditure rates ensures full indexation of the tax and welfare system. There is one exception to these indexation rules. Indexation of non-cyclical expenditure assumes it grows at its "long-run" growth rate which we implement as a nine-year average growth rate. This is intended to capture a measure of indexation that is neutral with respect to the cycle.

The derivation of an indexed budget using the model can be illustrated in a simplified example as follows. Define T as total revenue, GTR as cyclical expenditure (transfers) and GO as non-cyclical expenditure, then the actual budget balance B in year t is:

$$\mathrm{B}_{\mathrm{t}} = \mathrm{T}_{\mathrm{t}} - GTR_t - GO_t \tag{23}$$

Define t as the average tax rate (T/Y), rtr as the average rate of cyclical expenditure (GC/Y), rgo as the average rate of non-cyclical expenditure (GO/Y). Then the budget balance can be expressed as a function of average tax and expenditure rates, which are discretionary policy instruments, times the base Y, where the base is determined by the rate of economic growth:

$$\mathrm{B}_{\mathrm{t}} = \mathrm{t}_{\mathrm{t}} Y_t - rtr_t Y_t - rgo_t Y_t \tag{24}$$

Now define z_t as the actual growth rate in year t, Y_t / Y_{t-1}, and z^* as the "long-run" growth rate in non-cyclical expenditure. The budget balance indexed on the previous year's budget is then:

$$\tilde{\mathrm{B}}_{\mathrm{t}} = \mathrm{t}_{\mathrm{t-1}} Y_{t-1}.z_t - rtr_{t-1} Y_{t-1}.z_t - rgo_{t-1} Y_{t-1}.z^*{}_t \tag{25}$$

where $z_t . Y_{t-1} = Y_t$. With some manipulation this can be derived as:

$$\tilde{\mathrm{B}}_{\mathrm{t}} - \mathrm{B}_{\mathrm{t}} = -\left(\Delta \mathrm{t}_{\mathrm{t}} - \Delta rtr_t - (rgo_t - rgo_{t-1}.\frac{z^*}{z}) \right).Y_t \tag{26}$$

From the formula we can see that increases in average tax rates will tighten fiscal stance while increases in average transfer rates will loosen fiscal stance. The last term implies that if non-cyclical expenditure grows faster than its long-run growth rate, this will loosen fiscal stance.[15]

The main tax revenues are determined as the product of a tax "rate" by a "tax base":

$$\mathrm{T_{it}} = \mathrm{t_{it}} . \mathrm{BASE_{it}} \quad (27)$$

For the purposes of indexation, there are detailed separate revenue categories identified. These include expenditure taxes (VAT receipts, customs taxes, excise taxes, agricultural levies, motor vehicle duties, etc.) and income taxes (personal income taxes, social security contributions, corporate income taxes, DIRT taxes, agricultural income taxes, etc.). Appendix 2 gives the detailed indexation rules applied for each category of revenue. Typically indexation to the previous year's budget is implemented by setting the tax rate equal to that of the previous year, as follows:

$$\tilde{\mathrm{T}}_{\mathrm{it}} = \mathrm{t_{it\text{-}1}} . \mathrm{BASE_{it}} \quad (28)$$

There are some exceptions to this rule built in to the model to ensure accurate indexation. For example, the *rate* of excise duty is indexed to the deflator of private consumption because excise duties are levied on volumes.

The indexation of expenditure items is more complicated because not all items of expenditure are cyclical. For cyclical items the indexation rules used can be summarised as follows:

Unemployment transfers, GTRU, are modelled as the product of an unemployment transfer "rate" ru, applied to the "base" of total numbers unemployed, U:

$$\mathrm{GTRU_t} = \mathrm{ru_t} . \mathrm{U_t} \quad (29)$$

Because numbers employed is a volume base, the rate must be indexed to the appropriate price. In the HERMES model indexation of the rate of transfer payments uses a weighted average of the private consumption deflator and the average wage rate as the price term:

$$\widetilde{GTRU}_{\mathrm{t}} = \mathrm{ru_{t\text{-}1}}.(\alpha\dot{\mathrm{P}}_{\mathrm{t}} + (1\text{-}\alpha)\dot{\mathrm{W}}_{\mathrm{t}}) . \mathrm{U_{it}} \quad (30)$$

Indexation of other personal transfers applies a similar price adjustment. In addition, because these transfers are mainly to the elderly (pensions) and the young (children's allowance) there is a volume adjustment based on the growth in the dependency rate (the proportion of the population over 65 and under 14 years of age).

Indexation of subsidy payments imposes a growth rate equal to the growth in the relevant subsidy base. For example, agricultural subsidies are assumed to grow at the same rate as agricultural output.

[15] This can be seen by rewriting this third term as follows:

$$rgo_t - rgo_{t-1} . \frac{z'}{z} = \frac{G_t - G_{t-1}.z'}{Y_t}$$

For non-cyclical expenditure items, we assume no volume growth as a pure indexation rule. Indexed values of four categories of public investment, two categories of employment and public consumption were all computed on this basis (Appendix 2).[16] While in normal times such an indexation rule would be deflationary[17], given the collapse in the economy, this could in itself be regarded as having an expansionary bias in 2009-2012. To the extent that this is the case, our estimate of the fiscal stance will in effect *overstate* the contractionary effect of fiscal policy. On balance we considered that a no-growth indexation rule is the best approximation for a realistic no policy change stance over the period in question.

2.4.2 Endogenising the government risk premium

An important new mechanism in this version of HERMES is the endogenisation of the government risk premium relative to German interest rates. The interest rate on Irish government borrowing is affected by a range of factors. Firstly there are the factors that affect the interest rate of "safe" Eurozone bonds, such as German bonds. Then there are the factors that determine the Irish risk premium relative to those "safe" bonds.

Since the advent of EMU until the onset of the crisis, the Irish risk premium (relative to Germany) was close to zero (see Figure 5). However, as the crisis began, and Irish government borrowing and the debt level rose dramatically, the risk premium also rose. There are a number of explanations suggested as to why risk premia rose so sharply in recent years. The core explanation is the role of macroeconomic fundamentals, where the risk premium rises in line with the levels of debt and the deficit (measure of the rate of change in debt levels) facing an economy.

However macroeconomic fundamentals are not sufficient to explain large, discrete changes in the risk premium, at a time of widespread financial crisis and contagion. In the Irish case, an additional explanation for the discrete spike in the risk premium in 2010 would include announcements of bank rescue packages, which transfered risk from the private sector to the government (Attinasi et al. (2010)). Further, Gunn and Johnri (2012) argue that the sovereign risk premium rises as countries move closer to an expectation of default.

The risk premium is also affected by factors outside Irish control. Towards the end of 2010 the promise of €67.5 billion in relatively low cost funding from the Troika calmed markets and reduced the risk premium for Ireland. Again in July 2012, the intervention of the President of the ECB calmed financial markets, bringing about a very significant reduction in the risk premium for Ireland, Italy, Spain, Portugal and Greece. In both cases the risk premium was on a trajectory that could have resulted in the cost of funds becoming prohibitive, but the intervention of EU policy-makers shifted the trajectory onto a sustainable path.

[16] These are investment in public administration, health and education, local authority housing and roads, water supply and sewerage; employment in public administration, and health and education; and government's purchases of goods and services.

[17] In Kearney et al (2001) and Barrett et al (2009) we used a long-run volume growth rate, estimated using a nine-period centred moving average as an indexation rule.

Finally, experience of the last few years has shown that contagion can happen in the financial markets. Problems in one country, for example, Greece, can result in an increase in the risk premium for Ireland and other vulnerable countries.

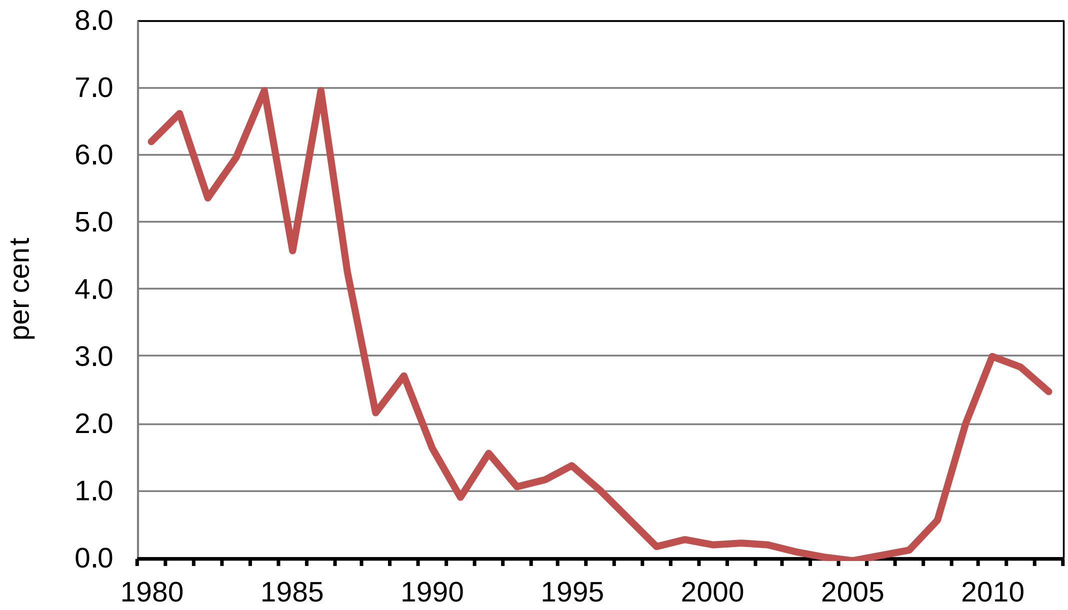
The empirical evidence to date suggests that there is a non-linear relationship between risk premia and expected debt levels (Corsetti, Kuester, Meier and Muller (2012)). In addition, as the experience of Ireland, Greece and Portugal showed, above a certain level of borrowing and debt, the risk premium can rise exponentially, so that funding is effectively unavailable.

Thus modelling the risk premium is a complex task. For the purposes of the HERMES-13 model we have developed a calibration of the risk premium for Ireland as a function of government borrowing and government debt. While this is an undue simplification of the real world, it does capture a critical mechanism through which domestic fiscal policy action can have consequences for the risk premium. Many recent studies emphasise the trade-off for countries with public debt crises between corrective fiscal policy action, which has negative consequences for the economy, and reductions in sovereign debt risk, which help stabilize debt (Muller 2013). We use this calibration in the scenarios we develop in this Review as we believe that it is preferable to recognise that domestic fiscal policy can have consequences for the risk premium rather than to assume that there are no consequences.

The interest rate on borrowing paid by the government in Ireland (r_{IRL}) is, in principle, the sum of two components (equation 31). The first component is the risk-free interest rate paid by Germany (r_{GER}), a state with essentially no risk of default on its debt. The second component is the risk premium ($\Pi_{IRL,GER}$). This is defined as the cost of borrowing incurred by the government of Ireland that is over and above the risk-free interest rate incurred by Germany ($\Pi_{\mathrm{IRL,GER}}$).

$$\mathrm{r_{IRL}} = \mathrm{r_{GER}} + \Pi_{\mathrm{IRL,GER}} \tag{31}$$

Figure 5: Risk Premium for Irish 10 year Government Bonds Relative to German Bonds



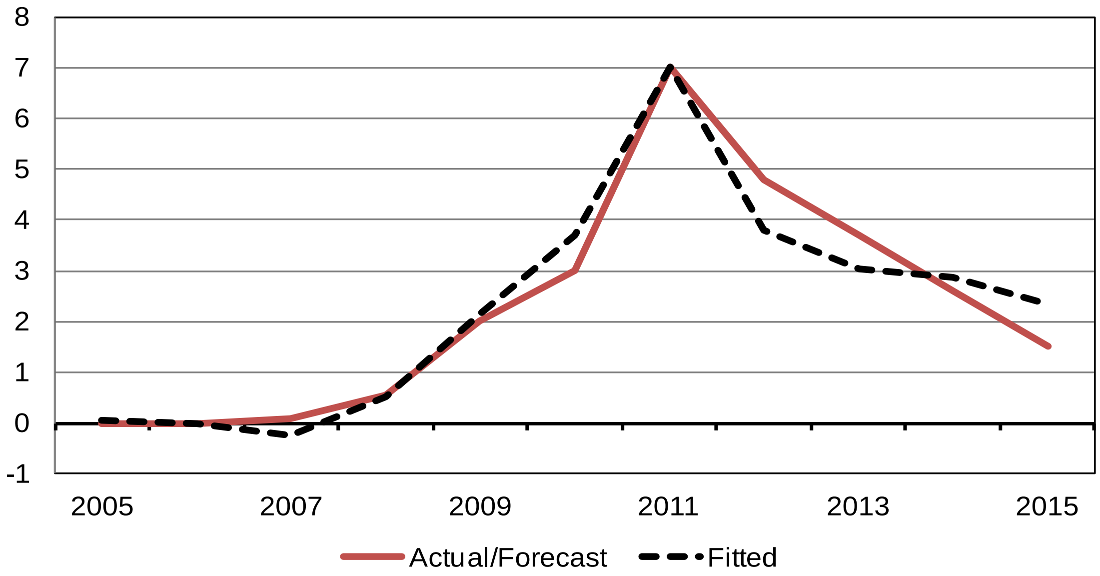
The risk premium on Irish government debt[18] represents financial markets' perception of the risk that the government of Ireland would default on its debt obligations. In other words, the risk premium is the markets' collective assessment of the sustainability of Irish public finances. Accordingly, the risk premium on Irish government borrowing has fluctuated substantially over the last thirty years. In the 1980s, with high borrowing, high debt ratios and an independent exchange rate, the risk premium was high (Figure 5). However, over the 1990s the economic success of Ireland and the move to EMU brought down the risk premium by the end of the decade (Baker, FitzGerald & Honohan, 1996; Conefrey & FitzGerald, 2010). The risk premium remained low during the period to 2006, but it rose dramatically from 2008 in the face of the collapse of the economy and the dramatic increase in government indebtedness.

Past experience elsewhere shows that beyond a certain threshold, adverse movements in the public finances have consequences for the risk premium. Experience in the 1980s showed that fiscal tightening, ceteris paribus, was likely to reduce the interest rate paid by the Irish government, while a failure to tackle fiscal problems would be likely to increase the risk premium. Since Ireland joined EMU, the risk premium remained low as long as the debt-to-GDP ratio remained below 60 per cent. However, once the public finances experienced a very severe deterioration in 2008, the risk premium rose rapidly.

In Bergin et al., 2010, the potential impact on the risk premium of different fiscal policy options was modelled using discrete changes in the risk premium based on limited evidence. Using past experience and the experience of the current crisis, a more systematic calibration of this effect has been implemented in HERMES-13. This calibration should not only capture the rise in the risk premium to 2011; it should also handle an unwinding of the premium in an appropriate manner as the problems with public finances are gradually resolved. To this end we combine data since 2005 with the Department of Finance/NTMA assumptions about nominal GDP, borrowing and debt out to 2015 and we use these data to calibrate a model of the risk premium.

[18] Measured as the gap between the yield on Irish and German ten year government bonds.

Figure 6: Government Risk Premium: Actual vs. Fitted Values



The risk premium in each year is modelled as a simple function of the government borrowing in the previous year (expressed as a percentage of GDP), RGBR, and of the debt-to-GDP ratio, RGGD. Government borrowing includes the cost of financing the banking system, a very important factor in the loss of confidence in the Irish economy over the period 2008-11.[19]

According to this calibration, a 1 per cent increase in the previous year's government borrowing as percentage of GDP will increase the risk premium by 0.15 per cent, while a 1% increase in debt-to-GDP ratio will increase the risk premium by 0.02 per cent. This calibration tracks the rise in the risk premium reasonably well to its peak, as well as the recent fall in 2012 (Figure 6).

The calibration implies that with a debt/GDP ratio of 60 per cent and an elimination of the government deficit, the risk premium would fall to 1.5 per cent. While this might seem high by historical standards, it is nonetheless a plausible calibration in the current economic context.

This new equation is used in the HERMES model to provide a calibration of the effects of changes in the public finances on Irish government interest rates. In turn, this interest rate has a significant feed–back effect on the economy, both through its effects on government debt interest payments and through its effects on interest rates for the private sector.

2.5 The current account in the long run

The current account is determined by the usual series of identities. Merchandise exports are a function of domestic output and imports are residually determined as the difference

[19] This approach abstracts from the possibility that there are multiple possible equilibria for the economy: one where interest rates are very high, making default likely, and another, where interest rates remain low, making it unlikely.

between domestic output and demand. In addition, as discussed above there is an equation that determines the level of profit repatriations as a function of profits in the high tech. manufacturing sector and in the business and financial services sector.

Over time a current account surplus or deficit adds or subtracts from private sector net foreign assets. A technical equation relates the residual factor income (after profit repatriations and national debt interest) to the stock of net foreign assets and a rate of return. This ensures that continuous imbalances on the current account show up in increasing flows of factor income from or to abroad.

In the model there is no explicit mechanism to ensure long-term equilibrium in the current account. However there is an optional rule that will constrain government borrowing to a specified level. If it is constrained to a level that ensures that the national debt (national asset) position is stable in the long run then public sector dissaving or saving will not contribute to a long-term imbalance on the current account.

The new consumption function plays a similar role for the household sector. If the current account were in surplus and the household sector saved, that saving would result in an accumulation of foreign assets; then the rising household foreign asset position would eventually result in increased consumption. Alternatively, as is the case today, the need to rebuild the households' net financial asset position results in higher savings and lower consumption, pulling the current account back towards balance from a position where it is in deficit.

When taken together, these mechanisms will result in the current account tending to return to equilibrium when the model is perturbed.

2.6 The Energy Model

The energy sub-model is used to produce consistent forecasts of energy demand and of greenhouse gas emissions from energy. The modelling framework makes it possible to simulate the effects of alternative policies on reducing greenhouse gas emissions, see Bergin, Fitz Gerald and Kearney, 2002, FitzGerald and Hennessy, 2011 and di Cosmo and Hyland, 2012.

The energy model is built up as four separate, though interrelated, blocks. The model examines the demand for six types of primary energy: coal, oil, peat, gas, electricity and renewables by six sectors of the economy: industry, households, services (commercial and public), agriculture, transport and energy. The demand for energy in the various sectors is modelled in the first block of the model. In each sector, electricity demand is modelled separately from the "rest of energy" and then the "rest of energy" category is broken down between the different fuels. The electricity demand from all sectors is then aggregated to give total electricity demand.

Given the demand for energy, the second block then covers the electricity generation sector, based on a series of exogenous engineering relationships. A separate electricity model examines how these engineering relationships determine the optimal fuel mix in the sector. The results of this electricity model are used as an input into the wider energy model.

The third block of the energy model generates the carbon dioxide emissions associated with the levels of energy consumption. Since each fuel will release a different amount of CO_2 when burned, the aggregate emissions from energy are obtained by multiplying the estimate of consumption of each fuel by an appropriate emissions factor.

Finally the fourth block of the energy model develops a series of relationships that provide a direct link between the energy model and the medium-term model. Price determination for different fuels is included within this block. The price determination takes account of the possible impact of a carbon tax (or of tradable emissions permits). Given the mix of fuels used in each sector, and allowing for the distribution margin, the price of energy used by each sector is derived.

The energy model specification is linked to the model of the utilities sector. It is through the equations in this sector that the engineering data on the consumption and production of energy measured in tonnes of oil equivalent (TOEs) from the energy model are converted into economic variables determining output, inputs and prices in the utilities sector. Furthermore in the determination of household consumption, the consumption of energy has been separated from non-energy consumption, and a personal consumption deflator for energy is derived.

2.7 Model closure

As discussed above, in order to ensure that the output and the expenditure sides of the model are consistent in volume terms imports are treated as a residual. This means that all the errors that come through from the individual equations are concentrated in this variable. While a simple model would produce a much more reliable "estimate" of imports it would only mean that some other variable would have had to be chosen to make the model "add up".

In value terms the residual item making the output, expenditure and income sides add up is output of the business and financial sector, in particular profits in that sector. Because it concentrates all the errors on the value side in these variables they are very volatile in model simulations. This also affects the deflator for value added in the business and financial sector. Because this deflator is used elsewhere in the model a separate equation is also directly estimated for this deflator. This estimate, or "instrument", is then used whenever the deflator is used in other parts of the model to ensure that the errors arising from residual determination do not propagate through the model.

3 The behaviour of the model: Simulations

A key test of any macro-economic model is to perturb individual variables in the model and examine how these perturbations affect the full economy. It is only through such tests that the full behaviour of the model as a system can be determined. The approach adopted is first to prepare a baseline scenario to 2030. In this case the baseline is based on the *Recovery* scenario presented in the 2013 MTR. However, experience has shown that the results obtained are relatively invariant with respect to the precise base used.[20]

To consider the impact on the economy of changes in chosen variables, the relevant aggregates are changed one at a time by a fixed amount, for example by 1 per cent of GDP or €1 billion. The model is then simulated with this one change, holding all other exogenous variables unchanged at their baseline levels. The resulting simulation results are then compared to the baseline thereby isolating the effect of a change in the relevant variable.

The first set of shocks, "growth and competitiveness shocks" relate to exogenous shocks to growth and competitiveness. Specifically in Sections 3.2-3.6 we look at the effects of a shock to world growth, world prices, domestic wages, domestic interest rates and house prices.

The second set of shocks, "policy shocks" contrast the effects of alternative approaches to achieving an €1billion reduction in the government deficit. These are reported in Sections 3.7-3.11. To do this we look at a set of standardised fiscal shocks where each shock is calibrated to ensure an *ex ante* effect of €1 billion adjustment to the government balance. So for example, when looking at tax multipliers, the income tax rate is adjusted to ensure that the total income tax bill will yield an additional €1 billion in 2013 (0.74 per cent of GDP and 0.6 per cent of GDP). Alternatively, for the public sector wage shock the public sector wage rate in public administration, health and education is adjusted so that the total public sector wage bill falls by €1 billion in 2013. In each case the shocks are implemented in 2013 and then held unchanged in subsequent years.

3.1 Methodology

In carrying out these simulations all exogenous variables and parameters, other than those being perturbed, are held at baseline levels. Of course, in the real world many exogenous variables change continuously. For example, when examining the effects of a particular government budget package many different exogenous variables may change and some crucial parameters may also be affected such as through the effect of fiscal policy on consumer confidence. As a result, when using the model to examine real life policy changes or exogenous shocks to the Irish economy, it is necessary to carry out a full simulation, considering the effects of the policy change (or shocks) on all the exogenous variables and parameters in the model. We present the results of two such scenarios in Section 3.3.

[20] An alternative approach to developing a baseline, which is sometimes adopted, is to forecast forward all exogenous variables (including time) unchanged to generate the base. Then the changes are superimposed on this artificial base. While this approach has the advantage that the results are not affected by changing levels of key variables in the base, it raises difficulties as to how to handle inflation rates and rates of return, including interest rates. Generally in such cases interest rates and rates of return should be held fixed in real terms. Because of these problems we favour the baseline approach – superimposing shocks to the model on a baseline forecast. In that regard, past experience in using the model indicates that the results of shocks or perturbations are relatively invariant to changes in the baseline.

Finally there are two technical considerations which are important when interpreting the results:

No balanced budget rule. Unless otherwise specified, the government borrowing requirement is allowed to change as a result of the shock.

The risk premium is exogenous. This facilitates comparisons with results from previous versions of the model in Bergin *et al.,* 2009 and Conefrey *et al.*, 2012.

The results for each of the different shocks are presented for a standard set of variables in a series of tables.[21] In each case the results are presented as changes compared to the baseline, e.g. the change in GNP resulting from the shock. Unless otherwise specified, each shock is initiated in 2013 and the results are then examined for the period to 2018, holding the shock unchanged over that period. Generally, the discussion centers on the medium term impact of the different shocks, concentrating on the results for 2018. However, each of the tables shows the impact effects for 2013 and the results for the intervening years. For a shock implemented in 2013, the first full year impact is in 2014, given lags in the model.

In interpreting the results it should be noted that a positive sign denotes a reduction in the current account deficit (or, equivalently, an increase in the surplus) and a reduction in the government borrowing requirement (or, equivalently, an increase in the financial surplus).

3.2 Growth & Competitiveness shock: Increase in world demand

In this shock we simulate the effects of an increase in world output of 1 percentage point from 2013. This shock illustrates how a recovery in world output would impact on the Irish economy. The results of this shock are presented in Table 7 which shows the deviations of variables from their baseline values. The shock to world output would increase the volume of output in the industrial and market services sectors in Ireland. With the bulk of output in the manufacturing sector being destined for export, the increase in world demand would have a large effect on output in that sector which would rise by around 1.4 per cent over the medium-term. With a growing share of services sector output now exported, the impact of the shock on the output of the market services sector would be similar to that for manufacturing at +1.5 per cent. This represents a change in the behaviour of the economy compared to previous results when a shock to world demand was transmitted to the Irish economy primarily through its impact on the manufacturing sector (see Section 2.1.3 above for details).

The overall increase in employment arising from the shock to world output would be less than the increase in output. Total employment would be up by 0.6 per cent in 2018 while the unemployment rate would fall by 0.4 percentage points. As a result of the tightening in the labour market, wage rates would end up around 0.7 per cent higher than in the base. This would have some offsetting effect on Irish output and employment, through reducing

[21] The effects on all the other variables in the model are available, on request, from the authors.

Irish competitiveness. However, if a similar rise took place in prices and wages outside Ireland this negative offset would not occur[22].

It is assumed that there is no change in fiscal policy other than through indexation. The increase in output and employment in the economy would increase government revenue from a range of taxes while the fall in the unemployment rate would reduce government welfare payments. The net effect on the public finances would be a substantial reduction in the government borrowing requirement as a percentage of GDP of 0.3 percentage points after five years.

There would also be a positive impact on the current account (a 0.3 percentage point increase in the surplus) as a result of the foreign stimulus. While such an improvement in the current account could endure for quite a number of years, in the long term it would result in higher domestic consumption. If this long-term wealth effect on consumption were taken into account, so that the current account of the balance of payments was unchanged, then the positive impact on growth and the public finances would be enhanced.

Table 7: World growth shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	0.8	0.9	1.0	1.1	1.1	1.1
GNP	%Δ	0.5	0.7	0.8	0.9	1.0	1.0
Value added in industry	%Δ	1.3	1.3	1.3	1.3	1.3	1.3
Value added in market services	%Δ	0.9	1.2	1.3	1.4	1.4	1.5
Consumption	%Δ	-0.1	0.2	0.3	0.5	0.6	0.6
Investment	%Δ	1.1	1.6	1.4	1.3	1.3	1.3
Exports of Goods and Services	%Δ	3.2	3.4	3.5	3.6	3.7	3.8
Consumption deflator	%Δ	0.0	0.1	0.1	0.1	0.1	0.1
Wages (non-agricultural)	%Δ	0.0	0.3	0.4	0.5	0.6	0.7
Total employment	%Δ	0.3	0.4	0.5	0.6	0.6	0.6
Employment in services sector	%Δ	0.2	0.4	0.4	0.5	0.5	0.5
Balances							
Unemployment Rate (ILO)	Δ	-0.2	-0.4	-0.4	-0.4	-0.4	-0.4
Current account of BOP as % of GDP	Δ	0.1	0.2	0.2	0.2	0.2	0.3
General Government Deficit as % of GDP	Δ	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3
General Government Debt as % of GDP	Δ	-0.9	-1.3	-1.6	-2.0	-2.2	-2.4
Welfare							
GDP per capita	%Δ	0.8	0.9	0.9	1.0	1.0	1.0
Consumption per capita	%Δ	-0.1	0.2	0.3	0.5	0.5	0.5
Net Emigration	Δ	0.0	-0.7	-1.5	-1.2	-1.1	-0.8
The shock							
Foreign Demand *		1%	1%	1%	1%	1%	1%

* GDP in UK, USA, EU and OECD

22 Under normal conditions a positive shock to word output would see some increase in wage rates in our competitors.

Consumer prices would increase by 0.1 per cent as a result of higher wage rates in the economy. This would act as only a partial offset to the rise in wage rates, so that real personal disposable income would be substantially increased. This would sustain an increase in consumption of 0.6 per cent compared to the base in 2018.

Overall, GDP in Ireland would be increased by 1.1 per cent in 2018 as a result of this shock to world output.

3.3 Growth & Competitiveness shock: foreign prices

In this shock we simulate an improvement in Irish competitiveness by increasing wage rates and prices in Ireland's main competitor economies, including the US, the UK and the EU, by 1 percentage point compared to the baseline. This can be seen as replicating a change in the external value of the currency. Changing external prices affects the economy in two ways. Firstly, as a result of the rise in foreign prices the output price of manufacturing firms in Ireland would also increase as they are price takers on the world market. This would increase their profitability by more than a similar reduction in wage rates. Secondly, it would affect the relative returns to working in Ireland and abroad and, hence, it would affect labour supply through migration.

It is chiefly through the output of the industrial and market services sectors that the improvement in competitiveness would affect the Irish economy. As shown in this simulation (Table 8), manufacturing output would increase by 1.7 per cent when faced with a one percentage point improvement in competitiveness. The market services sector would still produce the majority of its output for the domestic market and it would, thus, show less responsiveness to an improvement in Irish competitiveness. Net output (GDP arising) in services would increase by 0.5 per cent in 2018 as a result of the shock.

The increase in output in both industry and services would feed through to an increase in total employment of 0.2 per cent and a reduction in the unemployment rate of 0.1 percentage points. As a result of this improvement in labour market conditions, Irish wage rates would be around 0.6 per cent above base by 2018.

Higher levels of output and employment would increase government revenue from taxation with the result that the government borrowing requirement as a percentage of GDP would fall by over 0.2 percentage points. Overall GNP would increase by 0.5 per cent in volume terms by 2018 while GDP would be up by around 0.8 per cent. Higher exports would lead to a significant improvement in the current account of the balance of payments of close to 0.5 percentage points while consumer prices would increase slightly by 0.3 per cent.

Table 8: International competitiveness, foreign prices shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	0.5	0.6	0.7	0.8	0.8	0.8
GNP	%Δ	0.0	0.2	0.3	0.4	0.5	0.5
Value added in industry	%Δ	1.6	1.7	1.7	1.8	1.8	1.7
Value added in market services	%Δ	0.1	0.3	0.4	0.5	0.5	0.5
Consumption	%Δ	0.0	0.2	0.3	0.5	0.6	0.6
Investment	%Δ	0.4	0.6	0.8	0.8	0.7	0.7
Exports of Goods and Services	%Δ	0.0	0.3	0.4	0.4	0.4	0.4
Consumption deflator	%Δ	0.2	0.2	0.3	0.3	0.3	0.3
Wages (non-agricultural)	%Δ	0.0	0.2	0.4	0.5	0.6	0.6
Total employment	%Δ	0.1	0.2	0.2	0.2	0.2	0.2
Employment in services sector	%Δ	0.1	0.2	0.2	0.2	0.2	0.2
Balances							
Unemployment Rate (ILO)	Δ	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1
Current account of BOP as % of GDP	Δ	0.2	0.3	0.4	0.4	0.4	0.5
General Government Deficit as % of GDP	Δ	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
General Government Debt as % of GDP	Δ	-1.5	-1.9	-2.1	-2.4	-2.5	-2.6
Welfare							
GDP per capita	%Δ	0.5	0.6	0.7	0.8	0.8	0.8
Consumption per capita	%Δ	0.0	0.2	0.3	0.5	0.5	0.5
Net Emigration	Δ	0.0	0.1	-0.4	-0.7	-0.7	-0.5
The shock							
Foreign Prices *		1%	1%	1%	1%	1%	1%

* Output prices in Germany, UK, EU and USA; consumption prices in Germany and UK; wage rates in UK

3.4 Growth & Competitiveness shock: domestic wage shock

In this simulation we consider the impact of an increase in the level of non-agricultural wage rates in 2013 of one per cent relative to the base, with this increase in the level of wage rates of 1 per cent relative to the base being maintained for the full period to 2018.

The potential impact of this increase in wage rates on a range of key variables is shown in Table 9. The economy would take time to adjust to such a sudden change. It would take time for the rise in wage rates to feed through into the prices of domestic inputs and, hence, Irish and foreign firms would be slow to react to the change. The full implications for investment in new capital equipment would only materialise with a lag. As a result, the long-term effects are best considered by concentrating on the results for 2015-2018.

The rise in wage rates would have a negative impact on economic activity, employment and the public finances in the medium term. The simulation indicates that the deterioration in competitiveness brought about by the wage increase would reduce GDP by around 0.1 per cent by 2018 while GNP would fall by a similar amount. As indicated above, the initial impact would be small as it would take time for the economy to adjust.

The damage to Ireland's competitiveness would result in lower output in manufacturing and market services. GDP arising in industry would fall by around 0.4 per cent as a result of the wage shock.

In turn, the reduction in output would give rise to a fall in employment. Total employment would be down by 0.3 per cent by 2018. The effect on labour supply would be quite uncertain because of the unusual external environment – a recession in many other labour markets. The model assumes that the higher unemployment rate would partly offset the increase in real after tax wage rates in Ireland, moderating the impact on migration.

Table 9: International competitiveness, domestic wage shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	0.0	0.0	0.0	-0.1	-0.1	-0.1
GNP	%Δ	0.0	0.1	0.1	0.0	0.0	-0.1
Value added in industry	%Δ	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4
Value added in market services	%Δ	0.0	0.0	0.0	0.0	0.0	-0.1
Consumption	%Δ	0.3	0.4	0.4	0.4	0.3	0.2
Investment	%Δ	-0.1	0.1	0.2	0.2	0.0	-0.1
Exports of Goods and Services	%Δ	0.0	-0.1	-0.2	-0.3	-0.3	-0.4
Consumption deflator	%Δ	0.2	0.2	0.2	0.2	0.2	0.2
Wages (non-agricultural)	%Δ	1.0	1.0	1.0	1.0	1.0	1.0
Total employment	%Δ	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3
Employment in services sector	%Δ	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
Balances							
Unemployment Rate (ILO)	Δ	0.2	0.3	0.3	0.4	0.4	0.5
Current account of BOP as % of GDP	Δ	0.0	-0.1	-0.1	-0.1	-0.1	0.0
General Government Deficit as % of GDP	Δ	0.0	0.0	0.0	0.0	0.1	0.1
General Government Debt as % of GDP	Δ	-0.3	-0.3	-0.3	-0.2	0.0	0.1
Welfare							
GDP per capita	%Δ	0.0	-0.1	-0.1	-0.1	-0.2	-0.2
Consumption per capita	%Δ	0.3	0.3	0.4	0.3	0.2	0.2
Net Emigration	Δ	0.0	-1.5	-0.7	-0.3	0.0	0.2
The shock							
Non Agricultural Wages		1%	1%	1%	1%	1%	1%

The rise in the unemployment rate of around 0.5 percentage points by 2018 would increase government welfare payments. The economy-wide increase in wage rates would also increase the cost of the public sector pay bill, as public sector wage rates are assumed to adjust in line with wage rates in the private sector.[23] On the revenue side, while initially higher incomes would increase income tax receipts, this would be offset by lower employment and business activity. The government borrowing requirement as a percentage

[23] If, instead, government expenditure on pay was held constant, with services and numbers employed being cut instead, the negative impact on GNP and employment would be magnified.

of GDP would rise by around 0.1 percentage point by 2018. If the government were to react to hold the general government deficit unchanged, the negative impact on GNP and employment would be magnified.

Finally, the increase in wage rates would result in higher consumer prices of around 0.2 per cent.

3.5 Growth & Competitiveness shock: Increase in domestic interest rates

In this simulation we examine the impact of a 1 per cent increase in domestic interest rates. The shock is implemented by increasing the rate of interest on government bonds which, in turn, determines all domestic interest rates in the model. There are a number of channels through which the shock to interest rates is transmitted to the Irish economy. In the manufacturing sector, a rise in interest rates would result in an increase in the cost of capital, leading to a shift away from domestic value added as firms increase their imports at the expense of domestic production. The shift away from domestic value added would be influenced by the relative profitability of production in Ireland versus the rest of the world. The volume of value added arising in the manufacturing sector would decline by 1.8 per cent in the long run (Table 10).

The increase in the cost of capital would lead to a reduction in the optimal capital stock in the manufacturing sector. As the actual capital stock adjusts to this lower optimal stock, investment would fall relative to the baseline. As a result, the rise in the cost of capital following the interest rate shock would lead directly to a reduction in investment by firms in the manufacturing sector. Overall, investment would decline by around 1 per cent over the medium term.

There are a number of important caveats to note when interpreting the results of the interest rate simulation. In the current specification of *HERMES*, an increase in interest rates does not affect the cost of capital for the services sector; hence, the results described here do not capture all of the likely effects of a rise in interest rates on the economy. The simulation assumes that foreign owned multinationals in the manufacturing sector are affected by the rise in domestic interest rates. Given these firms' access to other sources of finance, this assumption exaggerates the impact of the shock on manufacturing output.

For households, the higher interest rate would make borrowing to fund investment in dwellings more expensive. Housing completions would fall by around 1.4 per cent and house prices would be reduced by over 2 per cent after five years. The decline in house prices, affecting housing wealth, would contribute to a fall in consumption of around 0.4 per cent by 2016.

Lower output, investment and consumption would lead to deterioration in labour market conditions. Overall employment would fall by 0.3 per cent, mostly as a result of lower manufacturing employment, giving rise to an increase in the unemployment rate of around 0.2 per cent.

Lower output and profitability in the manufacturing sector would reduce government revenue from taxation while government spending would increase to fund the rise in unemployment transfers. The increase in the cost of borrowing would also result in higher government debt interest payments abroad. As a consequence, the government borrowing requirement would rise by around €950 million or 0.4 per cent of GDP by the end of the period.

Table 10: Interest rate shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	0.0	-0.2	-0.4	-0.5	-0.5	-0.5
GNP	%Δ	0.0	-0.3	-0.4	-0.4	-0.4	-0.3
Value added in industry	%Δ	-0.1	-0.4	-0.9	-1.3	-1.6	-1.8
Value added in market services	%Δ	0.0	-0.1	-0.2	-0.2	-0.1	0.0
Consumption	%Δ	0.0	-0.3	-0.3	-0.4	-0.1	0.2
Investment	%Δ	-0.1	-0.8	-1.5	-1.5	-1.2	-0.9
Exports of Goods and Services	%Δ	0.0	-0.1	-0.2	-0.2	-0.3	-0.2
Consumption deflator	%Δ	0.0	0.0	0.0	0.0	-0.1	-0.1
Wages (non-agricultural)	%Δ	0.0	0.0	-0.1	-0.2	-0.3	-0.4
Total employment	%Δ	0.0	-0.1	-0.2	-0.3	-0.3	-0.3
Employment in services sector	%Δ	0.0	0.0	-0.1	-0.1	0.0	0.0
Balances							
Unemployment Rate (ILO)	Δ	0.0	0.1	0.2	0.3	0.2	0.2
Current account of BOP as % of GDP	Δ	0.0	0.0	0.1	0.1	-0.1	-0.2
General Government Deficit as % of	Δ	0.0	0.3	0.4	0.4	0.5	0.4
General Government Debt as % of	Δ	0.0	0.5	1.1	1.7	2.1	2.4
Welfare							
GDP per capita	%Δ	0.0	-0.2	-0.4	-0.5	-0.5	-0.5
Consumption per capita	%Δ	0.0	-0.3	-0.3	-0.3	0.0	0.3
Net Emigration	Δ	0.0	0.0	0.1	0.7	0.8	0.6
The shock							
Interest Rate*							

3.6 Growth & Competitiveness shock: Fall in house prices

Given the importance of house price movements to developments in the macro economy, this simulation examines the impact of a 10 per cent fall in house prices from 2013. Consumption is one of the key channels through which the fall in house prices influences the economy. In considering the effect on consumption, it is important to distinguish between the short-run and long-run response. In response to a fall in house prices, which erodes housing wealth, households would initially react by reducing their consumption and increasing their savings. Consumption would fall by close to 1.3 per cent after two years. The increase in the savings rate would cause households to accumulate a larger stock of financial assets. In the long-run the build-up of financial assets would be slowly unwound, which would eventually feed through to stronger consumption. As a result, the initial negative effect on consumption arising from the fall in house prices would gradually dissipate and, as households begin to consume out of accumulated financial wealth, the consumption effect would turn positive after around nine years (Table 11).

With a large proportion of the output of the services sector sold domestically, lower household consumption would reduce services sector output by around 0.5 per cent in the short-run. The fall in house prices would have a significant impact on output and investment in the building and construction sector. Housing completions would decline by 6 per cent by the end of the period which would contribute to a fall in overall industrial output of around 0.5 per cent. Total investment would be around 3.3 per cent lower by the end of the period.

Lower consumption, output and investment would reduce the demand for labour so that total employment would fall by around 0.5 in the long-run and the unemployment rate would increase by 0.3 percentage points. The fall in house prices would have a sizable employment impact given the labour intensity of the building and construction and services sectors.

Table 11: House price shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	-0.5	-0.6	-0.6	-0.4	-0.3	-0.2
GNP	%Δ	-0.7	-0.7	-0.6	-0.3	-0.1	0.0
Value added in industry	%Δ	-0.5	-1.1	-1.1	-0.8	-0.7	-0.5
Value added in market services	%Δ	-0.6	-0.5	-0.4	-0.3	-0.2	-0.2
Consumption	%Δ	-1.3	-0.5	-0.4	-0.4	-0.2	0.0
Investment	%Δ	-4.3	-8.1	-7.2	-4.2	-3.4	-3.3
Exports of Goods and Services	%Δ	0.0	0.0	0.0	0.0	0.1	0.1
Consumption deflator	%Δ	0.0	0.0	-0.1	-0.1	-0.1	-0.1
Wages (non-agricultural)	%Δ	0.0	-0.2	-0.3	-0.4	-0.4	-0.4
Total employment	%Δ	-0.5	-0.9	-0.8	-0.6	-0.5	-0.5
Employment in services sector	%Δ	-0.2	-0.2	-0.2	-0.1	-0.1	0.0
Balances							
Unemployment Rate (ILO)	Δ	0.4	0.7	0.7	0.4	0.3	0.3
Current account of BOP as % of GDP	Δ	0.6	0.6	0.6	0.6	0.5	0.5
General Government Deficit as % of GDP	Δ	0.5	0.9	0.8	0.5	0.5	0.4
General Government Debt as % of GDP	Δ	1.3	2.1	2.9	3.2	3.4	3.5
Welfare							
GDP per capita	%Δ	-0.5	-0.6	-0.5	-0.3	-0.2	-0.1
Consumption per capita	%Δ	-1.3	-0.5	-0.3	-0.3	-0.1	0.1
Net Emigration	Δ	0.0	1.0	1.7	1.6	0.7	-0.1
The shock							
House Prices		-10%	-10%	-10%	-10%	-10%	-10%

The public finances would deteriorate due to a combination of lower taxation receipts from VAT, company taxes and a range of other sources as well as higher current expenditure due to the increase in unemployment. The borrowing requirement would increase by around 0.9 per cent at peak after 3 years but would narrow thereafter as the negative drag from consumption would ease.

The overall impact of this shock to house prices would be to reduce GDP by around 0.2 per cent by 2018. This simulation does not take account of the impact on banks' balance sheets or on NAMA of the decline in house prices. To the extent that the fall in house prices gave rise to additional bank losses or to losses on NAMA's portfolio, the impact on the public finances could be much more severe than presented in Table 11 (Kelly and McQuinn, 2013).

3.7 Policy shock: public sector wage

In this simulation we consider the impact of a fall in nominal wage rates in the public sector that would reduce the public sector pay bill by €1 billion in 2013. Wage rates in the private sector are assumed to be unaffected by the fall in public sector rates. The cut in public sector wage rates would result in lower incomes and would reduce government tax revenue. The overall impact would be a net improvement in the government deficit of 0.4 per cent of GDP by 2018.

The fall in wage rates would lead to a reduction in consumption and a lower level of demand in the economy. In turn, this would impact on the output of the market services sector. Assuming that there was no response by private sector wages, there would be no direct impact on competitiveness. As a result, output in the rest of the economy would not respond and the cut in wage rates would lead to a reduction in GNP of 0.2% by 2018. With tax rates held constant there would be no impact on consumer prices. The reduction in consumption would see an improvement in the current account by 2018 of 0.3 percentage points of GDP (Table 12).

3.8 Policy shock: public sector employment

In this simulation the numbers employed in the public sector were reduced so that the total public sector wage bill fell by €1 billion in 2013. The reduction in employment is assumed to be maintained below the baseline level until 2018. This shock would directly affect the volume of GNP and GDP by reducing public consumption by the amount of the fall in the public sector wage bill. This would reflect the loss of public welfare as a result of the major reduction in the level of public services.

Table 12: Public sector wage shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2
GNP	%Δ	-0.3	-0.4	-0.4	-0.4	-0.3	-0.2
Value added in industry	%Δ	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1
Value added in market services	%Δ	-0.3	-0.4	-0.4	-0.4	-0.3	-0.3
Consumption	%Δ	-0.7	-0.9	-1.1	-1.0	-0.9	-0.8
Investment	%Δ	-0.8	-1.3	-1.5	-1.1	-0.8	-0.5
Exports of Goods and Services	%Δ	0.0	0.0	0.0	0.0	0.0	0.0
Consumption deflator	%Δ	0.0	0.0	0.0	0.0	0.0	0.0
Wages (non-agricultural)	%Δ	0.0	0.0	-0.1	-0.1	-0.1	-0.1
Total employment	%Δ	-0.1	-0.2	-0.3	-0.2	-0.2	-0.2
Employment in services sector	%Δ	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1
Balances							
Unemployment Rate (ILO)	Δ	0.1	0.0	-0.1	-0.1	-0.2	-0.3
Current account of BOP as % of GDP	Δ	0.3	0.4	0.4	0.4	0.3	0.3
General Government Deficit as % of GDP	Δ	-0.3	-0.3	-0.2	-0.3	-0.3	-0.4
General Government Debt as % of GDP	Δ	0.6	0.3	0.1	-0.2	-0.6	-1.1
Welfare							
GDP per capita	%Δ	-0.2	-0.2	-0.2	-0.1	-0.1	0.0
Consumption per capita	%Δ	-0.7	-0.8	-0.9	-0.9	-0.7	-0.6
Net Emigration	Δ	0.0	4.3	2.5	1.3	0.6	0.1
The shock							
Public Sector Wage Bill	€bn	-1.0	-1.0	-1.0	-1.0	-1.1	-1.2

As shown in Table 13, the shock would have a significant impact on the volume of GNP and GDP, which would fall by 0.7 and 0.8 per cent respectively by 2018. The second round effects of this shock would arise from the reduction in purchasing power due to the reduction in the public sector pay bill. As a result, the volume of consumption would fall by 0.7 per cent by 2018.

The reduction in health and education employment would affect the economy through a range of channels. Firstly the unemployment rate would initially rise by 1 percentage point. However, with emigration it would eventually fall back to 0.6 percentage points by 2018. The effect on labour supply would be uncertain because of the unusual international environment. If the external environment were to continue to be very difficult such a level of emigration might not materialise resulting in higher unemployment in the medium term.

The reduction in wage rates of 0.5 per cent in 2018 as a result of the higher unemployment would improve competitiveness, resulting in a gradual increase in the volume of exports.

By 2018 the reduction in the government borrowing requirement arising from the cut in employment would amount to around 0.2 percentage points of GDP.

Table 13: Public sector employment shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	-0.7	-0.8	-0.8	-0.8	-0.7	-0.7
GNP	%Δ	-0.8	-1.0	-1.0	-1.0	-0.9	-0.8
Consumption	%Δ	-0.2	-0.7	-0.8	-0.9	-0.8	-0.7
Investment	%Δ	-0.3	-0.8	-1.0	-0.9	-0.7	-0.5
Exports of Goods and Services	%Δ	0.0	0.0	0.0	0.1	0.1	0.1
Consumption deflator	%Δ	0.0	0.0	-0.1	-0.1	-0.1	-0.1
Wages (non-agricultural)	%Δ	0.0	-0.3	-0.3	-0.4	-0.4	-0.5
Total employment	%Δ	-1.2	-1.2	-1.2	-1.2	-1.1	-1.1
Balances							
Unemployment Rate (ILO)	Δ	1.0	0.9	0.8	0.8	0.7	0.6
Current account of BOP as % of GDP	Δ	0.1	0.2	0.3	0.3	0.3	0.2
General Government Deficit as % of GDP	Δ	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
General Government Debt as % of GDP	Δ	0.6	0.5	0.4	0.2	0.0	-0.3
Welfare							
GDP per capita	%Δ	-0.7	-0.7	-0.7	-0.6	-0.5	-0.4
Consumption per capita	%Δ	-0.2	-0.6	-0.7	-0.7	-0.6	-0.4
Net Emigration	Δ	0.0	4.0	3.3	1.8	1.1	0.5
The shock							
Public Sector Wage Bill	€bn	-1.0	-1.1	-1.1	-1.1	-1.2	-1.2

3.9 Policy shock: transfer payments

This simulation examines the impact of a €1 billion reduction in government current expenditure on transfers. The cut in government transfers would reduce household disposable income and, as a result, consumption would fall by 1 per cent by 2015. Lower consumption would reduce the level of demand in the economy with the result that output in market services would fall by around 0.4 per cent after three years. Lower imports would result in an improvement in the current account as a percentage of GDP of around 0.2 per cent in the medium run (Table 14).

As a consequence of the fall in output, and also because of the fall in consumption, total employment would fall by 0.2 per cent by 2018 due mainly to a reduction in service's sector employment. The unemployment rate would increase slightly by 0.1 percentage points in the long-run.

The reduction in government spending would lead directly to a reduction in the government deficit of 0.4 per cent of GDP. However, the deficit would not improve by the full amount of the reduction in government spending (€1 billion) as some of the savings from reduced transfers would be offset by lower taxes from other sources as a result of the decline in services output and consumption.

In the medium-term, both GNP and GDP would be reduced by around 0.2 per cent. Regarding economic welfare, the reduction in transfers would result in consumption per head being 0.5 per cent lower by the end of the period.

Table 14: Government transfers shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	-0.2	-0.3	-0.4	-0.3	-0.3	-0.2
GNP	%Δ	-0.3	-0.4	-0.4	-0.4	-0.3	-0.2
Value added in industry	%Δ	-0.1	-0.2	-0.3	-0.2	-0.2	-0.1
Value added in market services	%Δ	-0.3	-0.4	-0.5	-0.4	-0.3	-0.2
Consumption	%Δ	-0.8	-1.0	-1.1	-1.0	-0.8	-0.6
Investment	%Δ	-0.9	-1.5	-1.7	-1.2	-0.7	-0.4
Exports of Goods and Services	%Δ	0.0	0.0	0.0	0.0	0.0	0.0
Consumption deflator	%Δ	0.0	0.0	0.0	0.0	0.0	0.0
Wages (non-agricultural)	%Δ	0.0	0.0	0.0	0.0	0.0	0.0
Total employment	%Δ	-0.1	-0.2	-0.3	-0.3	-0.2	-0.2
Employment in services sector	%Δ	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
Balances							
Unemployment Rate (ILO)	Δ	0.1	0.2	0.2	0.2	0.1	0.1
Current account of BOP as % of GDP	Δ	0.3	0.4	0.4	0.4	0.3	0.2
General Government Deficit as % of GDP	Δ	-0.5	-0.4	-0.3	-0.3	-0.4	-0.4
General Government Debt as % of GDP	Δ	-0.2	-0.5	-0.7	-1.0	-1.4	-1.8
Welfare							
GDP per capita	%Δ	-0.2	-0.3	-0.3	-0.3	-0.2	-0.1
Consumption per capita	%Δ	-0.8	-1.0	-1.1	-1.0	-0.7	-0.5
Net Emigration	Δ	0.0	1.0	0.8	0.6	0.3	0.0
The shock							
Transfers	€bn	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

3.10 Policy shock: public investment

In this simulation we consider the impact of a €1 billion reduction in expenditure on public investment. These results only take account of the demand side impact of the change in investment. They take no account of the longer-term supply side impact reducing national output and productivity as a result of the reduced stock of infrastructure. If the investment were in productive infrastructure this supply side effect could dominate the short-term demand effects (FitzGerald and Morgenroth, 2006, Bradley and Untiedt, 2012).

Table 15 shows that the demand side impact of this shock would have a relatively minor effect on output and employment in the economy in the short to medium term. The primary incidence of the shock would be on the building sector where output, employment and investment would fall. The lower level of demand in the building sector would lead to a small reduction in total employment and a rise in the unemployment rate of 0.2 percentage points. As a result there would be a slight reduction of 0.2 per cent in wage rates by 2018.

Over the medium term, GNP and GDP would fall by 0.2 percentage points. The €1 billion cut in investment expenditure would have a big effect on the public finances, with the government deficit as a percentage of GDP falling by around 0.4 percentage points in the long run.

Table 15: Public sector investment shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	-0.3	-0.4	-0.4	-0.3	-0.3	-0.2
GNP	%Δ	-0.4	-0.4	-0.4	-0.3	-0.3	-0.2
Value added in industry	%Δ	-0.9	-0.9	-0.8	-0.7	-0.5	-0.3
Value added in market services	%Δ	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2
Consumption	%Δ	0.0	-0.2	-0.2	-0.3	-0.2	-0.2
Investment	%Δ	-6.6	-5.9	-4.8	-3.6	-2.8	-2.5
Exports of Goods and Services	%Δ	0.0	0.0	0.0	0.0	0.1	0.1
Consumption deflator	%Δ	0.0	0.0	0.0	0.0	-0.1	0.0
Wages (non-agricultural)	%Δ	0.0	-0.2	-0.2	-0.3	-0.3	-0.2
Total employment	%Δ	-0.6	-0.6	-0.6	-0.5	-0.4	-0.4
Employment in services sector	%Δ	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Balances							
Unemployment Rate (ILO)	Δ	0.5	0.5	0.4	0.4	0.3	0.2
Current account of BOP as % of GDP	Δ	0.4	0.4	0.4	0.4	0.3	0.3
General Government Deficit as % of GDP	Δ	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
General Government Debt as % of GDP	Δ	0.0	-0.3	-0.6	-0.9	-1.3	-1.7
Welfare							
GDP per capita	%Δ	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1
Consumption per capita	%Δ	0.0	-0.1	-0.1	-0.2	-0.2	-0.1
Net Emigration	Δ	0.0	1.3	1.3	0.8	0.4	0.1
The shock							
Public Sector Investment	€bn	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

3.11 Policy shock: increase in income tax

In this shock the average rate of income tax was increased by an amount sufficient to raise €1 billion in income tax revenue in 2013 (0.6 per cent of GDP). Table 16 shows the results for the period 2013-2018. The peak impact is in 2015. The increase in the personal income tax rate would reduce purchasing power and consequently the volume of consumption would be 1.1 per cent below the base in 2015. As a result output in market services would be reduced by 0.5 per cent and GNP would fall by 0.5 percentage points.

The model assumes that workers bargain in terms of their real after-tax wage rate. As a result some of the increase in the tax rate would be passed on to employers in terms of higher wage demands. By 2018 wage rates would rise by 0.8 per cent.[24] This would result in

[24] However, actual wage rates may be above their long-term equilibrium level with the adjustment to that equilibrium slowed by the stickiness of nominal wage rates in a downward direction. Under

a loss of competitiveness in the Irish economy and consequently output in the manufacturing sector would fall by 0.4 per cent by 2018. Lower levels of activity in manufacturing and market services would reduce total employment by 0.5 per cent by 2018 and this would lead to an increase in the unemployment rate of 0.2 percentage points.

The increase in the tax rate would lead to a lower level of demand in the economy and would reduce consumption and output. As a result, there would be a reduction in tax revenue due to lower profits and consumption. However, the increase in the tax rate would lead directly to an increase in government revenue. The overall impact would be a net improvement in the government borrowing requirement of 0.5 per cent of GDP.

In the long run the current account would improve by 0.3 percentage points of GDP as a result of the shock, reflecting the deflationary impact of the tax increase.

Table 16: Income tax shock, change from baseline

		2013	2014	2015	2016	2017	2018
Growth, prices, employment							
GDP	%Δ	-0.2	-0.4	-0.4	-0.4	-0.4	-0.3
GNP	%Δ	-0.3	-0.4	-0.5	-0.4	-0.3	-0.3
Value added in industry	%Δ	-0.1	-0.3	-0.4	-0.4	-0.4	-0.4
Value added in market services	%Δ	-0.3	-0.4	-0.5	-0.5	-0.4	-0.4
Consumption	%Δ	-0.8	-1.0	-1.1	-1.0	-0.8	-0.7
Investment	%Δ	-0.9	-1.6	-1.7	-1.3	-0.9	-0.7
Exports of Goods and Services	%Δ	0.0	0.0	-0.1	-0.1	-0.2	-0.2
Consumption deflator	%Δ	0.0	0.1	0.1	0.1	0.1	0.1
Wages (non-agricultural)	%Δ	0.0	0.4	0.6	0.7	0.7	0.8
Total employment	%Δ	-0.1	-0.3	-0.5	-0.5	-0.5	-0.5
Employment in services sector	%Δ	-0.1	-0.2	-0.3	-0.3	-0.3	-0.4
Balances							
Unemployment Rate (ILO)	Δ	0.1	0.1	0.2	0.2	0.2	0.2
Current account of BOP as % of GDP	Δ	0.3	0.4	0.5	0.4	0.4	0.3
General Government Deficit as % of GDP	Δ	-0.5	-0.4	-0.3	-0.4	-0.4	-0.5
General Government Debt as % of GDP	Δ	-0.2	-0.6	-0.9	-1.2	-1.7	-2.1
Welfare							
GDP per capita	%Δ	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2
Consumption per capita	%Δ	-0.8	-0.9	-1.0	-0.9	-0.7	-0.6
Net Emigration	Δ	0.0	3.4	1.7	0.8	0.5	0.1
The shock							
Income Tax Receipts	€bn	1.0	1.1	1.1	1.2	1.3	1.4

these circumstances a rise in taxation may not be passed on in terms of higher wage rates. In turn, the negative labour market effects might be slightly less than shown here.

4 Summary of results

Table 17 summarises the results of the shocks reported on in Section 3.

In relation to the growth and competitiveness shocks, the results suggest the following:

A positive external shock to the economy, whether it be through an increase in world growth or an increase in competitor's prices, has a significant effect on GDP over the medium-term.

By contrast, an improvement in competitiveness through a reduction in domestic wages, an internal devaluation, has a much lower effect on GDP.

In comparing the policy shocks, which give guidance on the medium-term impacts of adjusting different components of the budget the results suggest that there are indeed significant differences in the medium-term impact n the economy of the policy mix.

For the same initial ex ante saving of €1 billion, the results suggest that cuts in public sector employment have the biggest negative effect on GDP over the medium term, while cuts in public sector wages or transfer payments have a much less severe impact on GDP over the medium-term. This is because cuts in employment directly reduce output and productivity, while cuts in wages or investment can result in significant cost savings.

In relation to the deficit, a €1 billion increase in income tax has the strongest effect in reducing the deficit over the medium-term.

Table 17: Overview of shocks: change from baseline.

YEAR		1	2	5	1	2	5	1	2	5
		GDP			Unemployment			Deficit as % GDP		
		%Δ			Δ			Δ		
Growth and competitiveness shocks:										
World growth	+1%	0.8	0.9	1.1	-0.2	-0.4	-0.4	-0.1	-0.2	-0.3
Foreign prices	+1%	0.5	0.6	0.8	-0.1	-0.2	-0.2	-0.1	-0.2	-0.2
Domestic wage rates	+1%	0.0	0.0	-0.1	0.2	0.3	0.4	0.0	0.0	0.1
Domestic interest rates	+1pp	0.0	-0.2	-0.5	0.0	0.1	0.2	0.0	0.3	0.5
House Prices	-10%	-0.5	-0.6	-0.3	0.4	0.7	0.3	0.5	0.9	0.5
Standardised policy shocks:										
Income tax	+€1bn	-0.2	-0.4	-0.4	0.1	0.1	0.2	-0.5	-0.4	-0.4
Public sector wage	-€1bn	-0.2	-0.3	-0.3	0.1	0.0	-0.2	-0.3	-0.3	-0.3
Public sector employment	-€1bn	-0.7	-0.8	-0.7	1.0	0.9	0.7	-0.2	-0.2	-0.2
Current transfer Payments	-€1bn	-0.2	-0.3	-0.3	0.1	0.2	0.1	-0.5	-0.4	-0.4
Capital expenditure	-€1bn	-0.3	-0.4	-0.3	0.5	0.5	0.3	-0.4	-0.4	-0.4

In Table 18 we summarise the fiscal multipliers. The table shows estimates of both the impact and cumulative fiscal multipliers that pertain to each shock. The impact multiplier is defined as:

$$\frac{\Delta Y(t)}{\Delta X(t)} \quad (31)$$

where X is the fiscal instrument and Y is GDP. So for example in the case of income taxes, X is total income tax revenue. The cumulative multiplier[25] is defined as:

$$\frac{\sum_{j=0}^{N}(1+i)^{-t}\Delta Y(t+j)}{\sum_{j=0}^{N}(1+i)^{-t}\Delta X(t+j)} \qquad (32)$$

Table 18: Estimates of Fiscal Multipliers

	Impact multiplier		Cumulative multiplier	
	nominal GDP	real GDP	nominal GDP	real GDP
TAXATION				
Income Tax	-0.4	-0.4	-0.3	-0.6
CURRENT EXPENDITURE				
Wages	1.3	0.3	1.5	0.5
Employment	1.2	1.2	1.5	1.2
Transfers	0.4	0.4	0.5	0.5
CAPITAL EXPENDITURE				
Investment	0.5	0.6	0.8	0.6

The results suggest that *ceteris paribus* a reduction in government current transfers has the smallest effect on output, while a reduction in public sector employment has the largest effect on output. The range is very wide, from 0.4 for current transfers or income tax, to 1.2 for public sector employment. This means that at the margin a cut in public sector employment has a much more negative effect on GDP than a cut in wages, a cut in investment spending or an increase in taxes.

5 Conclusion

This paper provides a description of the main mechanisms and behaviour of the HERMES model with a focus on how the model has evolved over time to reflect the changing structure of the Irish economy. The first part of the paper provides an overview of the sub-sectors of the model starting with the output side. The manufacturing and services sectors account for the bulk of the output produced in the economy and the structure of these sub-models is outlined in detail. The modelling of the services sector has undergone significant change due to the growing importance of services in total exports and the sector is now a key channel through which world economic growth is transmitted to the Irish economy. On the expenditure side of the model, Section 2.3 outlines the new consumption function included in the latest version of the model which can be used to proxy the impact of household deleveraging.

Section 2.2 sets out how labour demand, labour supply and wages are modelled within HERMES. The labour market model draws extensively on existing research and evidence

[25] See Spilimbergo *et al.* (2009). The interest rate *i* used was 5%.

from microeconomic studies as well as the ESRI's detailed demographic model in order to explain the complex workings of the Irish labour market. The model's detailed treatment of the public finances and the determination of national debt interest payments are discussed in Section 2.4. The disaggregated approach to modelling the public finances allows for two different ways of handling the public sector that facilitate the use of the model to explore the possible effects of discrete public policy decisions as distinct from changes in underlying macroeconomic assumptions. In the first, the rates of taxation and government expenditure are indexed so that changes in the assumptions affecting the rate of inflation can directly affect government expenditure and revenue. Secondly, the model can be forced to track a target borrowing requirement in the face of the different scenarios. These options in the model have been used extensively to analyse the stance of fiscal policy from the 1970s to the present. This section also discusses an enhancement to HERMES-13 whereby the risk premium on government debt is linked to the level of the deficit and the overall national debt.

Accompanying the description of the model in the main paper is a full listing of the equations in the model by sector with links to the associated regression output. This is provided with the intention of allowing interested readers and modelling practitioners to delve further into the details of the model specification. The information forms a basic reference manual which can enhance the capacity of those who read and use the model's output to better understand the key mechanisms in the model. It is planned to continue expanding this material in future.

Further insights into the behaviour of the model are explored in Section 3. For a model to be useful for policy purposes, attention must be paid to its long-run properties. By changing the values of key variables in the model we trace how these changes percolate through the model. This in turn throws light on how the economy is likely to behave in the face of changes in key external variables, such as world growth, and important policy variables, such as taxes and public expenditure. These results are valid given current economic conditions but would need to be re-examined in the face of a general change in the macroeconomic environment. In particular, the likely unemployment and general labour market impact of different shocks is uncertain given the high level of uncertainty about the pattern of migration in the immediate future.

There are a number of channels which are not well developed in the model. HERMES does not explicitly handle how households' expectations are formed and how they affect consumption and household investment. This means that the model may not fully capture the short-term response of households to fiscal policy. For example, if households expect the government to tighten fiscal policy in the future they may react by increasing savings in the expectation of future tax increases. Thus it is possible that the deflationary impact of a rise in taxes this year may already have been partly discounted by households as reflected in the dramatic increase in the savings rate. This factor must be taken into account when interpreting the results shown here.

Although various options can be used in the model to proxy the impact of credit constraints, HERMES does not have a well-developed banking sector. Since the global financial crisis, research on macro-financial linkages has increased significantly although much of the work remains at an early stage. Research is ongoing to develop the treatment of the banking sector so that the transmission of financial sector shocks to the economy can be better understood.

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7 Appendix 1: Full Model Listing of HERMES-13

This appendix provides a full listing of all 824 equations which form the latest HERMES-13 simulation model. This model is estimated and simulated using Troll software, and full details of the variables and underlying data sources can be found at http://www.esri.ie/research/research_areas/macroeconomics/the-hermes-model/. Below this listing we include a non-technical description of equations 1 through to 646. For readers interested in the description of the energy equations 647-804, please refer to Hennessy and Fitz Gerald (2011) which contains a detailed description of the blocks in the energy sub-model.

Blocks in the HERMES Model	Equations:
Manufacturing: High Tech	1-22
Manufacturing:Traditional	23-43
Manufacturing: Food Processing	44-65
Building & construction	66-90
Utilities	91-114
Aggregating total manufacturing and total industry	115-149
Agriculture	150-164
Market Services: Distribution	165-181
Market Services: Business and Financial Services	182-198
Market services: Transport and Communication	199-214
Aggregating Market Services	215-240
Imports and the Balance of Payments	241-256
Demographics	257-270
Labour Supply	271-301
Consumption and the consumption function	302-331
The housing market	332-340
Other expenditure (investment and exports)	341-389
Deflators	390-431
The government sector:	432-569
- indexation rules	437-485
- The government accounts	486-549
- Debt and debt interest	550-569
Other equations reconciling output, expenditure and income	570-594
Flow of funds	595-605
Financial variables	606-628
Banking sector balance sheet	629-646
Energy model	647-803
Employment on an ILO basis	804-822
Miscellaneous	823-824

Listing of Equations

The High Tech Sector

```
1:LOG(QGIMH_STAR) =
A1_QGIMH+A2_QGIMH*LOG(GDP_USA)+A3_QGIMH*LOG(PTQGIMH/(WIMT_UK*REX_UK))+A4_QGIMH*D95
+QGIMH_STAR_FIX
2:DEL(1:LOG(QGIMH)) = A12_QGIMH*DEL(1:LOG(GDP_USA))+A00_QGIMH*(LOG(QGIMH(-1))-LOG(QGIMH_STAR(-
1)))+QGIMH_FIX
3:LOG(KIMH) = A1_KIMH+A2_KIMH*DEL(1:LOG(KIMH_STAR))+A3_KIMH*(LOG(KIMH(-1))-LOG(KIMH_STAR(-
1)))+LOG(KIMH(-1))+KIMH_FIX
4:IIMH = IF (TYEAR<1980) THEN (KIMH-0.92*KIMH(-1)) ELSE (KIMH-0.86*KIMH(-1))
5:LOG(PQMIMH) = A1_PQMIMH+A2_PQMIMH*LOG(PQEIMT)+(1-A2_PQMIMH)*LOG(PQRIMH)+PQMIMH_FIX
6:LOG(PQGIMH) = A1_PQGIMH+A2_PQGIMH*LOG(PQGIMT_GER*REX_GER)+(1-
A2_PQGIMH)*LOG(PQGIMT_USA*REX_USA)+A3_PQGIMH*ZT_PQGIMH+PQGIMH_FIX
7:LOG(WIMH/WNA) = A1_WIMH+A2_WIMH*ZT_WIMH+WIMH_FIX
8:LIMH/QGIMH*Z2_LIMH =
A1_LIMH+A3_LIMH*ZT_LIMH**0.5+A4_LIMH*(KIMH*Z3_LIMH/QGIMH)**0.5+A7_LIMH*(PQMIMH*Z6_LIMH/(WIMH*Z4_LI
MH))**0.5+A5_LIMH*(KIMH*Z3_LIMH*ZT_LIMH/QGIMH)**0.5+A6_LIMH*KIMH*Z3_LIMH/QGIMH+A8_LIMH*ZT_LIMH+LIM
H_FIX
9:QMIMH/QGIMH =
A1_QMIMH+A7_LIMH*(WIMH*Z4_LIMH/(PQMIMH*Z6_LIMH))**0.5+A3_QMIMH*ZT_LIMH**0.5+A4_QMIMH*(KIMH*Z3_LIMH
/QGIMH)**0.5+A5_LIMH*(KIMH*Z3_LIMH*ZT_LIMH/QGIMH)**0.5+A6_LIMH*KIMH*Z3_LIMH/QGIMH+A8_LIMH*ZT_LIMH+
QMIMH_FIX
10:KISTAR_KIMH = ((-0.5*A4_LIMH*QGIMH**0.5*WIMH*Z4_LIMH-0.5*A4_QMIMH*QGIMH**0.5*PQMIMH*Z6_LIMH-
0.5*(QGIMH*ZT_LIMH)**0.5*(WIMH*Z4_LIMH+PQMIMH*Z6_LIMH)*A5_LIMH)/(PKIMH*Z1_LIMH+A6_LIMH*(WIMH*Z4_LI
MH+PQMIMH*Z6_LIMH)))**2
11:PTQGIMH =
2*(+A7_LIMH)*(PQMIMH*Z6_LIMH*WIMH*Z4_LIMH)**0.5+A1_LIMH*WIMH*Z4_LIMH+A1_QMIMH*PQMIMH*Z6_LIMH+(A3_L
IMH*WIMH*Z4_LIMH+A3_QMIMH*PQMIMH*Z6_LIMH)*ZT_LIMH**0.5+A8_LIMH*ZT_LIMH*(WIMH*Z4_LIMH+PQMIMH*Z6_LIM
H)+(A4_LIMH*WIMH*Z4_LIMH+A4_QMIMH*PQMIMH*Z6_LIMH+A5_LIMH*ZT_LIMH**0.5*(WIMH*Z4_LIMH+PQMIMH*Z6_LIMH
))*(KISTAR_KIMH/QGIMH)**0.5+A6_LIMH*(WIMH*Z4_LIMH+PQMIMH*Z6_LIMH)*KISTAR_KIMH/QGIMH+PKIMH*KIMH_STA
RS/QGIMH+PTQGIMH_FIX
12:KIMH_STARS = KISTAR_KIMH*Z1_KISTARH
13:KQGIMH_STAR = KIMH_STARS/QGIMH
14:KIMH_STAR = KQGIMH_STAR*QGIMH_STAR
15:PQRIMH =
EXP((IO_PQRIMH_PQGA*LOG(PQGA)+IO_PQRIMH_PQGIMH*LOG(PQGIMH)+IO_PQRIMH_PQGIMD*LOG(PQGIMD)+IO_PQRIMH_
PQGIMF*LOG(PQGIMF)+IO_PQRIMH_POSMDI*LOG(POSMDI)+IO_PQRIMH_POSMTC*LOG(POSMTCM)+IO_PQRIMH_POSMPF*LOG
(POSMPF_INS)+IO_PQRIMH_PMNE*LOG(PMNE))/(IO_PQRIMH_PQGA+IO_PQRIMH_PQGIMH+IO_PQRIMH_PQGIMD+IO_PQRIMH
_POSMDI+IO_PQRIMH_POSMTC+IO_PQRIMH_PQGIMF+IO_PQRIMH_POSMPF+IO_PQRIMH_PMNE))/A1_PQRIMH
16:QMIMHV = PQMIMH*QMIMH
17:YWIMH = WIMH*LIMH
18:QGIMHV = QGIMH*PQGIMH
19:QNIMHV = QGIMHV-QMIMHV
20:QNIMH = QNIMHV/PQGIMH
21:YCIMH = QNIMHV-YWIMH
22:IIMHV = PIIMH*IIMH
23:PKIMH = PKIMH_FIX*(IF (TYEAR<1985) THEN (PIIMH*(1-GKTI/IIMTV)*((IF ((RPL+RISK_IMH)/100-
DEL(1:PQGIMH)/PQGIMH(-1)<0.02) THEN 0.02 ELSE ((RPL+RISK_IMH)/100-DEL(1:PQGIMH)/PQGIMH(-
1)))+0.1)/(1-RCORP3)*A1_PKIMH) ELSE (PIIMH*(((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMH)/100*(1-RCORP4)-
DEL(1:PQGIMH)/PQGIMH(-1)+(0.72*RLAA1T3(-1)+0.28*RLAA5T7(-1)+RISK_IMH)/100*(1-RCORP4(-1))-
DEL(1:PQGIMH(-1))/PQGIMH(-2)+(0.72*RLAA1T3(-2)+0.28*RLAA5T7(-2)+RISK_IMH)/100*(1-RCORP4(-2))-
DEL(1:PQGIMH(-2))/PQGIMH(-3))/3+0.72*DEPM_IMT+0.28*DEPB_IMT-(DEL(1:PIIMH)/PIIMH(-1)-
DEL(1:PQGIMH)/PQGIMH(-1)+DEL(1:PIIMH(-1))/PIIMH(-2)-DEL(1:PQGIMH(-1))/PQGIMH(-2)+DEL(1:PIIMH(-
2))/PIIMH(-3)-DEL(1:PQGIMH(-2))/PQGIMH(-3))/3)/(1-RCORP4)*(1-GIMT)*(1-
(0.72*RIAM+0.28*RIAB)*RCORP4--
(0.72*RDEPM+0.28*RDEPB)/((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMH)/100*(1-
RCORP4)+0.72*RDEPM+0.28*RDEPB)*(EXP(-(1-
(0.72*RIAM+0.28*RIAB))/(0.72*RDEPM+0.28*RDEPB)*((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMH)/100*(1-
RCORP4)+0.72*RDEPM+0.28*RDEPB))-1)*RCORP4)))
24:LIMH_PES = LIMH*LIMH_PES_FIX
```

The Traditional Sector

```
23:LOG(QGIMD_STAR) =
A1_QGIMD+A2_QGIMD*LOG(PTQGIMD/(pqgimt_UK*REX_UK))+A3_QGIMD*LOG(GDP_UK)+QGIMD_STAR_FIX
24:DEL(1:LOG(QGIMD)) = A11_QGIMD*DEL(1:LOG(GDP_UK))+A00_QGIMD*(LOG(QGIMD(-1))-LOG(QGIMD_STAR(-
1)))+QGIMD_FIX
25:LOG(KIMD) = A1_KIMD+A00_KIMD*(LOG(KIMD(-1))-LOG(KIMD_STAR(-1)))+LOG(KIMD(-1))+KIMD_FIX
26:IIMD = KIMD-(IF (TYEAR<1980) THEN 0.92 ELSE 0.9)*KIMD(-1)
27:LOG(PQMIMD) = A1_PQMIMD+A2_PQMIMD*LOG(PQEIMT)+(1-A2_PQMIMD)*LOG(PQRIMD)+PQMIMD_FIX
28:LOG(PQGIMD_STAR) = A1_PQGIMD+A2_PQGIMD*LOG(PQGIMT_GER*REX_GER)+(1-
A2_PQGIMD)*LOG(pqgimt_UK*REX_UK)+A3_PQGIMD*ZT_PQGIMD+PQGIMD_STAR_FIX
29:DEL(1:LOG(PQGIMD)) = A11_PQGIMD*DEL(1:LOG(pqgimt_UK*REX_UK))+A00_PQGIMD*(LOG(PQGIMD(-1))-
LOG(PQGIMD_STAR(-1)))+PQGIMD_FIX
30:LOG(WIMD/WNA) = A1_WIMD+A2_WIMD*ZT_WIMD+WIMD_FIX
31:LIMD/QGIMD*Z2_LIMD =
A1_LIMD+A3_LIMD*ZT_LIMD**0.5+A4_LIMD*(KIMD*Z3_LIMD/QGIMD)**0.5+A7_LIMD*(PQMIMD*Z6_LIMD/(WIMD*Z4_LI
MD))**0.5+A5_LIMD*(KIMD*Z3_LIMD*ZT_LIMD/QGIMD)**0.5+A6_LIMD*KIMD*Z3_LIMD/QGIMD+A8_LIMD*ZT_LIMD+LIM
D_FIX
```

```
32:QMIMD/QGIMD =
A1_QMIMD+A7_LIMD*(WIMD*Z4_LIMD/(PQMIMD*Z6_LIMD))**0.5+A3_QMIMD*ZT_LIMD**0.5+A4_QMIMD*(KIMD*Z3_LIMD
/QGIMD)**0.5+A5_LIMD*(KIMD*Z3_LIMD*ZT_LIMD/QGIMD)**0.5+A6_LIMD*KIMD*Z3_LIMD/QGIMD+A8_LIMD*ZT_LIMD+
QMIMD_FIX
33:KISTAR_KIMD = ((-0.5*A4_LIMD*QGIMD**0.5*WIMD*Z4_LIMD-0.5*A4_QMIMD*QGIMD**0.5*PQMIMD*Z6_LIMD-
0.5*(QGIMD*ZT_LIMD)**0.5*(WIMD*Z4_LIMD+PQMIMD*Z6_LIMD)*A5_LIMD)/(PKIMD*Z1_LIMD+A6_LIMD*(WIMD*Z4_LI
MD+PQMIMD*Z6_LIMD)))**2
34:PTQGIMD =
2*(+A7_LIMD)*(PQMIMD*Z6_LIMD*WIMD*Z4_LIMD)**0.5+A1_LIMD*WIMD*Z4_LIMD+A1_QMIMD*PQMIMD*Z6_LIMD+(A3_L
IMD*WIMD*Z4_LIMD+A3_QMIMD*PQMIMD*Z6_LIMD)*ZT_LIMD**0.5+A8_LIMD*ZT_LIMD*(WIMD*Z4_LIMD+PQMIMD*Z6_LIM
D)+(A4_LIMD*WIMD*Z4_LIMD+A4_QMIMD*PQMIMD*Z6_LIMD+A5_LIMD*ZT_LIMD**0.5*(WIMD*Z4_LIMD+PQMIMD*Z6_LIMD
))*(KISTAR_KIMD/QGIMD)**0.5+A6_LIMD*(WIMD*Z4_LIMD+PQMIMD*Z6_LIMD)*KISTAR_KIMD/QGIMD+PKIMD*KISTAR_K
IMD*Z1_KISTARD/QGIMD+PTQGIMD_FIX
35:KIMD_STAR = KISTAR_KIMD*Z1_KISTARD/QGIMD*QGIMD_STAR
36:QMIMDV = QMIMD*PQMIMD
37:QGIMDV = QGIMD*PQGIMD
38:YWIMD = WIMD*LIMD
39:QNIMDV = QGIMDV-QMIMDV
40:QNIMD = QNIMDV/PQGIMD
41:PQRIMD =
EXP((IO_PQRIMD_PQGA*LOG(PQGA)+IO_PQRIMD_PQGIMH*LOG(PQGIMH)+IO_PQRIMD_PQGIMD*LOG(PQGIMD)+IO_PQRIMD_
PQGIMF*LOG(PQGIMF)+IO_PQRIMD_POSMDI*LOG(POSMDI)+IO_PQRIMD_POSMTC*LOG(POSMTCM)+IO_PQRIMD_POSMPF*LOG
(POSMPF_INS)+IO_PQRIMD_PMNE*LOG(PMNE))/(IO_PQRIMD_PQGA+IO_PQRIMD_PQGIMH+IO_PQRIMD_PQGIMD+IO_PQRIMD
_POSMDI+IO_PQRIMD_POSMTC+IO_PQRIMD_PQGIMF+IO_PQRIMD_POSMPF+IO_PQRIMD_PMNE))/A1_PQRIMD
42:PKIMD = PKIMD_FIX*(IF (TYEAR<1985) THEN (PIIMD*(1-GKTI/IIMTV)*((IF ((RPL+RISK_IMD)/100-
DEL(1:PQGIMD)/PQGIMD(-1)<0.02) THEN 0.02 ELSE ((RPL+RISK_IMD)/100-DEL(1:PQGIMD)/PQGIMD(-
1)))+0.08)/(1-RCORP4)*A1_PKIMD) ELSE (PIIMD*(((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMD)/100*(1-RCORP4)-
DEL(1:PQGIMD)/PQGIMD(-1)+(0.72*RLAA1T3(-1)+0.28*RLAA5T7(-1)+RISK_IMD)/100*(1-RCORP4(-1))-
DEL(1:PQGIMD(-1))/PQGIMD(-2)+(0.72*RLAA1T3(-2)+0.28*RLAA5T7(-2)+RISK_IMD)/100*(1-RCORP4(-2))-
DEL(1:PQGIMD(-2))/PQGIMD(-3))/3+0.72*DEPM_IMT+0.28*DEPB_IMT-(DEL(1:PIIMD)/PIIMD(-1)-
DEL(1:PQGIMD)/PQGIMD(-1)+DEL(1:PIIMD(-1))/PIIMD(-2)-DEL(1:PQGIMD(-1))/PQGIMD(-2)+DEL(1:PIIMD(-
2))/PIIMD(-3)-DEL(1:PQGIMD(-2))/PQGIMD(-3))/3)/(1-RCORP4)*(1-GIMT)*(1-
(0.72*RIAM+0.28*RIAB)*RCORP4--
(0.72*RDEPM+0.28*RDEPB)/((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMD)/100*(1-
RCORP4)+0.72*RDEPM+0.28*RDEPB)*(EXP(-(1-
(0.72*RIAM+0.28*RIAB))/(0.72*RDEPM+0.28*RDEPB)*((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMD)/100*(1-
RCORP4)+0.72*RDEPM+0.28*RDEPB))-1)*RCORP4)))
43:LIMD_PES = LIMD*LIMD_PES_FIX
```

The Food Sector

```
44:LOG(QGIMF_STAR) =
A11_QGIMF+A12_QGIMF*LOG(GDP_UK)+A13_QGIMF*LOG(PTQGIMF/(WIMT_UK*REX_UK))+QGIMF_STAR_FIX
45:DEL(1:LOG(QGIMF)) = A00_QGIMF*(LOG(QGIMF(-1))-LOG(QGIMF_STAR(-1)))+QGIMF_FIX
46:DEL(1:LOG(KIMF)) = A1_KIMF+A2_KIMF*(LOG(KIMF(-1))-LOG(KIMF_STAR(-1)))+A3_KIMF*TYEAR+KIMF_FIX
47:IIMF = IF (TYEAR<1980) THEN (KIMF-0.92*KIMF(-1)) ELSE (KIMF-0.9*KIMF(-1))
48:LOG(PQGIMF) = IF (TYEAR<1999) THEN (A1_PQGIMF+A3_PQGIMF*LOG(PTQGIMF)+PQGIMF_FIX) ELSE
(A11_PQGIMF+A13_PQGIMF*LOG(PQGIMT_EU)+PQGIMF_FIX)
49:LOG(PQMIMF) = A1_PQMIMF+A2_PQMIMF*LOG(PQEIMT)+(1-A2_PQMIMF)*LOG(PQRIMF)+PQMIMF_FIX
50:LOG(WIMF/WNA) = A1_WIMF+A2_WIMF*ZT_WIMF+WIMF_FIX
51:LIMF/QGIMF*Z2_LIMF =
A1_LIMF+A3_LIMF*ZT_LIMF**0.5+A4_LIMF*(KIMF*Z3_LIMF/QGIMF)**0.5+A7_LIMF*(PQMIMF*Z6_LIMF/(WIMF*Z4_LI
MF))**0.5+A5_LIMF*(KIMF*Z3_LIMF*ZT_LIMF/QGIMF)**0.5+A6_LIMF*KIMF*Z3_LIMF/QGIMF+A8_LIMF*ZT_LIMF+LIM
F_FIX
52:QMIMF/QGIMF =
A1_QMIMF+A7_LIMF*(WIMF*Z4_LIMF/(PQMIMF*Z6_LIMF))**0.5+A3_QMIMF*ZT_LIMF**0.5+A4_QMIMF*(KIMF*Z3_LIMF
/QGIMF)**0.5+A5_LIMF*(KIMF*Z3_LIMF*ZT_LIMF/QGIMF)**0.5+A6_LIMF*KIMF*Z3_LIMF/QGIMF+A8_LIMF*ZT_LIMF+
QMIMF_FIX
53:KISTAR_KIMF = ((-0.5*A4_LIMF*QGIMF**0.5*WIMF*Z4_LIMF-0.5*A4_QMIMF*QGIMF**0.5*PQMIMF*Z6_LIMF-
0.5*(QGIMF*ZT_LIMF)**0.5*(WIMF*Z4_LIMF+PQMIMF*Z6_LIMF)*A5_LIMF)/(PKIMF*Z1_LIMF+A6_LIMF*(WIMF*Z4_LI
MF+PQMIMF*Z6_LIMF)))**2
54:PTQGIMF =
2*(+A7_LIMF)*(PQMIMF*Z6_LIMF*WIMF*Z4_LIMF)**0.5+A1_LIMF*WIMF*Z4_LIMF+A1_QMIMF*PQMIMF*Z6_LIMF+(A3_L
IMF*WIMF*Z4_LIMF+A3_QMIMF*PQMIMF*Z6_LIMF)*ZT_LIMF**0.5+A8_LIMF*ZT_LIMF*(WIMF*Z4_LIMF+PQMIMF*Z6_LIM
F)+(A4_LIMF*WIMF*Z4_LIMF+A4_QMIMF*PQMIMF*Z6_LIMF+A5_LIMF*ZT_LIMF**0.5*(WIMF*Z4_LIMF+PQMIMF*Z6_LIMF
))*(KISTAR_KIMF/QGIMF)**0.5+A6_LIMF*(WIMF*Z4_LIMF+PQMIMF*Z6_LIMF)*KISTAR_KIMF/QGIMF+PKIMF*KISTAR_K
IMF*Z1_KISTARF/QGIMF+PTQGIMF_FIX
55:KIMF_STAR = KISTAR_KIMF*Z1_KISTARF/QGIMF*QGIMF_STAR
56:QGIMFV = QGIMF*PQGIMF
57:YWIMF = WIMF*LIMF
58:QMIMFV = QMIMF*PQMIMF
59:QNIMFV = QGIMFV-QMIMFV
60:QNIMF = QNIMFV/PQGIMF
61:YCIMF = QNIMFV-YWIMF
62:IIMFV = PIIMF*IIMF
63:PQRIMF =
EXP((IO_PQRIMF_PQGA*LOG(PQGA)+IO_PQRIMF_PQGIMH*LOG(PQGIMH)+IO_PQRIMF_PQGIMD*LOG(PQGIMD)+IO_PQRIMF_
PQGIMF*LOG(PQGIMF)+IO_PQRIMF_POSMDI*LOG(POSMDI)+IO_PQRIMF_POSMTC*LOG(POSMTCM)+IO_PQRIMF_POSMPF*LOG
(POSMPF_INS)+IO_PQRIMF_PMNE*LOG(PMNE))/(IO_PQRIMF_PQGA+IO_PQRIMF_PQGIMH+IO_PQRIMF_PQGIMD+IO_PQRIMF
_POSMDI+IO_PQRIMF_POSMTC+IO_PQRIMF_PQGIMF+IO_PQRIMF_POSMPF+IO_PQRIMF_PMNE))/A1_PQRIMF
64:PKIMF = PKIMF_FIX*(IF (TYEAR<1985) THEN (PIIMF*(1-GKTI/IIMTV)*((IF ((RPL+RISK_IMF)/100-
DEL(1:PQGIMF)/PQGIMF(-1)<0.02) THEN 0.02 ELSE ((RPL+RISK_IMF)/100-DEL(1:PQGIMF)/PQGIMF(-
1)))+0.08)/(1-RCORP4)*A1_PKIMF) ELSE (PIIMF*(((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMF)/100*(1-RCORP4)-
DEL(1:PQGIMF)/PQGIMF(-1)+(0.72*RLAA1T3(-1)+0.28*RLAA5T7(-1)+RISK_IMF)/100*(1-RCORP4(-1))-
DEL(1:PQGIMF(-1))/PQGIMF(-2)+(0.72*RLAA1T3(-2)+0.28*RLAA5T7(-2)+RISK_IMF)/100*(1-RCORP4(-2))-
DEL(1:PQGIMF(-2))/PQGIMF(-3))/3+0.72*DEPM_IMT+0.28*DEPB_IMT-(DEL(1:PIIMF)/PIIMF(-1)-
```

```
DEL(1:PQGIMF)/PQGIMF(-1)+DEL(1:PIIMF(-1))/PIIMF(-2)-DEL(1:PQGIMF(-1))/PQGIMF(-
2)+DEL(1:PIIMF(-2))/PIIMF(-3)-DEL(1:PQGIMF(-2))/PQGIMF(-3))/3)/(1-RCORP4)*(1-GIMT)*(1-
(0.72*RIAM+0.28*RIAB)*RCORP4--
(0.72*RDEPM+0.28*RDEPB)/((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMF)/100*(1-
RCORP4)+0.72*RDEPM+0.28*RDEPB)*(EXP(-(1-
(0.72*RIAM+0.28*RIAB))/(0.72*RDEPM+0.28*RDEPB)*((0.72*RLAA1T3+0.28*RLAA5T7+RISK_IMF)/100*(1-
RCORP4)+0.72*RDEPM+0.28*RDEPB))-1)*RCORP4)))
65:LIMF_PES = LIMF*LIMF_PES_FIX
```

The Building Sector

```
66:DEL(1:LOG(KIB)) = A2_KIB*DEL(1:LOG(KIB_STAR))+A00_KIB*(LOG(KIB(-1))-LOG(KIB_STAR(-1)))+KIB_FIX
67:LOG(WIB/WNA) = A1_WIB+A2_WIB*ZT_WIB+WIB_FIX
68:LOG(IH) = IF (TYEAR<1990) THEN (A4_IH+A5_IH*LOG(HCOMP)+A6_IH*LOG(YRPERD)+IH_FIX) ELSE
(A1_IH+A2_IH*LOG(HCOMP)+A3_IH*LOG(YRPERD)+IH_FIX)
69:LOG(PIH) = IF (TYEAR<1991) THEN (A1_PIH+A2_PIH*LOG(PHNEW)+PIH_FIX) ELSE
(A4_PIH+A5_PIH*LOG(PHNEW)+PIH_FIX)
70:LIB/QGIB*AIB2_QGIB =
A1_LIB+A2_LIB*ZT_LIB**0.5+A3_LIB*(KIB*AIB3_QGIB/QGIB)**0.5+A6_LIB*(PQMIB*AIB6_QGIB/(WIB*AIB4_QGIB)
)**0.5+A4_LIB*(KIB*AIB3_QGIB*ZT_LIB/QGIB)**0.5+A5_LIB*KIB*AIB3_QGIB/QGIB+A7_LIB*ZT_LIB+LIB_FIX
71:QMIB/QGIB =
A1_QMIB+A6_LIB*(WIB*AIB4_QGIB/(PQMIB*AIB6_QGIB))**0.5+A3_QMIB*ZT_LIB**0.5+A4_QMIB*(KIB*AIB3_QGIB/Q
GIB)**0.5+A4_LIB*(KIB*AIB3_QGIB*ZT_LIB/QGIB)**0.5+A5_LIB*KIB*AIB3_QGIB/QGIB+A7_LIB*ZT_LIB+QMIB_FIX
72:KISTAR_KIB = ((-0.5*A3_LIB*QGIB**0.5*WIB*AIB4_QGIB-0.5*A4_QMIB*QGIB**0.5*PQMIB*AIB6_QGIB-
0.5*(QGIB*ZT_LIB)**0.5*(WIB*AIB4_QGIB+PQMIB*AIB6_QGIB)*A4_LIB)/(PKIB5*AIB1_QGIB+A5_LIB*(WIB*AIB4_Q
GIB+PQMIB*AIB6_QGIB)))**2
73:KIB_STAR = KISTAR_KIB*Z1_KISTARB/QGIB*QGIB_STAR
74:PVQGIB =
2*A6_LIB*(PQMIB*AIB6_QGIB*WIB*AIB4_QGIB)**0.5+A1_LIB*WIB*AIB4_QGIB+A1_QMIB*PQMIB*AIB6_QGIB+(A2_LIB
*WIB*AIB4_QGIB+A3_QMIB*PQMIB*AIB6_QGIB)*ZT_LIB**0.5+A7_LIB*ZT_LIB*(WIB*AIB4_QGIB+PQMIB*AIB6_QGIB)+
(A3_LIB*WIB*AIB4_QGIB+A4_QMIB*PQMIB*AIB6_QGIB+A4_LIB*ZT_LIB**0.5*(WIB*AIB4_QGIB+PQMIB*AIB6_QGIB))*
(KIB*AIB3_QGIB/QGIB)**0.5+A5_LIB*(WIB*AIB4_QGIB+PQMIB*AIB6_QGIB)*KIB*AIB3_QGIB/QGIB
75:PTQGIB =
2*(+A6_LIB)*(PQMIB*AIB6_QGIB*WIB*AIB4_QGIB)**0.5+A1_LIB*WIB*AIB4_QGIB+A1_QMIB*PQMIB*AIB6_QGIB+(A2_
LIB*WIB*AIB4_QGIB+A3_QMIB*PQMIB*AIB6_QGIB)*T70**0.5+A7_LIB*T70*(WIB*AIB4_QGIB+PQMIB*AIB6_QGIB)+(A3
_LIB*WIB*AIB4_QGIB+A4_QMIB*PQMIB*AIB6_QGIB+A4_LIB*T70**0.5*(WIB*AIB4_QGIB+PQMIB*AIB6_QGIB))*(KISTA
R_KIB/QGIB)**0.5+A5_LIB*(WIB*AIB4_QGIB+PQMIB*AIB6_QGIB)*KISTAR_KIB/QGIB+PKIB5*KISTAR_KIB*Z1_KISTAR
B/QGIB
76:IIB = KIB-0.85*KIB(-1)
77:QGIB = IB
78:QGIBV = IBV
79:PQGIB = QGIBV/QGIB
80:QMIBV = QMIB*PQMIB
81:YWIB = WIB*LIB
82:QNIBV = QGIBV-QMIBV
83:YCIB = OIBV-YWIB
84:IIBV = IIB*PIIB
85:PKIB = PIIB*((IF ((RPL+RISK_IB)/100-DEL(1:PIB)/PIB(-1)<0.02) THEN 0.02 ELSE ((RPL+RISK_IB)/100-
DEL(1:PIB)/PIB(-1)))+0.15)/(1-RCORP1)
86:PKIB5 = (PKIB+PKIB(-1)+PKIB(-2)+PKIB(-3)+PKIB(-4))/5
87:PQMIB =
EXP((IO_PQMIB_PQGIMH*LOG(PQGIMH)+IO_PQMIB_PQGIMD*LOG(PQGIMD)+IO_PQMIB_PQGIU*LOG(PQGIU)+IO_PQMIB_PO
SMDI*LOG(POSMDI)+IO_PQMIB_POSMTC*LOG(POSMTCM)+IO_PQMIB_POSMPF*LOG(POSMPF_INS)+IO_PQMIB_PM3*LOG(PM3
)+IO_PQMIB_PMNE*LOG(PMNE))/(IO_PQMIB_PQGIMH+IO_PQMIB_PQGIMD+IO_PQMIB_PQGIU+IO_PQMIB_POSMDI+IO_PQMI
B_POSMTC+IO_PQMIB_POSMPF+IO_PQMIB_PM3+IO_PQMIB_PMNE))/A1_PQMIB
88:OIB = QGIB*OIB_FIX
89:OIBV = QNIBV*OIBV_FIX
90:POIB = OIBV/OIB
```

The Utilities Sector

```
91:LOG(QGIU) = A1_QGIU+A2_QGIU*LOG(EN7FC_T)+QGIU_FIX
92:LOG(PQGIU) = A1_PQGIU+A2_PQGIU*LOG(PEN71_T)+PQGIU_FIX
93:LOG(QEIU) = A1_QEIU+A2_QEIU*LOG(ENE_T)+A3_QEIU*LOG(KIU)+QEIU_FIX
94:LOG(LIU/QGIU) = A1_LIU+A2_LIU*LOG(WIU/PQGIU)+A3_LIU*ZT_LIU+LIU_FIX
95:QRIUV/QGIUV = A1_QRIU+A2_QRIU*LOG(EN7FC_T)+A3_QRIU*LOG(KIU)+A4_QRIU*LOG(PQRIU/PQGIU)+QRIUV_FIX
96:WIU/WNA = WIU_FIX
97:FDXQGIU =
IO_FDXQGIU_QMA*QMA+IO_FDXQGIU_QRIMD*QMIMD+IO_FDXQGIU_QRIMF*QMIMF+IO_FDXQGIU_QRIMH*QMIMH+IO_FDXQGIU
_QGIU*QGIU+IO_FDXQGIU_QMIB*QMIB+IO_FDXQGIU_OSMDI*OSMDI+IO_FDXQGIU_OSMTC*OSMTC+IO_FDXQGIU_OSMPF*OSM
PF+IO_FDXQGIU_OSNHE*OSNHE+IO_FDXQGIU_OSNP*OSNP+IO_FDXQGIU_C*C+IO_FDXQGIU_IB*IB+IO_FDXQGIU_IME*IME+
IO_FDXQGIU_STNADL*STNADL+IO_FDXQGIU_STIVDL*STIVDL+IO_FDXQGIU_XA*XA+IO_FDXQGIU_XI*XI+IO_FDXQGIU_XS*
XS+IO_FDXQGIU_GCGNP*GCGNP
98:QGIUV = PQGIU*QGIU
99:PQEIU =
EXP((EN1E_T*LOG(PEN1E_T)+EN4E_T*LOG(PEN43E_T)+EN6E_T*LOG(PEN6E_T)+EN8E_T*LOG(PEN8E_T))/(EN1E_T+EN4
E_T+EN6E_T+EN8E_T))/A1_PQEIU*PQEIU_FIX
 100:PQRIU =
EXP((IO_PQRIU_PQGA*LOG(PQGA)+IO_PQRIU_PQGIMH*LOG(PQGIMH)+IO_PQRIU_PQGIMD*LOG(PQGIMD)+IO_PQRIU_PQGI
MF*LOG(PQGIMF)+IO_PQRIU_POSMDI*LOG(POSMDI)+IO_PQRIU_POSMTC*LOG(POSMTCM)+IO_PQRIU_POSMPF*LOG(POSMPF
_INS)+IO_PQRIU_PMNE*LOG(PMNE))/(IO_PQRIU_PQGA+IO_PQRIU_PQGIMH+IO_PQRIU_PQGIMD+IO_PQRIU_POSMDI+IO_P
QRIU_POSMTC+IO_PQRIU_PQGIMF+IO_PQRIU_POSMPF+IO_PQRIU_PMNE))/A1_PQRIU
 101:YWIU = WIU*LIU
 102:QEIUV = QEIU*PQEIU
 103:QRIU = QRIUV/PQRIU
```

```
104:QMIUV = QEIUV+QRIUV
105:QMIU = (QEIU+QRIU)*QMIU_FIX
106:PQMIU = QMIUV/QMIU
107:QNIUV = QGIUV-QEIUV-QRIUV
108:QNIU = QNIUV/PQGIU
109:PQNIU = QNIUV/QNIU
110:OIUV = OIU*POIU
111:OIU/QNIU = OIU_FIX
112:POIU/PQNIU = POIU_FIX
113:IIUV = PIIU*IIU
114:KIU = IIU+0.95*KIU(-1)
```

Aggregating the Manufacturing Sector

```
115:LOG(DEPI) = IF (TYEAR<1991) THEN (A3_DEPI+A4_DEPI*LOG(PII(-1)*KI(-1))+DEPI_FIX) ELSE
(A1_DEPI+A2_DEPI*LOG(PII(-1)*KI(-1))+DEPI_FIX)
116:QGIMT = (QGIMH+QGIMF+QGIMD)*QGIMT_FIX
117:QGIMTV = QGIMHV+QGIMFV+QGIMDV
118:PQGIMT = QGIMTV/QGIMT
119:QMIMTV = QMIMFV+QMIMDV+QMIMHV
120:QMIMT = (QMIMF+QMIMH+QMIMD)*QMIMT_FIX
121:PQMIMT = QMIMTV/QMIMT
122:QNIMT = QNIMH+QNIMD+QNIMF
123:QNIMTV = QGIMTV-QMIMTV
124:YWIMT = (YWIMF+YWIMH+YWIMD)*YWIMT_FIX
125:OIMTV = QNIMTV*OIMTV_FIX
126:OIMT = QNIMT*OIMT_FIX
127:POIMT = OIMTV/OIMT
128:IIMTV = (IIMHV+IIMFV+IIMDV)*IIMTV_FIX
129:IIMT = (IIMH+IIMF+IIMD)*IIMT_FIX
130:KIMT = KIMH+KIMF+KIMD
131:LIMT = LIMH_PES+LIMF_PES+LIMD_PES
132:WIMT = YWIMT/LIMT
133:YCIMT = OIMTV-YWIMT
134:OPRIMT = OIMT/LIMT
135:UCLIMT = WIMT/OPRIMT
136:OI = OIU+OIB+OIMT+OI_FIX
137:OIV = OIUV+OIBV+OIMTV
138:POI = OIV/OI
139:LI = LIU+LIB+LIMT
140:II = IIU+IIB+IIMT
141:IIV = IIUV+IIBV+IIMTV
142:PII = IIV/II
143:KI = KIU+KIB+KIMT
144:YWI = (YWIMT+YWIU+YWIB)*YWI_FIX
145:WI = YWI/LI
146:YCI = OIV-YWI
147:OPRI = OI/LI
148:UCLI = WI/OPRI
149:YCIREP = A1_YCIREP+A2_YCIREP*YCIMH+A3_YCIREP*YCSMPF+YCIREP_FIX
```

The Agricultural Sector

```
150:LOG(QMA/QGA) = A1_QMA+A2_QMA*LOG(KAG/QGA)+QMA_FIX
151:QDAG1/(QGA+QGIMF-QMIMF) = A1_QDAG+A2_QDAG*ZT_QDAG+QDAG1_FIX
152:LOG(LAG) = A1_LAG+A2_LAG*ZT_LAG+LAG_FIX
153:LOG(KAG_STAR/OAG) = A1_KAG_STAR+A2_KAG_STAR*LOG(PKAG/WNA)+A3_KAG_STAR*ZT_KAG+KAG_STAR_FIX
154:DEL(1:LOG(KAG)) = A2_KAG*DEL(1:LOG(OAG))+A00_KAG*(LOG(KAG(-1))-LOG(KAG_STAR(-1)))+KAG_FIX
155:LOG(DEPAG) = A1_DEPAG+A2_DEPAG*LOG(PIAG(-1)*KAG(-1))+DEPAG_FIX
156:OA = QGA-QMA
157:OAG = OA+OAFF
158:POAG = OAGV/OAG
159:QGAV = PQGA*QGA
160:QMAV = PQMA*QMA
161:OAV = QGAV-QMAV
162:OAGV = OAV+OAFFV
163:YAG = OAGV-DEPAG
164:IAG = KAG-(1-0.05)*KAG(-1)
```

The Distribution Sector

```
165:LOG(OSMDI) = A1_OSMDI+A2_OSMDI*LOG(FDXOSMDI-
XS*IO_FDXOSMDI_XS)+A3_OSMDI*LOG(POSMDI/PC)+A4_OSMDI*LOG(XTO)+A5_OSMDI*D89*STIVDL+OSMDI_FIX
166:YWSMDI_STAR/OSMDIV = A1_YWSMDI+A2_YWSMDI*LOG(WSMDI/PKSMDI)+A3_YWSMDI*1/(ZT_YWSMDI-
1970)+YWSMDI_STAR_FIX
167:LSMDI_STAR = YWSMDI_STAR/WSMDI
168:DEL(1:LOG(LSMDI)) = A01_LSMDI*DEL(1:LOG(OSMDI))+A00_LSMDI*(LOG(LSMDI(-1))-LOG(LSMDI_STAR(-
1)))+LSMDI_FIX
169:KSMDI_STAR = (OSMDIV-YWSMDI_STAR)/PKSMDI/Z1_KSMDI_STAR
170:DEL(1:LOG(KSMDI)) = A2_KSMDI*DEL(1:LOG(OSMDI))+A00_KSMDI*(LOG(KSMDI(-1))-LOG(KSMDI_STAR(-
1)))+KSMDI_FIX
171:LOG(POSMDI) = A1_POSMDI+A2_POSMDI*LOG(WSMDI)+POSMDI_FIX
172:LOG(WSMDI/WNA) = A1_WSMDI+A2_WSMDI*ZT_WSMDI+WSMDI_FIX
173:ISMDI = KSMDI-(1-0.05)*KSMDI(-1)
```

```
174:ISMDIV = ISMDI*PISMDI
175:OSMDIV = POSMDI*OSMDI
176:YWSMDI = LSMDI*WSMDI
177:YCSMDI = OSMDIV-YWSMDI
178:PKSMDI = PISMDI*((IF ((RPL+RISK_SMDI)/100-PC_DOT/100<0.02) THEN 0.02 ELSE
((RPL+RISK_SMDI)/100-PC_DOT/100))+0.05)/(1-RCORP1)
179:OPRSMDI = OSMDI/LSMDI
180:UCLSMDI = WSMDI/OPRSMDI
181:FDXOSMDI =
IO_FDXOSMDI_QMA*QMA+IO_FDXOSMDI_QRIMD*QMIMD+IO_FDXOSMDI_QRIMF*QMIMF+IO_FDXOSMDI_QRIMH*QMIMH+IO_FDX
OSMDI_QGIU*QGIU+IO_FDXOSMDI_QMIB*QMIB+IO_FDXOSMDI_OSMDI*OSMDI+IO_FDXOSMDI_OSMTC*OSMTC+IO_FDXOSMDI_
OSMPF*OSMPF+IO_FDXOSMDI_OSNHE*OSNHE+IO_FDXOSMDI_OSNP*OSNP+IO_FDXOSMDI_C*C+IO_FDXOSMDI_IB*IB+IO_FDX
OSMDI_IME*IME+IO_FDXOSMDI_STNADL*STNADL+IO_FDXOSMDI_STIVDL*STIVDL+IO_FDXOSMDI_XA*XA+IO_FDXOSMDI_XI
*XI+IO_FDXOSMDI_XS*XS+IO_FDXOSMDI_GCGNP*GCGNP
```

Professional and Financial Services Sector

```
182:LOG(OSMPF) = A1_OSMPF+A2_OSMPF*LOG(POSMPF_INS/(WIMT_UK*REX_UK))+A3_OSMPF*LOG(FDXOSMPF-
IO_FDXOSMPF_XS*XOS)+A4_OSMPF*LOG(XOS)+OSMPF_FIX
183:LOG(LSMPF_STAR) =
A1_LSMPF+A2_LSMPF*LOG(WSMPF/POSMPF_INS)+A3_LSMPF*LOG(OSMPF)+A4_LSMPF*LOG(KSMPF)+LSMPF_STAR_FIX
184:DEL(1:LOG(LSMPF)) =
A5_LSMPF*DEL(1:LOG(OSMPF))+A6_LSMPF*DEL(1:LOG(WSMPF/POSMPF_INS))+A00_LSMPF*(LOG(LSMPF(-1))-
LOG(LSMPF_STAR(-1)))+LSMPF_FIX
185:LOG(KSMPF_STAR) =
A11_KSMPF+A12_KSMPF*ZT_KSMPF+A13_KSMPF*LOG(OSMPF)+A14_KSMPF*LOG(POSMPF_INS/PGNP)+KSMPF_STAR_FIX
186:DEL(1:LOG(KSMPF)) = A2_KSMPF*DEL(1:LOG(OSMPF))+A00_KSMPF*(LOG(KSMPF(-1))-LOG(KSMPF_STAR(-
1)))+KSMPF_FIX
187:LOG(POSMPF_INS) =
A1_POSMPF+0.4*LOG(WSMPF)+A2_POSMPF*LOG(PC_UK*REX_UK)+A3_POSMPF*ZT_POSMPF+POSMPF_FIX
188:LOG(WSMPF/WNA) = A1_WSMPF+A2_WSMPF*ZT_WSMPF+WSMPF_FIX
189:YWSMPF = LSMPF*WSMPF
190:ISMPF = KSMPF-(1-0.08)*KSMPF(-1)
191:ISMPFV = ISMV-(ISMDIV+ISMTCV+ISMGV+ISMV_FIX)
192:OSMPFV = GDAV+XGSV-MGSV-STATDISV-(OIV+OAGV+OSMDIV+OSMTCV+OSNHEV+OSNPV+TE-SUB+STATDISV)
193:POSMPF = OSMPFV/OSMPF
194:YCSMPF = OSMPFV-YWSMPF
195:PKSMPF = PISMPF*((IF (RPL/100-DEL(1:POSMPF_INS)/POSMPF_INS(-1)<0.02) THEN 0.02 ELSE (RPL/100-
DEL(1:POSMPF_INS)/POSMPF_INS(-1)))+0.05)/(1-RCORP1)
196:OPRSMPF = OSMPF/LSMPF
197:UCLSMPF = WSMPF/OPRSMPF
198:FDXOSMPF =
IO_FDXOSMPF_QMA*QMA+IO_FDXOSMPF_QRIMD*QMIMD+IO_FDXOSMPF_QRIMF*QMIMF+IO_FDXOSMPF_QRIMH*QMIMH+IO_FDX
OSMPF_QGIU*QGIU+IO_FDXOSMPF_QMIB*QMIB+IO_FDXOSMPF_OSMDI*OSMDI+IO_FDXOSMPF_OSMTC*OSMTC+IO_FDXOSMPF_
OSMPF*OSMPF+IO_FDXOSMPF_OSNHE*OSNHE+IO_FDXOSMPF_OSNP*OSNP+IO_FDXOSMPF_C*C+IO_FDXOSMPF_IB*IB+IO_FDX
OSMPF_IME*IME+IO_FDXOSMPF_STNADL*STNADL+IO_FDXOSMPF_STIVDL*STIVDL+IO_FDXOSMPF_XA*XA+IO_FDXOSMPF_XI
*XI+IO_FDXOSMPF_XS*XS+IO_FDXOSMPF_GCGNP*GCGNP
```

Transport and Communications Sector

```
199:LOG(OSMTC) = IF (TYEAR<1991) THEN (A1_OSMTC+A2_OSMTC*LOG(FDXOSMTC-
XS*IO_FDXOSMTC_XS)+A3_OSMTC*LOG(XTO+MTO)+A4_OSMTC*ZT_OSMTC+OSMTC_FIX) ELSE
(A5_OSMTC+A6_OSMTC*LOG(FDXOSMTC-
XS*IO_FDXOSMTC_XS)+A7_OSMTC*LOG(XTO+MTO)+A8_OSMTC*ZT_OSMTC+OSMTC_FIX)
200:LOG(LSMTC) =
A1_LSMTC+A2_LSMTC*LOG(OSMTC)+A3_LSMTC*LOG(WSMTC/POSMTC)+A4_LSMTC*LOG(KSMTC)+LSMTC_FIX
201:LOG(KSMTC_STAR) = IF (TYEAR>1994) THEN (A1_KSMTC_STAR+A2_KSMTC_STAR*LOG(OSMTC)*ZT_KSMTC_STAR-
0.04*LOG(PKSMTC/PGNP)+KSMTC_STAR_FIX) ELSE
(A5_KSMTC_STAR+A6_KSMTC_STAR*ZT_KSMTC_STAR+KSMTC_STAR_FIX)
202:DEL(1:LOG(KSMTC)) = A2_KSMTC+A00_KSMTC*(LOG(KSMTC(-1))-LOG(KSMTC_STAR(-1)))+KSMTC_FIX
203:LOG(POSMTC) = A1_POSMTC+A2_POSMTC*LOG(WSMTC/OPRSMTC)+A3_POSMTC*ZT_POSMTC+POSMTC_FIX
204:LOG(WSMTC/WNA) = IF (TYEAR<1990) THEN (A1_WSMTC+A2_WSMTC*ZT_WSMTC+WSMTC_FIX) ELSE
(A3_WSMTC+A4_WSMTC*ZT_WSMTC+WSMTC_FIX)
205:YWSMTC = LSMTC*WSMTC
206:ISMTC = KSMTC-(1-0.05)*KSMTC(-1)
207:ISMTCV = ISMTC*PISMTC
208:OSMTCV = POSMTC*OSMTC
209:POSMTCM = (OSMTCV-GCSCT)/OSMTC*Z1_OSMTC*POSMTCM_FIX
210:YCSMTC = OSMTCV-YWSMTC
211:PKSMTC = PISMTC*((IF (RPL/100-DEL(1:POSMTC)/POSMTC(-1)<0.02) THEN 0.02 ELSE (RPL/100-
DEL(1:POSMTC)/POSMTC(-1)))+0.1)/(1-RCORP1)
212:OPRSMTC = OSMTC/LSMTC
213:UCLSMTC = WSMTC/OPRSMTC
214:FDXOSMTC =
IO_FDXOSMTC_QMA*QMA+IO_FDXOSMTC_QRIMD*QMIMD+IO_FDXOSMTC_QRIMF*QMIMF+IO_FDXOSMTC_QRIMH*QMIMH+IO_FDX
OSMTC_QGIU*QGIU+IO_FDXOSMTC_QMIB*QMIB+IO_FDXOSMTC_OSMDI*OSMDI+IO_FDXOSMTC_OSMTC*OSMTC+IO_FDXOSMTC_
OSMPF*OSMPF+IO_FDXOSMTC_OSNHE*OSNHE+IO_FDXOSMTC_OSNP*OSNP+IO_FDXOSMTC_C*C+IO_FDXOSMTC_IB*IB+IO_FDX
OSMTC_IME*IME+IO_FDXOSMTC_STNADL*STNADL+IO_FDXOSMTC_STIVDL*STIVDL+IO_FDXOSMTC_XA*XA+IO_FDXOSMTC_XI
*XI+IO_FDXOSMTC_XS*XS+IO_FDXOSMTC_GCGNP*GCGNP
```

Aggregating the Services Sector

```
215:LOG(DEPS) = A1_DEPS+A2_DEPS*LOG(PIS(-1)*KS(-1))+DEPS_FIX
216:OSM = OSMTC+OSMPF+OSMDI+OSM_FIX
```

```
217:OSMV = OSMTCV+OSMPFV+OSMDIV
218:POSM = OSMV/OSM
219:ISM = ISMDI+ISMPF+ISMTC+ISMG+ISM_FIX
220:KSMG = ISMG+(1-0.01)*KSMG(-1)
221:KSNP = ISNP+(1-0.02)*KSNP(-1)
222:KSNHE = ISNHE+(1-0.02)*KSNHE(-1)
223:KSM = KSMDI+KSMPF+KSMTC+KSMG
224:KSN = KSNP+KSNHE
225:KS = KSM+KSN
226:LSM = LSMDI+LSMPF+LSMTC
227:YWSM = YWSMDI+YWSMPF+YWSMTC
228:YCSM = OSMV-YWSM
229:OPRSM = OSM/LSM
230:WSM = YWSM/LSM
231:UCLSM = WSM/OPRSM
232:OSNHE = OSNHE_FIX*LSNHE
233:OSNHEV = YWSNHE+YCSNHE
234:YCSNHE = KYCSNHE*OSNHEV
235:OSNP = OSNP_FIX*LSNP
236:OSNPV = YWSNP
237:OSNV = OSNHEV+OSNPV
238:OSN = OSNHE+OSNP
239:POSN = OSNV/OSN
240:POSNP = OSNPV/OSNP
241:LOG(MNE_INS) = IF (TYEAR<1982) THEN (A1_MNE+A2_MNE*LOG(FDXMGS)+A3_MNE*ZT_MNE+MNE_FIX) ELSE
(A4_MNE+A5_MNE*LOG(FDXMGS-IO_FDXMGS_XI*XI)+A6_MNE*LOG(XI)+A7_MNE*ZT_MNE+MNE_FIX)
242:M3V = PM3*M3
243:MNE = GFD-GDP-STATDIS-M3
244:MNEV = PMNE*MNE
245:LOG(MTO) = MTO_FIX+(IF (TYEAR>1989) THEN (A1_MTO+A2_MTO*LOG(C)+A3_MTO/(ZT_MTO-1950)) ELSE
(A4_MTO+A5_MTO*LOG(C)))
246:MGS = MNE+M3
247:MGSV = MNEV+M3V
248:PMGS = MGSV/MGS
249:BPT = XGSV-MGSV
250:BPPK = DEL(1:R)-BP-DEL(1:NFLB)-BPTCK-GFBORF-GFBORD
251:KBPPKV = KBPPKV(-1)*PQGIMT_USUKGER/PQGIMT_USUKGER(-1)-BPPK
252:NFLP = KBPPKV-NFLB
253:YFNPO = KYFNPO*NFLP(-1)+YFNPO_FIX
254:PYCIREP = EXP(0.25*LOG(POSMPF_INS)+0.75*LOG(PQGIMH))
255:YFN = YFNPO-GCTNFT-YCIREP
256:YRFN = (YFNPO-GCTNFT)/PXGS-YCIREP/PYCIREP+YRFN_FIX
```

Demographics and Labour Supply

```
257:N0014_MALE =
A1_N0014_MALE+A2_N0014_MALE*NI0014_MALE+A3_N0014_MALE*NMA_MALE+N0014_MALE_FIX+N0014_MALE(-1)
258:N0014_FEM =
A1_N0014_FEM+A2_N0014_FEM*NI0014_FEM+A3_N0014_FEM*NMA_FEM+N0014_FEM_FIX+N0014_FEM(-1)
259:N1524_MALE =
A1_N1524_MALE+A2_N1524_MALE*NI1524_MALE+A3_N1524_MALE*NMA_MALE+N1524_MALE_FIX+N1524_MALE(-1)
260:N1524_FEM =
A1_N1524_FEM+A2_N1524_FEM*NI1524_FEM+A3_N1524_FEM*NMA_FEM+N1524_FEM_FIX+N1524_FEM(-1)
261:N2564_MALE =
A1_N2564_MALE+A2_N2564_MALE*NI2564_MALE+A3_N2564_MALE*NMA_MALE+N2564_MALE_FIX+N2564_MALE(-1)
262:N2564_FEM =
A1_N2564_FEM+A2_N2564_FEM*NI2564_FEM+A3_N2564_FEM*NMA_FEM+N2564_FEM_FIX+N2564_FEM(-1)
263:N65_MALE = A1_N65_MALE+A2_N65_MALE*NI65_MALE+A3_N65_MALE*NMA_MALE+N65_MALE_FIX+N65_MALE(-1)
264:N65_FEM = A1_N65_FEM+A2_N65_FEM*NI65_FEM+A3_N65_FEM*NMA_FEM+N65_FEM_FIX+N65_FEM(-1)
265:NMAT_STAR = A4_NMAT+A5_NMAT*(1-UR/100)/(1-
UR_UK/100)+A6_NMAT*LOG(RELWNA)+A7_NMAT*D0110T+NMAT_STAR_FIX
266:NMA = Z_NMA*(NMA_FIX+(IF (TYEAR>1989) THEN (A01_NMAT*D0110+A00_NMAT*(NMAT(-1)-NMAT_STAR(-1)))
ELSE (A02_NMAT*DEL(1:RELWNA)+A03_NMAT*(NMAT(-1)-NMAT_STAR(-1)))))+(1-Z_NMA)*(A1_NMA+A2_NMA*(1-UR(-
1)/100)/(1-UR_UK(-1)/100)+A3_NMA*RELWNA(-1)+A4_NMA*D0110+NMA2_FIX)
267:NMAT = NMAT(-1)+NMA
268:RELWNA = WNA_INS*(1-RGTYP_IRL)/PC/(WNA_UK*(1-RGTYP_UK)/PC_UK)/A1_RELWNA
269:NMA_FEM = NMA*NMA_FEM_FIX
270:NMA_MALE = NMA-NMA_FEM
271:LFPR2564_FEM_STAR = A1_LFPR2564_FEM+0.49/LFPR2564_FEM*LOG(WNA_INS*(1-
RGTYP_IRL)/PC)+A3_LFPR2564_FEM*ZT_LFPR2564_FEM+LFPR2564_FEM_STAR_FIX
272:DEL(1:LFPR2564_FEM) = A00_LFPR2564_FEM*(LFPR2564_FEM(-1)-LFPR2564_FEM_STAR(-
1))+LFPR2564_FEM_FIX
273:LFPR2564_MALE_STAR = A1_LFPR2564_MALE+0.09/LFPR2564_MALE*LOG(WNA_INS*(1-
RGTYP_IRL)/PC)+A3_LFPR2564_MALE*ZT_LFPR2564_MALE+LFPR2564_MALE_STAR_FIX
274:DEL(1:LFPR2564_MALE) = A00_LFPR2564_MALE*(LFPR2564_MALE(-1)-LFPR2564_MALE_STAR(-
1))+LFPR2564_MALE_FIX
275:LFPR1524_FEM_STAR = A1_LFPR1524_FEM+A2_LFPR1524_FEM*LOG(WNA_INS*(1-
RGTYP_IRL)/PC)+A3_LFPR1524_FEM*ZT_LFPR1524_FEM+LFPR1524_FEM_STAR_FIX
276:DEL(1:LFPR1524_FEM) = A00_LFPR1524_FEM*(LFPR1524_FEM(-1)-LFPR1524_FEM_STAR(-
1))+LFPR1524_FEM_FIX
277:LFPR1524_MALE_STAR = A1_LFPR1524_MALE+A2_LFPR1524_MALE*LOG(WNA_INS*(1-
RGTYP_IRL)/PC)+A3_LFPR1524_MALE*ZT_LFPR1524_MALE+LFPR1524_MALE_STAR_FIX
278:DEL(1:LFPR1524_MALE) = A00_LFPR1524_MALE*(LFPR1524_MALE(-1)-LFPR1524_MALE_STAR(-
1))+LFPR1524_MALE_FIX
279:LF2564_FEM = LFPR2564_FEM*N2564_FEM/100
280:LF1524_FEM = LFPR1524_FEM*N1524_FEM/100
```

```
281:LF2564_MALE = LFPR2564_MALE*N2564_MALE/100
282:LF1524_MALE = LFPR1524_MALE*N1524_MALE/100
283:N1564_FEM = N1524_FEM+N2564_FEM
284:N1564_MALE = N1524_MALE+N2564_MALE
285:NLE14 = N0014_FEM+N0014_MALE
286:N1564 = N1564_FEM+N1564_MALE
287:NGE65 = N65_FEM+N65_MALE
288:NT = NLE14+N1564+NGE65
289:LF_FEM = LF1524_FEM+LF2564_FEM+LF65_FEM
290:LF_MALE = LF1524_MALE+LF2564_MALE+LF65_MALE
291:LFPR_FEM = LF_FEM/N1564_FEM*100
292:LFPR_MALE = LF_MALE/N1564_MALE*100
293:LFPR = (LF_FEM+LF_MALE)/(N1564_FEM+N1564_MALE)*100
294:LF = LF_MALE+LF_FEM
295:LSN = LSNHE+LSNP
296:LS = LSM+LSN
297:LTOT = LI+LAG+LS
298:LNA = LI+LS
299:LM = LAG+LI+LSM
300:U = LF-LTOT
301:UR = 100*U/LF
```

The Consumption Function

```
302:LOG(C_STAR1/NT) = A1_C+A2_C*LOG(YRPERD/NT)+A3_C*DUM75+A4_C*LOG(N1564/NT)+C_STAR1_FIX
 303:LOG(C_STAR2/NT) = A5_C+A6_C*LOG(YRPERD/NT)+A7_C*LOG(HSTOCK(-1)*(PHNEW(-1)+PHOLD(-1))/2/PC(-
1)/NT(-1))+A8_C*LOG(NFW(-1)/PC(-1)/NT(-1))+C_STAR2_FIX
 304:DEL(1:LOG(C/NT)) = IF (Z_SAVRAT<TWO) THEN
(Z_SAVRAT*(C1_FIX+A12_C*DEL(1:LOG(YRPERD/NT))+A00_C*(LOG(C(-1)/NT(-1))-LOG(C_STAR1(-1)/NT(-
1))))+(1-
Z_SAVRAT)*(C2_FIX+A24_C*DEL(1:LOG(YRPERD/NT))+A25_c*DEL(1:LOG(HSTOCK*(PHNEW+PHOLD)/2/PC/NT))-
0.45*(LOG(C(-1)/NT(-1))-LOG(C_STAR2(-1)/NT(-1))))) ELSE (LOG(YRPERD/NT*SAVRAT_FIX))
 305:LOG(CELEC) = A1_CELEC+A2_CELEC*LOG(EN7C_T)+CELEC_FIX
 306:LOG(COEN) = A1_COEN+A2_COEN*LOG(ENCW_T)+COEN_FIX
 307:LOG(CPET) = A1_CPET+A2_CPET*LOG(EN4ST_T)+CPET_FIX
 308:LOG(PCELEC) = A1_PCELEC+A2_PCELEC*LOG(PEN7C_T)+PCELEC_FIX
 309:LOG(PCOEN) = A1_PCOEN+A2_PCOEN*LOG(PENCOEN)+PCOEN_FIX
 310:LOG(PCPET) = A1_PCPET+A2_PCPET*LOG(PEN41U_T)+PCPET_FIX
 311:LOG(PCXEN) = IF (TYEAR<1991) THEN
(A11_PCXEN+A12_PCXEN*LOG(PAC1)+0.75*LOG(1+RVATR)+W_REX*LOG(REX)+PCXEN_FIX) ELSE
(A15_PCXEN+A16_PCXEN*LOG(PAC1)+0.75*LOG(1+RVATR)+W_REX*LOG(REX)+PCXEN_FIX)
 312:SAVRAT = (1-CV/YPERD)*100
 313:CEN = CELEC+COEN+CPET
 314:PENCOEN = EXP((EN1C_T(-1)*LOG(PEN1C_T)+EN4C_T(-1)*LOG(PEN422C_T)+EN6C_T(-
1)*LOG(PEN6C_T)+EN8C_T(-1)*LOG(PEN81C_T))/(EN1C_T(-1)+EN4C_T(-1)+EN6C_T(-1)+EN8C_T(-
1)))/A1_PENCOEN
 315:CELECV = CELEC*PCELEC
 316:COENV = COEN*PCOEN
 317:CPETV = CPET*PCPET
 318:CENV = CELECV+COENV+CPETV
 319:PCEN = CENV/CEN
 320:CXEN = C-CEN
 321:PAC1 =
EXP((IO_PAC1_PQGA*LOG(PQGA)+IO_PAC1_PQGIMF*LOG(PQGIMF)+IO_PAC1_PQGIMH*LOG(PQGIMH)+IO_PAC1_PQGIMD*L
OG(PQGIMD)+IO_PAC1_PQGIU*LOG(PQGIU)+IO_PAC1_PQGIB*LOG(PQGIB)+IO_PAC1_POSMDI*LOG(POSMDI)+IO_PAC1_PO
SMTC*LOG(POSMTCM)+IO_PAC1_POSMPF*LOG(POSMPF_INS)+IO_PAC1_PMNE*LOG(PMNE)+IO_PAC1_PM3*LOG(PM3))/IO_P
AC1_SUMIO)
 322:CXENV = CXEN*PCXEN
 323:CV = CXENV+CENV
 324:PC = CV/C
 325:GCGV = OSNPV+GCGOWV+GCGNPV
 326:GCGNP = GCGNPV/PGCGNP
 327:GCG = OSNP+GCGOW+GCGNP
 328:GCGOWV = YWSNHE-GCTW
 329:GCGOW = GCGOWV/PGCGOW
 330:PGCGOW = PGCGOW(-1)*WSNHE/WSNHE(-1)
 331:NFW = NFW(-1)*(1+RL_GER/100)+FFAQH+NFW_FIX
```

The Housing Sector

```
332:LOG(PHNEW_STAR/PC) = A1_PHNEW+A2_PHNEW*LOG((YRPERD-
GCTNT/PC)/NT)+A3_PHNEW*LOG(1+HSTOCK/NT)+A4_PHNEW*NT2534/NT+A5_PHNEW*(RMRL(-1)/100-Z_PHNEW_E2-
Z_PHNEW_E1*0.5*LOG(PHOLD(-1)/PHOLD(-3)))+A6_PHNEW*D03_PHNEW+PHNEW_STAR_FIX
 333:DEL(1:LOG(PHNEW/PC)) = A12_PHNEW*DEL(1:LOG((YRPERD-GCTNT/PC)/NT))+A13_PHNEW*DEL(1:RMRL(-
1)/100-0.5*LOG(PHOLD(-1)/PHOLD(-3)))+A00_PHNEW*(LOG(PHNEW(-1)/PC(-1))-LOG(PHNEW_STAR(-1)/PC(-
1)))+PHNEW_FIX
 334:HCOMP = A1_HCOMP+A2_HCOMP*(PIH+PIH(-1))/(PTQGIB+PTQGIB(-1))+A3_HCOMP*HCOMP(-1)+HCOMP_FIX
 335:LOG(PHOLD/PC) = A1_PHOLD+A2_PHOLD*LOG((YRPERD-
GCTNT/PC)/NT)+A3_PHOLD*LOG(1+HSTOCK/NT)+A4_PHOLD*NT2534/NT+A5_PHOLD*(RMRL(-1)/100-0.5*LOG(PHOLD(-
1)/PHOLD(-3)))+PHOLD_FIX
 336:HSTOCK = HSTOCK(-1)*0.995+HCOMP+HSTOCK_FIX
```

Other Expenditure

```
337:IHV = PIH*IH
 338:IHP = IH-IHG
 339:IHPV = IHV-IHGV
 340:IHG = IHGV/PIH
 341:IME =
A1_IME+A2_IME*(0.62*IAG+0.72*IIMT+0.92*IIB+0.75*IIU+0.6*ISMTC+0.8*ISMDI+0.65*ISMPF+0.35*ISNP+0.45*
ISNHE)+IME_FIX
 342:STNADL = A1_STNADL+A2_STNADL*OI+A3_STNADL*STNA(-1)+STNADL_FIX
 343:XI/(QGIMH+QGIMD) = IF (TYEAR<2001) THEN (A1_XI+A2_XI*ZT_XI+XI_FIX) ELSE (A3_XI+XI_FIX)
 344:LOG(XTO_STAR) =
A1_XTO_STAR+A2_XTO_STAR*LOG(GDP_UK)+A3_XTO_STAR*LOG(PC/(PC_UK*REX_UK))+A4_XTO_STAR*LOG(PC/(PC_GER*
REX_GER))+XTO_STAR_FIX
 345:DEL(1:LOG(XTO)) = A2_XTO*DEL(1:LOG(XTO_STAR))+A00_XTO*(LOG(XTO(-1))-LOG(XTO_STAR(-
1)))+XTO_FIX
 346:LOG(XOS_STAR) =
A1_XOS+A2_XOS*LOG(WSMPF/(WIMT_UK*REX_UK))+A3_XOS*LOG(GDP_EU)+A4_XOS*DUM90*LOG(GDP_EU)+A5_XOS*RCORP
1+XOS_STAR_FIX
 347:DEL(1:LOG(XOS)) = A01_XOS*DEL(1:LOG(GDP_EU))+A00_XOS*(LOG(XOS(-1))-LOG(XOS_STAR(-1)))+XOS_FIX
 348:IMEV = PIME*IME
 349:IAGV = PIAG*IAG
 350:IS = ISM+ISNHE+ISNP
 351:ISV = ISMV+ISNHEV+ISNPV
 352:ISN = ISNP+ISNHE
 353:ISNV = ISNPV+ISNHEV
 354:PISN = ISNV/ISN
 355:ISNP = ISNPV/PISNP
 356:ISNHE = ISNHEV/PISNHE
 357:ISMG = ISMGV/PISMG
 358:ITOT = II+IAG+IS+IH+ITOT_DIS
 359:IBC = ITOT-IME-IH
 360:IBCV = PIBC*IBC
 361:LOG(PIBC) = A1_PIBC+A2_PIBC*LOG(PVQGIB)+PIBC_FIX
 362:IB = IH+IBC
 363:IBV = IHV+IBCV
 364:PIB = IBV/IB
 365:ITOTV = IBV+IMEV
 366:ISMV = ITOTV-(IIV+IAGV+ISNV+IHV+ITOTV_DIS)
 367:STNAVDL = PSTNADL*STNADL
 368:STNA = STNADL+STNA(-1)
 369:STNAV = PSTNA*STNA
 370:STDL = STADL+STNADL+STIVDL
 371:STVDL = STAVDL+STIVVDL+STNAVDL
 372:XA = QGA-QDAG1-QMIMF+QGIMF-STADL-STIVDL
 373:XAV = PXA*XA
 374:XIV = PXI*XI
 375:XS = XTO+XOS
 376:XSV = PXS*XS
 377:XNA = XI+XS
 378:XNAV = XIV+XSV
 379:XGS = XNA+XA
 380:XGSV = XNAV+XAV
 381:SAV = YPERD-CV
 382:SAVC = YCU-GTYC
 383:SAVTOT = SAV+SAVC+GBRC
 384:SAVNET = SAVTOT-YASA
 385:SAVG = SAVNET+DEP-BP
 386:GDA = C+GCG+ITOT+STDL
 387:GDAV = CV+GCGV+ITOTV+STVDL
 388:GFD = GDA+XGS
 389:GFDV = GDAV+XGSV
```

Prices

```
390:PM3 = PM3F/REXEFF
 391:PQE = PM3*(1+RGTEE*ENM_T/1000/ENTD_T)
 392:PMNE = PMNEF/REXEFF
 393:LOG(PQMA) = A1_PQMA+A2_PQMA*LOG(PQGIMT)+(1-A2_PQMA)*LOG(PQGA(-1))+PQMA_FIX
 394:LOG(PIME) = A1_PIME+A2_PIME*LOG(PMNE)+PIME_FIX
 395:LOG(PISMDI/(0.8*PIME+0.2*PIBC)) = A1_PISMDI+A2_PISMDI*ZT_PISMDI+PISMDI_FIX
 396:LOG(PISMTC) = A1_PISMTC+A2_PISMTC*LOG(PIBC)+(1-A2_PISMTC)*LOG(PIME)+PISMTC_FIX
 397:LOG(PXI) = A1_PXI+A2_PXI*LOG(PQGIMH)+(1-A2_PXI)*LOG(PQGIMD)+PXI_FIX
 398:PGDPFC = GDPFCV/GDPFC
 399:PASTNADL =
EXP((IO_PASTNADL_PQGA*LOG(PQGA)+IO_PASTNADL_PQGIMF*LOG(PQGIMF)+IO_PASTNADL_PQGIMH*LOG(PQGIMH)+IO_P
ASTNADL_PQGIMD*LOG(PQGIMD)+IO_PASTNADL_PQGIU*LOG(PQGIU)+IO_PASTNADL_PQGIB*LOG(PQGIB)+IO_PASTNADL_P
OSMDI*LOG(POSMDI)+IO_PASTNADL_POSMTC*LOG(POSMTCM)+IO_PASTNADL_POSMPF*LOG(POSMPF_INS)+IO_PASTNADL_P
MNE*LOG(PMNE)+IO_PASTNADL_PM3*LOG(PM3))/IO_PASTNADL_SUMIO)
 400:PAIME =
EXP((IO_PAIME_PQGA*LOG(PQGA)+IO_PAIME_PQGIMF*LOG(PQGIMF)+IO_PAIME_PQGIMH*LOG(PQGIMH)+IO_PAIME_PQGI
MD*LOG(PQGIMD)+IO_PAIME_PQGIU*LOG(PQGIU)+IO_PAIME_PQGIB*LOG(PQGIB)+IO_PAIME_POSMDI*LOG(POSMDI)+IO_
PAIME_POSMTC*LOG(POSMTCM)+IO_PAIME_POSMPF*LOG(POSMPF_INS)+IO_PAIME_PMNE*LOG(PMNE)+IO_PAIME_PM3*LOG
(PM3))/IO_PAIME_SUMIO)
 401:PC_DOT = 100*(PC/PC(-1)-1)
```

```
402:PGCGNP = PGCGNP_FIX*PC
403:PGCG = GCGV/GCG
404:PISNHE = PISNHE_FIX*(0.62*PIBC+0.38*PIME)
405:PISNP = PISNP_FIX*(0.53*PIBC+0.47*PIME)
406:PISMG = PIBC*PISMG_FIX
407:PIIB = (PIBC*0.08+0.92*PIME)*PIIB_FIX
408:PIIU = (PIBC*0.25+0.75*PIME)*PIIU_FIX
409:PIIMT = (PIBC*0.28+0.72*PIME)*PIIMT_FIX
410:PIIMH = PIIMT
411:PIIMF = PIIMT
412:PIIMD = PIIMT
413:PISMPF = ISMPFV/ISMPF*PISMPF_FIX
414:PISM = ISMV/ISM
415:PIS = ISV/IS
416:PIAG = (PIBC*0.5+0.5*PIME)*PIAG_FIX
417:PITOT = ITOTV/ITOT
418:PXA = PXAF/REXEFF
419:LOG(PXS) = LOG(PC)+LOG(PXS_FIX)
420:PXNA = XNAV/XNA
421:PXGS = XGSV/XGS
422:PSTNADL = PASTNADL*PSTNADL_FIX
423:PSTNA = PSTNADL*PSTNA_FIX
424:PSTDL = STVDL/STDL
425:PTE = TE/TRE
426:PSUB = SUB/SRUB
```

The Wage Equation

```
427:LOG(WNA_STAR) = (A1_WNA*LOG(GDPFC)+A0_WNA+Z_ELS*LOG(PC/(1-RGTYP_IRL)))/(Z_ELS-
Z_ELD)+WNA_STAR_FIX
428:LOG(WNA) = LOG(WNA(-1))+A11_WNA+A00_WNA*(LOG(WNA(-1))-LOG(WNA_STAR(-1)))+WNA_FIX
429:RGTYP_IRL = 1-(YPERD+GTWL)/YPER
430:WSNP = WNA*WSNP_FIX
431:WSNHE = WSNP*WSNHE_FIX
```

The Government Sector

```
432:LOG(GTEXT) = A1_GTEXT+A2_GTEXT*LOG(REX)+A3_GTEXT*LOG(C+XTO)+A4_GTEXT*LOG(PC)+GTEXT_FIX
433:LOG(GTEVAT) = A1_GTEVAT+A2_GTEVAT*LOG(5/6*RVATR+1/6*RVATR(-
1))+A3_GTEVAT*LOG((C+XTO+GCGNP)*5/6+1/6*(C(-1)+XTO(-1)+GCGNP(-
1)))+A4_GTEVAT*LOG(5/6*PAC1+1/6*PAC1(-1))+A5_GTEVAT*LOG(5/6*RV8*IHPV+1/6*RV8(-1)*IHPV(-
1))+GTEVAT_FIX
434:LOG(GTEO) = IF (TYEAR<1996) THEN
(A1_GTEO+A2_GTEO*LOG(RTEO)+A3_GTEO*LOG(C)+A4_GTEO*LOG(PC)+GTEO_FIX) ELSE
(A5_GTEO+A6_GTEO*LOG(RTEO)+A7_GTEO*LOG(IHV)+A8_GTEO*LOG(CV)+GTEO_FIX)
/* Indexation rules: to avoid indexation exogenise these variables.  */
435:LSNP = LSNP(-1)*LSNP_FIX
436:GCGNPV = GCGNPV(-1)*PGCGNP/PGCGNP(-1)*GCGNPV_FIX
437:RGCSAS = QGAV/QGAV(-1)*RGCSAS(-1)+RGCSAS_FIX
438:RGCSANS = QGAV/QGAV(-1)*RGCSANS(-1)+RGCSANS_FIX
439:RGCSONA = GDPFCV/GDPFCV(-1)*RGCSONA(-1)+RGCSONA_FIX
440:GCSCO = CV/CV(-1)*GCSCO(-1)+GCSCO_FIX
441:GCTAO = GCTAO(-1)*GNPV/GNPV(-1)*GCTAO_FIX
442:RGCSCT = OSMTCV/OSMTCV(-1)*RGCSCT(-1)+RGCSCT_FIX
443:RGCTU = (A1_RGCTU*RGCTU(-1)*WNA_INS/WNA_INS(-1)+(1-A1_RGCTU)*RGCTU(-1)*PC/PC(-1))*RGCTU_FIX
444:ISNPV = ISNP(-1)*PISNP*ISNPV_FIX
445:ISNHEV = ISNHE(-1)*PISNHE*ISNHEV_FIX
446:ISMGV = ISMG(-1)*PISMG*ISMGV_FIX
447:IHGV = IHG(-1)*PIH+IHGV_FIX
448:GKO = GKO(-1)*PGDP/PGDP(-1)*GKO_FIX
449:REECBUD = REECBUD(-1)*PGNP*GDP_OECD_NIESR/(PGNP(-1)*GDP_OECD_NIESR(-1))+REECBUD_FIX
450:REECS = REECS(-1)*PGNP*GDP_OECD_NIESR/(PGNP(-1)*GDP_OECD_NIESR(-1))+REECS_FIX
451:REECTG = REECTG(-1)*PGNP*GDP_OECD_NIESR/(PGNP(-1)*GDP_OECD_NIESR(-1))+REECTG_FIX
452:REECTO = REECTO(-1)*(GTAGLEV+GTECUSO)/(GTAGLEV(-1)+GTECUSO(-1))+REECTO_FIX
453:RV8 = RV8(-1)*RV8_FIX
454:REX = REX(-1)*PC/PC(-1)*REX_FIX
455:RCARS = RCARS(-1)*PC/PC(-1)*RCARS_FIX
456:RTEO = RTEO(-1)*PC/PC(-1)*RTEO_FIX
457:GRO = GRO(-1)*PGDP/PGDP(-1)*GRO_FIX
458:GTAGLEV = GTAGLEV(-1)*PQGA/PQGA(-1)*GTAGLEV_FIX
459:RGTERATE = RGTERATE(-1)*GNPV/GNPV(-1)+RGTERATE_FIX
460:RGTTABR = RGTTABR(-1)*GNPV/GNPV(-1)+RGTTABR_FIX
461:RGTTI = RGTTI(-1)*GNPV/GNPV(-1)+RGTTI_FIX
462:GTW = GTW(-1)*GNPV/GNPV(-1)+GTW_FIX
463:RGTYA = RGTYA(-1)*YAG/YAG(-1)+RGTYA_FIX
464:RGTYDIRTP = RGTYDIRTP(-1)*RD*GNPV/(RD(-1)*GNPV(-1))+RGTYDIRTP_FIX
465:RCUS = RCUS(-1)*RCUS_FIX
466:RGTEE = RGTEE(-1)*RGTEE_FIX
467:RGTECANT = RGTECANT(-1)*RGTECANT_FIX
468:RGTECAT = RGTECAT(-1)*RGTECAT_FIX
469:RGTYSP = RGTYSP(-1)*RGTYSP_FIX
470:RGTYC_SMPF = (W_COT_IFSC*RCORP2+W_COT_SMPF*RCORP1)/(W_COT_IFSC+W_COT_SMPF)
471:RGTYC_IMT = RCORP4
472:RGTYC_OTH = RCORP1
473:RCORP1 = RCORP1(-1)+RCORP1_FIX
```

```
 474:RCORP2 = RCORP2(-1)+RCORP2_FIX
 475:RCORP4 = RCORP4(-1)+RCORP4_FIX
 476:RCORP5 = RCORP1
 477:RGKTI = RGKTI(-1)*RGKTI_FIX
 478:RGKTH = RGKTH(-1)*RGKTH_FIX
/***********************************************************************/
/* Equations 479-485, if not exogenised, force the borrowing requirement*/
/* to track a pre-specified target with a choice of instrument to implement it.*/
/***********************************************************************/
 479:RTYPER = IF (Z_SOLVENCY==ONE) THEN (RTYPER(-1)-Z1_RTYPER*(Z2_RTYPER*(GBRR-GBRR_BAR)+(1-
Z2_RTYPER)*(GBRR(-1)-GBRR_BAR(-1)))) ELSE (RTYPER(-1)+RTYPER_FIX)
 480:RVATR = IF (Z_SOLVENCY==TWO) THEN (RVATR(-1)-Z1_RTYPER*(Z2_RTYPER*(GBRR-GBRR_BAR)+(1-
Z2_RTYPER)*(GBRR(-1)-GBRR_BAR(-1)))) ELSE (RVATR(-1)+RVATR_FIX)
 481:RGTWL = IF (Z_SOLVENCY==THREE) THEN (RGTWL(-1)-Z1_RTYPER*(Z2_RTYPER*(GBRR-GBRR_BAR)+(1-
Z2_RTYPER)*(GBRR(-1)-GBRR_BAR(-1)))) ELSE (RGTWL(-1)+RGTWL_FIX)
 482:RGTYCL = IF (Z_SOLVENCY==FOUR) THEN (RGTYCL(-1)-Z1_RTYPER*(Z2_RTYPER*(GBRR-GBRR_BAR)+(1-
Z2_RTYPER)*(GBRR(-1)-GBRR_BAR(-1)))) ELSE (RGTYCL(-1)+RGTYCL_FIX)
 483:RGTYSE = IF (Z_SOLVENCY==FIVE) THEN (RGTYSE(-1)-Z1_RTYPER*(Z2_RTYPER*(GBRR-GBRR_BAR)+(1-
Z2_RTYPER)*(GBRR(-1)-GBRR_BAR(-1)))) ELSE (RGTYSE(-1)*RGTYSE_FIX)
 484:LSNHE = IF (Z_SOLVENCY==SIX) THEN (LSNHE(-1)+Z1_RTYPER*(Z2_RTYPER*(GBRR-GBRR_BAR)+(1-
Z2_RTYPER)*(GBRR(-1)-GBRR_BAR(-1)))) ELSE (LSNHE(-1)*LSNHE_FIX)
 485:GCTREST = IF (Z_SOLVENCY==SEVEN) THEN (GCTREST(-1)+Z1_RTYPER*(Z2_RTYPER*(GBRR-GBRR_BAR)+(1-
Z2_RTYPER)*(GBRR(-1)-GBRR_BAR(-1)))) ELSE ((NGE65+NLE14)/(NGE65(-1)+NLE14(-
1))*(A1_GCTREST*GCTREST(-1)*WNA_INS/WNA_INS(-1)+(1-A1_GCTREST)*GCTREST(-1)*PC/PC(-1))*GCTREST_FIX)
 486:EECBUD = REECBUD*PGNP*GDP_OECD_NIESR+EECBUD_FIX
 487:EECS = REECS*PGNP*GDP_OECD_NIESR+EECS_FIX
 488:EECTG = REECTG*PGNP*GDP_OECD_NIESR+EECTG_FIX
 489:EECTO = REECTO*(GTAGLEV+GTECUSO)+EECTO_FIX
 490:GTERATE = RGTERATE*GNPV+GTERATE_FIX
 491:GTTABR = RGTTABR*GNPV+GTTABR_FIX
 492:GTTI = RGTTI*GNPV+GTTI_FIX
 493:GTYA = RGTYA*YAG+GTYA_FIX
 494:GTYDIRTP = RGTYDIRTP*RD*GNPV+GTYDIRTP_FIX
 495:GTMVD = RCARS*SCARS
 496:GTECUSO = RCUS*MGSV+GTECUSO_FIX
 497:GTEMVDC = GTMVD-GTYMVDP
 498:GTEE = RGTEE*ENTD_T/1000
 499:GTECANT = (CO2-A46_CARB*EN46ST_T*(1-Z_PEN46C)-CO27)*RGTECANT/1000
 500:GTECAT = CO27*RGTECAT/1000
 501:GTECA = GTECAT+GTECANT
 502:GTE = GTEXT+GTECUSO+GTEVAT+GTERATE+GTAGLEV+GTEO+GTEE+GTECA+GTEMVDC-EECTG
 503:TE = GTE+EECTE
 504:GTYPER = RTYPER*YPERT+GTYPER_FIX
 505:RGTYSL = RGTYSE+RGTYSP
 506:GTYSL = RGTYSL*(YWSM+YWI)+GTYSL_FIX
 507:GTYSE = KGTYSL*GTYSL
 508:GTYSP = GTYSL-GTYSE
 509:RTYPTOT = RTYPER+RGTYSP
 510:GTYCL = RGTYCL*YCI
 511:GTYC_IMT = AGTYC_IMT+RGTYC_IMT*YCIMT(-1)+GTYC_IMT_FIX
 512:GTYC_SMPF = AGTYC_SMPF+RGTYC_SMPF*YCSMPF(-1)+GTYC_SMPF_FIX
 513:GTYC_OTH = AGTYC_OTH+RGTYC_OTH*(YCI(-1)-YCIMT(-1)+POSMDI(-1)*OSMDI(-1)-YWSMDI(-1)+YCSMTC(-
1))+GTYC_OTH_FIX
 514:GTYC = IF (Z1_GTYC==ONE) THEN (GTYC_IMT+GTYC_SMPF+GTYC_OTH+GTYCL) ELSE (RGTYC*YC(-
1)+GTYCL+GTYC_FIX)
 515:GTYCTOT = GTYC+GTYDIRTC
 516:GTYMVDP = (1-KGTMVD)*GTMVD
 517:GTYDIRT = GTYDIRTC+GTYDIRTP
 518:GTY = GTYPER+GTYSL+GTYC+GTYMVDP+GTYA+GTYDIRT
 519:GTWL = RGTWL*YPER
 520:GTTOT = GTE+GTY+GTTI+GTTABR+GTW+GTWL
 521:YWSNHE = LSNHE*WSNHE
 522:YWSNP = LSNP*WSNP
 523:GCSANS = RGCSANS*QGAV+GCSANS_FIX
 524:GCSAS = RGCSAS*QGAV+GCSAS_FIX
 525:GCSONA = RGCSONA*GDPFCV+GCSONA_FIX
 526:GCSCT = RGCSCT*OSMTCV+GCSCT_FIX
 527:GCSC = GCSCO+GCSCT+GCSC_FIX
 528:GCSA = GCSANS+GCSAS
 529:GCSO = GCSA+GCSONA
 530:GCS = GCSC+GCSO
 531:SUB = GCS+EECS
 532:GCTW = LTEACH*WSNHE
 533:GCTU = RGCTU*U+GCTU_FIX
 534:GCTPER = GCTU+GCTREST+GCTW
 535:EECTE = EECTO+EECTG
 536:GCTAEO = EECBUD-EECTG
 537:GCTABR = GCTAEO+GCTAO
 538:GC = GCGV+SUB-EECS+GCTPER+GCTNT+GCTABR
 539:GKTI = RGKTI*IIV
 540:GKTH = RGKTH*IHPV
 541:GK = IHGV+ISNPV+ISNHEV+ISMGV+GKTI+GKTH+GKO+GKBANK
 542:GR = GRO+GRBANK
 543:GBR = GTTOT-GC+GR-GK
 544:EBR = GBR+EBR_FIX
 545:EBRR = 100*EBR/GDPV
 546:GBGGD = -GBR+GBGGD_FIX
 547:GBRC = GTTOT-GC
```

```
 548:CURDEF = GBRC+CURDEF_FIX
 549:GBRR = 100*GBR/GDPV
 550:DEL(1:GCTNB) = RGL(-1)/100*(DEL(1:GNB(-1))+GNBREP(-1))-GCTNBRI+GCTNB_FIX
/*********** NATIONAL DEBT AND DEBT INTEREST EQUATIONS **************************/
 551:GCTNSS = RSS/100*GNSS+GCTNSS_FIX
 552:GCTNF = RFI*GNF(-1)/100+GCTNF_FIX
 553:GCTN_DOC = GNDOC*RGCTN_DOC/100
 554:RGL_IBRC = RGL+PREM_IBRC
 555:GCTN_TROIKA = RGCTN_TROIKA/100*(GN_IMF+GN_EFSF+GN_EFSM)
 556:GCTN_IBRC = GN_IBRC*RGL_IBRC/100
 557:GCTNFT = GCTNF+GCTNB*RGCTNFT+GCTN_TROIKA
 558:GCTNDT = GCTNT-GCTNFT
 559:GCTNT = GCTNF+GCTNSS+GCTNB+GCTN_TROIKA+GCTN_IBRC-GCTN_DOC
 560:GNF = GNF(-1)*REXFB(-1)/REXFB+GNF_FIX
 561:GNSS = KGNSS*NFW+GNSS_FIX
 562:GFBORF = -(GBR+DEL(1:GNSS+GNF+GN_IMF+GN_EFSF+GN_EFSM-GNDOC))+GFBORF_FIX
 563:GNB = GNB(-1)+GFBORF+GNB_FIX
 564:GNT = GNB+GNSS+GNF+GN_IMF+GN_EFSF+GN_EFSM-GNDOC
 565:GNGGD = GNT+GNDOC+GN_IBRC+GN_OTH+GNGGD_FIX
 566:GNGGDN = GNGGD-GNDOC-GA_NPRF
 567:RDEBT = 100*GNT/GDPV
 568:RDEBTG = 100*GNGGD/GDPV
 569:RDEBTN = 100*GNGGDN/GDPV
```

Miscellaneous Equations

```
 570:(YCU-GTYC)/YC = A1_YCU+A2_YCU*LOG(GNP/GNP(-1))+A3_YCU*ZT_YCU+YCU_FIX
 571:GDPFCV = OIV+OAGV+OSMV+OSNHEV+OSNPV+STATDISV
 572:GDPFC = OI+OAG+OSM+OSNHE+OSNP+STATDIS+GDPFC_FIX
 573:LOG(TRE) = A1_TRE*LOG(C+XTO)+(1-A1_TRE)*LOG(MGS)+LOG(TRE_FIX)
 574:LOG(SRUB) = A1_SRUB*LOG(QGA)+A2_SRUB*LOG(C)+(1-A1_SRUB-A2_SRUB)*LOG(OI)+LOG(SRUB_FIX)
 575:GDPV = GDPFCV+TE-SUB
 576:GDP = GDPFC+TRE-SRUB
 577:GDP_DOT = 100*(GDP/GDP(-1)-1)
 578:PGDP = GDPV/GDP
 579:GNPV = GDPV+YFN
 580:GNP = GDP+YRFN
 581:GNP_DOT = 100*(GNP/GNP(-1)-1)
 582:PGNP = GNPV/GNP
 583:DEP = DEPI+DEPAG+DEPS
 584:NDPFCV = GDPFCV-DEP
 585:NNPFCV = NDPFCV+YFN+YASA
 586:YASA = DEL(1:STNAV)-STNAVDL+YASAIV+YASA_FIX
 587:YP = NNPFCV-GTTI+GCTNT+GCTPER+BPTPRNE
 588:YPER = YP-YCU
 589:YPERD = YPER-(GTYPER+GTYSL+GTYA+GTW+GTWL+GTYMVDP+GTYDIRT)
 590:YRPERD = YPERD/PC
 591:YC = NDPFCV-YAG-YWNA+YASA
 592:YPERT = IF (ZT_YPERT<1961) THEN (YWNA(-1)+YPO(-1)-GTYSE(-1)) ELSE (IF (ZT_YPERT<1975) THEN
(YWNA-YWSNP+YWSNP(-1)+YPO(-1)-GTYSE) ELSE (YWNA+YPO(-1)-GTYSE))
 593:YPO = YC-YCU-GTTI+GCTNT+YFN
 594:YWNA = YWI+YWSM+YWSNHE+YWSNP
 595:FFSC = SAVC-YASA+0.9*(DEP-DEPAG)+GKTI+GKO+GKBANK
 596:FFUC = IIV+ISMV-ISMGV+STNAVDL+STIVVDL
 597:FFAQC = FFSC-FFUC
 598:FFSH = SAV+DEPAG+0.1*(DEP-DEPAG)+GKTH
 599:FFUH = IHPV+IAGV+STAVDL
 600:FFAQH = FFSH-FFUH
 601:FFAQT = FFAQC+FFAQH
 602:RFFAQC = 100*FFAQC/FFSC
 603:RFFAQH = 100*FFAQH/FFSH
 604:RFFAQT = 100*FFAQT/(FFSH+FFSC)
 605:RFFGAQT = 100*DEL(1:GNBB+GNBP+GNSS)/(FFSH+FFSC)
 606:WREXEFF_USA = 1-WREXEFF_UK-WREXEFF_GER
 607:REXEFF =
1/EXP(LOG(REX_UK/A_REXUK)*WREXEFF_UK+LOG(REX_GER/A_REXGER)*WREXEFF_GER+LOG(REX_USA/A_REXUSA)*WREXE
FF_USA)
 608:WREXFB_UK = 1-WREXFB_USA-WREXFB_GER-WREXFB_JAP
 609:REXFB =
1/EXP(LOG(REX_UK/A_REXUK)*WREXFB_UK+LOG(REX_GER/A_REXGER)*WREXFB_GER+LOG(REX_USA/A_REXUSA)*WREXFB_
USA+LOG(REX_JAP/A_REXJAP)*WREXFB_JAP)
 610:RFI = IF (Z_RFI==ONE) THEN (RS_GER+RMFI) ELSE
(WREXFB_UK*RS_UK+WREXFB_USA*RS_USA+WREXFB_GER*RS_GER+WREXFB_JAP*RS_JAP+RMFI)
 611:RGL = RL_GER+RMGL_FIX+(IF (TYEAR<1999) THEN (A1_RISK+A2_RISK*RDEBT) ELSE (A3_RISK+A4_RISK*(-
GBGGD)(-1)/GDPV(-1)*100+A5_RISK*GNGGD/GDPV*100))
 612:RS = RMS+RGL
 613:RPL = RMPL+RGL
 614:RD = RMD+RGL
 615:RMRL = RMMRL+RGL
 616:RLAA1T3 = RMLAA1T3+RGL
 617:RLAA5T7 = RMLAA5T7+RGL
 618:REX_USA = REX_GER*REX_GERUSA
 619:REX_UK = REX_GER*REX_GERUK
 620:REX_JAP = REX_GER*REX_GERJAP
 621:REX_UK_E = (REX_UK(-3)+REX_UK(-2)+REX_UK(-1)+REX_UK)/4
 622:BPTCK = PGNP*GDP_OECD_NIESR/(PGNP(-1)*GDP_OECD_NIESR(-1))*BPTCK(-1)+BPTCK_FIX
```

```
 623:RBPTKNG = PGNP*GDP_OECD_NIESR/(PGNP(-1)*GDP_OECD_NIESR(-1))*RBPTKNG(-1)+RBPTKNG_FIX
 624:RBPTPRNE = PGNP*GDP_OECD_NIESR/(PGNP(-1)*GDP_OECD_NIESR(-1))*RBPTPRNE(-1)+RBPTPRNE_FIX
 625:BPTKNG = RBPTKNG*PGNP*GDP_OECD_NIESR+BPTKNG_FIX
 626:BPTPRNE = RBPTPRNE*PGNP*GDP_OECD_NIESR+BPTPRNE_FIX
 627:BP = BPT+YFN+BPTPRNE+GTTABR-GCTABR+EECS-EECTE
 628:BPR = 100*BP/GDPV
 629:DC = RDC*GDPV+DC_FIX
 630:BA_SEC = RBA_SEC*GNPV+BA_SEC_FIX
 631:BA_CB = RBA_CB*GNPV+BA_CB_FIX
 632:BA_OTH = RBA_OTH*GNPV+BA_OTH_FIX
 633:BA_TOT = GNBB+GNDOB+DC+BA_SEC+BA_FA+BA_CB+BA_OTH
 634:BL_CB = RBL_CB*GNPV+BL_CB_FIX
 635:BL_DEP = RBL_DEP*GNPV+BL_DEP_FIX
 636:BL_FL = RBL_FL*GDPV+BL_FL_FIX
 637:BL_OTH = BA_TOT-BL_CB-BL_DEP-BL_FL
 638:NFLB = BL_FL-BA_FA
 639:R = CBL_TOT-BL_CB-GNBC-CBA_OTH
 640:CBA_OTH = RCBA_OTH*GNPV+CBA_OTH_FIX
 641:CBL_CUR = RCBL_CUR*CV+CBL_CUR_FIX
 642:GNDOC = RGNDOC*GNPV+GNDOC_FIX
 643:CBL_GOV = GNDOC+CBL_GOV_FIX
 644:CBL_OTH = RCBL_OTH*GNPV+CBL_OTH_FIX
 645:CBL_TOT = CBL_OTH+BA_CB+CBL_GOV+CBL_ECB+CBL_CUR
 646:BMRES = R+BMSDR+BMRESDVC
```

The Energy Sub-model

```
/* Energy demand in the residential sector                          */
 647:LOG(ENCW_T_STAR) = ENCW_C1+ENCW_C2*LOG(YRPERD)+ENCW_C3*LOG(PENC(-1)/PC(-1))+ENCW_STAR_FIX
 648:DEL(1:LOG(ENCW_T)) = ENCW_A00*(LOG(ENCW_T(-1))-LOG(ENCW_T_STAR(-1)))+ENCW_FIX
 649:LOG(EN7C_T_STAR) =
EN7C_C1+EN7C_C2/HSTOCK+EN7C_C3*LOG(PEN7C_T/PC)+EN7C_C4*ZT_EN7C+EN7C_STAR_FIX
 650:DEL(1:LOG(EN7C_T)) = EN7C_C11*DEL(1:LOG(PEN7C_T/PC))+EN7C_A00*(LOG(EN7C_T(-1))-
LOG(EN7C_T_STAR(-1)))+EN7C_FIX
 651:EN6C_T/(ENC_T-EN7C_T) = 0.3/(1+EXP(EN6C_C1+EN6C_C2*(ZT_EN6C-1970)))+EN6C_FIX
 652:LOG(EN8C_T/(ENC_T-EN7C_T)) = EN8C_C1+EN8C_C2*ZT_EN8C+EN8C_FIX
 653:LOG(EN1C_T/(ENC_T-EN7C_T)) = EN1C_C1+EN1C_C2*ZT_EN1C+EN1C_FIX
 654:LOG(EN45C_T/EN4C_T) = EN45C_C1+EN45C_C2*ZT_EN45C+EN45C_FIX
 655:EN4C_T = (ENCW_T-(EN1C_T*A1_ENCW_T+EN6C_T*A6_ENCW_T+EN8C_T*A8_ENCW_T))/A4_ENCW_T
 656:ENC_T = EN1C_T+EN4C_T+EN6C_T+EN7C_T+EN8C_T+EN9C_T
 657:EN48C_T = EN4C_T-EN45C_T
/* Energy demand in the commercial and public sectors                        */
 658:LOG(ENSR_T_STAR) = ENS_C1+ENS_C2/(OSM+OSNHE+OSNP)+ENSR_STAR_FIX
 659:DEL(1:LOG(ENSR_T)) = ENS_C5*DEL(1:LOG(PENS_MOD/PC))+ENS_A00*(LOG(ENSR_T(-1))-
LOG(ENSR_T_STAR(-1)))+ENSR_FIX
 660:LOG(EN7S_T_STAR) = EN7S_C1+EN7S_C2/(OSM+OSNHE+OSNP)+EN7S_C3*LOG(PEN71_T/PC)+EN7S_STAR_FIX
 661:DEL(1:LOG(EN7S_T)) = EN7S_A00*(LOG(EN7S_T(-1))-LOG(EN7S_T_STAR(-1)))+EN7S_FIX
 662:LOG(EN6S_T/ENSR_T) = EN6S_C1+EN6S_C2*LOG(PEN6C_T/PEN422C_T)+EN6S_C3/ZT_EN6S+EN6S_FIX
 663:ENS_T = ENSR_T+EN7S_T
 664:EN6SCH_T = EN6CH_T*ENCHS*EN6SCH_T_FIX
 665:EN6SNH_T = EN6S_T-EN6SCH_T
 666:EN4S_T = ENS_T-EN7S_T-EN6S_T-EN1S_T-EN8S_T-EN9S_T
 667:EN48S_T = EN4S_T-EN45S_T
 668:LOG(ENIR_T_STAR) =
ENI_C1+ENI_C2/OI++ENI_C3*LOG(QNIMT/QGIMT)+ENI_C4*LOG(PENI/PQGIMT)+ENIR_STAR_FIX
/* Energy demand in the industrial sector                           */
 669:DEL(1:LOG(ENIR_T)) = ENI_A00*(LOG(ENIR_T(-1))-LOG(ENIR_T_STAR(-1)))+ENIR_FIX
 670:LOG(EN7I_T_STAR) = EN7I_C5+EN7I_C6*LOG(OI)+EN7I_C8*ZT_EN7I+EN7I_STAR_FIX
 671:DEL(1:LOG(EN7I_T)) = EN7I_C13*DEL(1:LOG(OI))+EN7I_A01*(LOG(EN7I_T(-1))-LOG(EN7I_T_STAR(-
1)))+EN7I_FIX
 672:LOG(EN1I_T/ENI_T) = EN1I_C4+EN1I_C5*LOG(PEN1I_T/PEN43I_T)+EN1I_C6*ZT_EN1I+EN1I_FIX
 673:LOG(EN45I_T/EN4I_T) = EN45I_C1+EN45I_C2*ZT_EN45I+EN45I_FIX
 674:ENI_T = ENIR_T+EN7I_T
 675:EN6ICH_T = EN6CH_T*ENCHI*EN6ICH_T_FIX
 676:EN6INH_T = (ENI_T-EN7I_T)*EN6ISH-EN6ICH_T+EN6INH_T_FIX
 677:EN6I_T = EN6ICH_T+EN6INH_T
 678:EN48I_T = ENI_T-EN1I_T-EN6I_T-EN7I_T-EN8I_T-EN9I_T-EN45I_T
 679:EN4I_T = EN45I_T+EN48I_T
/* Energy demand in the transport sector                            */
 680:EN49ST_T = EN41ST_T+EN42ST_T+EN43ST_T
 681:LOG(TRANS_TK) = A1_TRANS+A2_TRANS*LOG(GNP)+A3_TRANS*LOG(PEN41U_T/PC)+TRANS_FIX
 682:LOG(EN42ST_T+EN43ST_T) =
A1_EN42ST+A2_EN42ST*LOG(TRANS_TK)+A3_EN42ST*LOG(PEN41U_T/(PEN41U_T_UK*REX_UK))+EN42ST_FIX
 683:LOG(EN41ST_T) =
A1_EN41ST+A2_EN41ST*LOG(SCARS)+A3_EN41ST*LOG(PEN41U_T/(PEN41U_T_UK*REX_UK))+A4_EN41ST*ZT_EN41ST+EN
41ST_FIX
 684:LOG(EN46ST_T) = EN46ST_FIX+(IF (TYEAR>1993) THEN
(EN46ST_C4+EN46ST_C5*LOG(PEN46C_T/PC)+EN46ST_C6*LOG(XTO)) ELSE
(EN46ST_C1+EN46ST_C2*LOG(PEN46C_T/PC)+EN46ST_C3*LOG(XTO)))
 685:DEL(1:LOG(0.8/(SCARS/N1564)-1)) = A1_SCARS+A2_SCARS*DEL(1:YRPERD/N1564)+SCARS_FIX
 686:EN4ST_T = EN49ST_T+EN45ST_T+EN46ST_T
 687:ENST_T = EN4ST_T+EN7ST_T
/* Energy demand in the agricultural sector                                  */
 688:LOG(ENA_T) = ENA_C1+ENA_C2*LOG(QMA)+ENA_C3*ZT_ENA+ENA_FIX
 689:LOG(EN7A_T) = EN7A_C1+EN7A_C2*ZT_EN7A+EN7A_C3*LOG(QMA)+EN7A_FIX
 690:EN4A_T = ENA_T-EN7A_T-EN9A_T
```

```
/* Final Consumption of energy by fuel type                                 */
 691:EN1FC_T = EN1C_T+EN1S_T+EN1I_T
 692:EN4FC_T = EN4C_T+EN4S_T+EN4I_T+EN4ST_T+EN4A_T
 693:EN6FC_T = EN6C_T+EN6S_T+EN6I_T
 694:EN7FC_T = EN7C_T+EN7S_T+EN7I_T+EN7ST_T+EN7A_T
 695:EN8FC_T = EN8C_T+EN8S_T+EN8I_T
 696:EN9FC_T = EN9C_T+EN9S_T+EN9I_T+EN9A_T
 697:ENFC_T = EN1FC_T+EN4FC_T+EN6FC_T+EN7FC_T+EN8FC_T+EN9FC_T
/* Total primary energy requirement by fuel type by sector          */
 698:EN1CTD_T = EN1C_T
 699:EN4CTD_T = EN4C_T*(1+EN4TRLOS_T/EN4FC_T)
 700:EN6CTD_T = EN6C_T*(1+EN6TRLOS_T/EN6FC_T)
 701:EN7CTD_T = EN7C_T*(1+EN7TRLOS_T/EN7FC_T)
 702:EN8CTD_T = EN8C_T*(1+EN8TRLOS_T/EN8FC_T)
 703:EN9CTD_T = EN9C_T
 704:ENCTD_T = EN1CTD_T+EN4CTD_T+EN6CTD_T+EN7CTD_T+EN8CTD_T+EN9CTD_T
 705:EN1STD_T = EN1S_T
 706:EN4STD_T = EN4S_T*(1+EN4TRLOS_T/EN4FC_T)
 707:EN6STD_T = EN6S_T*(1+EN6TRLOS_T/EN6FC_T)
 708:EN8STD_T = EN8S_T*(1+EN8TRLOS_T/EN8FC_T)
 709:EN7STD_T = EN7S_T*(1+EN7TRLOS_T/EN7FC_T)
 710:EN9STD_T = EN9S_T
 711:ENSTD_T = EN1STD_T+EN4STD_T+EN6STD_T+EN7STD_T+EN8STD_T+EN9STD_T
 712:EN1ITD_T = EN1I_T
 713:EN4ITD_T = EN4I_T*(1+EN4TRLOS_T/EN4FC_T)
 714:EN6ITD_T = EN6I_T*(1+EN6TRLOS_T/EN6FC_T)
 715:EN8ITD_T = EN8I_T*(1+EN8TRLOS_T/EN8FC_T)
 716:EN7ITD_T = EN7I_T*(1+EN7TRLOS_T/EN7FC_T)
 717:EN9ITD_T = EN9I_T
 718:ENITD_T = EN1ITD_T+EN4ITD_T+EN6ITD_T+EN7ITD_T+EN8ITD_T+EN9ITD_T
 719:EN4STTD_T = EN4ST_T*(1+EN4TRLOS_T/EN4FC_T)
 720:EN7STTD_T = EN7ST_T*(1+EN7TRLOS_T/EN7FC_T)
 721:ENSTTD_T = EN4STTD_T+EN7STTD_T
 722:EN4ATD_T = EN4A_T*(1+EN4TRLOS_T/EN4FC_T)
 723:EN7ATD_T = EN7A_T*(1+EN7TRLOS_T/EN7FC_T)
 724:EN9ATD_T = EN9A_T
 725:ENATD_T = EN4ATD_T+EN7ATD_T+EN9ATD_T
 726:EN1TD_T = EN1CTD_T+EN1STD_T+EN1ITD_T+EN1E_T+EN1G_T+EN1TD_T_FIX
 727:EN4TD_T = EN4CTD_T+EN4STD_T+EN4ITD_T+EN4STTD_T+EN4ATD_T+EN4E_T+EN4G_T+EN4TD_T_FIX
 728:EN6TD_T = EN6CTD_T+EN6STD_T+EN6ITD_T+EN6E_T+EN6G_T
 729:EN8TD_T = EN8CTD_T+EN8STD_T+EN8ITD_T+EN8E_T
 730:EN9TD_T = EN9CTD_T+EN9STD_T+EN9ITD_T+EN9ATD_T+EN9E_T+EN9G_T+EN9TD_T_FIX
 731:ENTD_T = EN1TD_T+EN4TD_T+EN6TD_T+EN8TD_T+EN9TD_T+EN6IMCHF_T
 732:EN9QD_T = EN9TD_T
 733:ENQD_T = EN1QD_T+EN6QD_T+EN8QD_T+EN9QD_T+ENQD_T_FIX
 734:ENM_T = ENX_T+ENTD_T-ENQD_T-ENBA_T+ENM_T_FIX
 735:M3 = ENM_T*M3_DIS*M3_FIX
/* Electricity production by fuel type: driven by demand EN7FC_T     */
 736:EN9E_T = EN91E_T+EN92E_T+EN93E_T
 737:EN7G1_T = EN1E_T*ENGEFF1*EN7G1_T_FIX
 738:EN7G42_T = EN42E_T*ENGEFF42*EN7G42_T_FIX
 739:EN7G43_T = EN43E_T*ENGEFF43*EN7G43_T_FIX
 740:EN7G4_T = EN7G42_T+EN7G43_T
 741:EN7GCH6_T = EN6CH_T*(1-ENCHS-ENCHI)*ENGEFF6C*EN7GCH6_T_FIX
 742:EN7G8_T = EN8E_T*ENGEFF8*EN7G8_T_FIX
 743:EN7G91_T = EN91E_T*ENGEFF91*EN7G91_T_FIX
 744:EN7G92_T = EN92E_T*ENGEFF92*EN7G92_T_FIX
 745:EN7G93_T = EN93E_T*ENGEFF93*EN7G93_T_FIX
 746:EN7G9_T = EN7G91_T+EN7G92_T+EN7G93_T
 747:EN7GNH6_T = EN7GENES_T-(EN7G1_T+EN7G8_T+EN7G4_T+EN7GCH6_T+EN7G9_T)
 748:EN7G6_T = EN7GCH6_T+EN7GNH6_T
 749:EN6E_T = EN6CH_T*(1-ENCHS-ENCHI)+EN7GNH6_T/ENGEFF6N+EN6E_T_FIX
 750:EN4E_T = EN42E_T+EN43E_T
 751:ENE_T = EN1E_T+EN4E_T+EN6E_T+EN8E_T+EN9E_T
 752:EN7CONL_T = ENE_T-EN7GEN_T
 753:EN7GENAD_T = EN7GENES_T-EN7GEN_T
 754:EN7GENES_T = EN7GEN_T/EN7GENAD_FIX
 755:EN7GEN_T = EN7AVAIL_T-EN7M_T+EN7X_T
 756:EN7AVAIL_T = EN7GSO_T+EN7OUSE_T
 757:EN7OUSE_T = EN7GSO_T*EN7OUSE_FIX
 758:EN7GSO_T = EN7FC_T/(1-EN7TRL_FIX)
 759:EN7TRL_T = EN7GSO_T-EN7FC_T
 760:EN9TRLOS_T = EN9TD_T-EN9E_T-EN9FC_T
 761:EN7TRLOS_T = EN1E_T+EN4E_T+EN6E_T+EN8E_T+EN9E_T+EN7M_T-EN7X_T-EN7FC_T
 762:A7_CARB = (EN1E_T*A1_CARB+EN4E_T*A4E_CARB+EN6E_T*A6_CARB+EN8E_T*A8E_CARB)/EN7FC_T
 763:CO2LOS = EN4TRLOS_T*A4E_CARB+EN6TRLOS_T*A6_CARB+EN8TRLOS_T*A8E_CARB
 764:CO2C =
EN1C_T*A1_CARB+EN48C_T*A49_CARB+EN45C_T*A45_CARB+EN6C_T*A6_CARB+EN7C_T*A7_CARB+EN8C_T*A8_CARB
 765:CO2S =
EN1S_T*A1_CARB+EN48S_T*A49_CARB+EN45S_T*A45_CARB+EN6S_T*A6_CARB+EN7S_T*A7_CARB+EN8S_T*A8_CARB
 766:CO2I =
EN1I_T*A1_CARB+EN48I_T*A49_CARB+EN45I_T*A45_CARB+EN6I_T*A6_CARB+EN7I_T*A7_CARB+EN8I_T*A8_CARB
 767:CO2ST = EN49ST_T*A49_CARB+EN45ST_T*A45_CARB+EN46ST_T*A46_CARB+EN7ST_T*A7_CARB
 768:CO2A = EN4A_T*A49_CARB+EN7A_T*A7_CARB
 769:CO2IMCHF = ENIMCHF_T*A6IMCHF_CARB
 770:CO21 = EN1E_T*A1_CARB+EN1C_T*A1_CARB+EN1S_T*A1_CARB+EN1I_T*A1_CARB
 771:CO245 = EN45C_T*A45_CARB+EN45S_T*A45_CARB+EN45I_T*A45_CARB+EN45ST_T*A45_CARB
 772:CO246 = EN46ST_T*A46_CARB
```

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 773:CO24 =
EN4E_T*A4E_CARB+EN4TRLOS_T*A4E_CARB+EN48C_T*A49_CARB+EN45C_T*A45_CARB+EN48S_T*A49_CARB+EN45S_T*A45
_CARB++EN48I_T*A49_CARB+EN45I_T*A45_CARB+EN49ST_T*A49_CARB+EN45ST_T*A45_CARB+EN46ST_T*A46_CARB+EN4
A_T*A49_CARB
 774:CO249 = CO24-CO245-CO246
 775:CO26 = EN6E_T*A6_CARB+EN6TRLOS_T*A6_CARB+EN6C_T*A6_CARB+EN6S_T*A6_CARB+EN6I_T*A6_CARB
 776:CO27 = EN7C_T*A7_CARB+EN7S_T*A7_CARB+EN7I_T*A7_CARB+EN7ST_T*A7_CARB+EN7A_T*A7_CARB
 777:CO28 = EN8E_T*A8E_CARB+EN8TRLOS_T*A8E_CARB+EN8C_T*A8_CARB+EN8S_T*A8_CARB+EN8I_T*A8_CARB
 778:CO2 = CO2LOS+CO2C+CO2S+CO2I+CO2A+CO2ST+CO2IMCHF
 779:CO2ADJ = CO2-A46_CARB*EN46ST_T
/**********Energy Prices ******************************/
 780:PEN7I_T = EXP(A1_PEN7I+A2_PEN7I*LOG(PEN71_T)+PEN7I_FIX)
 781:PEN7C_T = EXP(A1_PEN7C+A2_PEN7C*LOG(PEN71_T)+PEN7C_FIX)
 782:PEN71_T =
EXP(A1_PEN71+A2_PEN71*LOG(PEN43E_T)+A3_PEN71*LOG(PEN1E_T)+A4_PEN71*LOG(PEN8E_T)+A5_PEN71*LOG(PEN6E
_T)+PEN71_FIX)
 783:LOG(PQEIMT) = A1_PQEIMT+A2_PQEIMT*LOG(PENI)+(1-A2_PQEIMT)*LOG(PQEIMT(-1))+PQEIMT_FIX
 784:PEN1C_T =
EXP(A1_PEN1C+A2_PEN1C*LOG(PEN1_T)+A3_PEN1C*LOG(WNA)+PEN1C_FIX)+RGTECANT*A1_CARB+RGTEE
 785:PEN1I_T = EXP(A1_PEN1I+A2_PEN1I*LOG(PEN1_T)+PEN1I_FIX)+RGTECANT*A1_CARB+RGTEE
 786:PEN41U_T =
EXP(A1_PEN41U+A2_PEN41U*LOG(PM3)+A3_PEN41U*LOG(REXPET)+PEN41U_FIX)+RGTECANT*A49_CARB+RGTEE
 787:PEN422I_T = EXP(A1_PEN422I+A2_PEN422I*LOG(PM3)+PEN422I_FIX)+RGTECANT*A49_CARB+RGTEE
 788:PEN422C_T = EXP(A1_PEN422C+A2_PEN422C*LOG(PM3)+PEN422C_FIX)+RGTECANT*A49_CARB+RGTEE
 789:PEN43I_T = EXP(A1_PEN43I+A2_PEN43I*LOG(PM3)+PEN43I_FIX)+RGTECANT*A49_CARB+RGTEE
 790:PEN81C_T =
EXP(A1_PEN81C+A2_PEN81C*LOG(PEN8_T)+A3_PEN81C*LOG(WNA)+PEN81C_FIX)+RGTECANT*A8_CARB+RGTEE
 791:PEN6C_T = EXP(A1_PEN6C+A2_PEN6C*LOG(PEN6_T)+PEN6C_FIX)+RGTECANT*A6_CARB+RGTEE
 792:PEN6I_T = EXP(A1_PEN6I+A2_PEN6I*LOG(PEN6_T)+PEN6I_FIX)+RGTECANT*A6_CARB+RGTEE
 793:PEN45C_T = EXP(A1_PEN45C+A2_PEN45C*LOG(PEN6C_T)+PEN45C_FIX)+RGTECANT*A45_CARB+RGTEE
 794:PEN46C_T = EXP(A1_PEN46C+A2_PEN46C*LOG(PM3)+PEN46C_FIX)+RGTEE+RGTECANT*A46_CARB*Z_PEN46C
 795:PEN43E_T = EXP(A1_PEN43E+A2_PEN43E*LOG(PM3)+PEN43E_FIX)+RGTECAT*A4E_CARB+RGTEE
 796:PENS_MOD = EXP((EN4S_T(-1)*LOG(PEN422C_T)+EN6S_T(-1)*LOG(PEN6C_T))/(EN4S_T(-1)+EN6S_T(-
1)))/A1_PENS_MOD*PENS_FIX
 797:PENI = EXP((EN1I_T(-1)*LOG(PEN1I_T)+EN42I_T(-1)*LOG(PEN422I_T)+EN43I_T(-
1)*LOG(PEN43I_T)+EN6I_T(-1)*LOG(PEN6I_T)+EN7I_T(-1)*LOG(PEN7I_T))/(EN1I_T(-1)+EN42I_T(-
1)+EN43I_T(-1)+EN6I_T(-1)+EN7I_T(-1)))/A1_PENI*PENI_FIX
 798:PEN1E_T = PEN1_T+RGTECAT*A1_CARB+RGTEE+PEN1E_FIX
 799:PEN6E_T = PEN6_T+RGTECAT*A6_CARB+RGTEE+PEN6E_FIX
 800:PEN8E_T = PEN8_T+RGTECAT*A8E_CARB+RGTEE+PEN8E_FIX
 801:PEN6IMCHF_T = PEN6I_T+PEN6IMCHF_FIX
 802:PQEIMTR = PQEIMT/PQGIMT
 803:PEN41UR = PEN41U_T/PC
/**********ILO Employment Link ******************************/
 804:LAG_ILO = LAG+LAG_ILO_FIX
 805:LIMD_ILO = LIMD_PES+LIMD_ILO_FIX
 806:LIMF_ILO = LIMF_PES+LIMF_ILO_FIX
 807:LIMH_ILO = LIMH_PES+LIMH_ILO_FIX
 808:LIMT_ILO = LIMT+LIMT_ILO_FIX
 809:LIB_ILO = LIB+LIB_ILO_FIX
 810:LIU_ILO = LIU+LIU_ILO_FIX
 811:LI_ILO = LIMT_ILO+LIB_ILO+LIU_ILO
 812:LSMDI_ILO = LSMDI+LSMDI_ILO_FIX
 813:LSMPF_ILO = LSMPF+LSMPF_ILO_FIX
 814:LSMTC_ILO = LSMTC+LSMTC_ILO_FIX
 815:LSM_ILO = LSMDI_ILO+LSMPF_ILO+LSMTC_ILO
 816:LSNP_ILO = LSNP+LSNP_ILO_FIX
 817:LSNHE_ILO = LSNHE+LSNHE_ILO_FIX
 818:LSN_ILO = LSNP_ILO+LSNHE_ILO
 819:LTOT_ILO = LAG_ILO+LI_ILO+LSM_ILO+LSN_ILO
 820:LF_ILO = LF+LF_ILO_FIX
 821:U_ILO = LF_ILO-LTOT_ILO
 822:UR_ILO = U_ILO/LF_ILO*100
 823:NT2534 = Z1_NT2534*(N2564_FEM+N2564_MALE)
 824:WNA_INS = YWNA/LNA
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Description of Equations in HERMES-13	
Eq	**Description**
	Manufacturing: High-Tech
1	Output in high-tech manufacturing - long run. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
2	Output in high-tech manufacturing, short run.
3	Capital stock in high-tech manufacturing, short run.
4	Investment in high-tech manufacturing, volume.
5	Price of material inputs in high-tech manufacturing.
6	Price of output in high-tech manufacturing.
7	Wage rate in high-tech manufacturing.
8	Labour share of output in high-tech manufacturing. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
9	Materials share of output in high-tech manufacturing. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
10	Optimal capital/output ratio in high tech manufacturing. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993).
11	Long run unit cost of production in high-tech manufacturing. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993)
12	Optimal capital stock in high-tech manufacturing. Derived from optimal capital/output ratio based on the factor demand system (Bradley, FitzGerald, Kearney; 1991)
13	Price of raw material inputs (incl. services) into high-tech manufacturing.
14	Material inputs into high-tech manufacturing, value.
15	Wage bill in high-tech manufacturing.
16	Gross output in high-tech manufacturing, value.
17	Net output in high-tech manufacturing, value.
18	Net output in high-tech manufacturing, volume.
19	Profits in high-tech manufacturing.
20	Investment in high-tech manufacturing, value.
21	Cost of capital in high-tech manufacturing. Derived in Žnuderl & Kearney, 2013.
22	Employment in high-tech manufacturing.
	Manufacturing: Traditional
23	Output in traditional manufacturing - long run. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
24	Output in traditional manufacturing, short run.
25	Capital stock in traditional manufacturing, short run.
26	Investment in traditional manufacturing, volume.
27	Price of material inputs in traditional manufacturing.
28	Price of output in traditional manufacturing, long run.
29	Price of output in traditional manufacturing, short run.
30	Wage rate in traditional manufacturing.
31	Labour share of output in traditional manufacturing. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
32	Materials share of output in traditional manufacturing. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
33	Optimal capital/output ratio in high tech manufacturing. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993).
34	Long run unit cost of production in traditional manufacturing. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993)
35	Optimal capital stock in traditional manufacturing. Derived from optimal capital/output ratio based on

	the factor demand system (Bradley, FitzGerald, Kearney; 1991)
36	Material inputs into traditional manufacturing, value.
37	Gross output in traditional manufacturing, value.
38	Wage bill in traditional manufacturing.
39	Net output in traditional manufacturing, value.
40	Net output in traditional manufacturing, volume.
41	Price of raw material inputs (incl. services) into traditional manufacturing.
42	Cost of capital in traditional manufacturing. Derived in Žnuderl & Kearney, 2013.
43	Employment in traditional manufacturing.
	Manufacturing: Food Processing
44	Output in food processing - long run. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
45	Output in food processing, short run.
46	Capital stock in food processing, short run.
47	Investment in food processing, volume.
48	Price of output in food processing.
49	Price of material inputs in food processing.
50	Wage rate in food processing.
51	Labour share of output in food processing. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
52	Materials share of output in food processing. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993)
53	Optimal capital/output ratio in high tech manufacturing. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993).
54	Long run unit cost of production in food processing. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993)
55	Optimal capital stock in food processing. Derived from optimal capital/output ratio based on the factor demand system (Bradley, FitzGerald, Kearney; 1991)
56	Gross output in food processing, value.
57	Wage bill in food processing.
58	Material inputs into food processing, value.
59	Net output in food processing, value.
60	Net output in food processing, volume.
61	Profits in food processing.
62	Investment in food processing, value.
63	Price of raw material inputs (incl. services) into food processing.
64	Cost of capital in food processing. Derived in Žnuderl & Kearney, 2013.
65	Employment in food processing.
	Industry: Building & Construction
66	Output in building and construction, short run. Long-run output in building and construction is based on the factor demand system (Bradley, FitzGerald, Kearney; 1993).
67	Wage rate in building and construction.
68	Investment in housing, volume.
69	Investment deflator for housing.
70	Labour share of output in building and construction. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993).
71	Materials share of output in building and construction. Estimated as part of a factor demand system (Bradley, FitzGerald, Kearney; 1993).
72	Optimal capital/output ratio in building and construction. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993).

73	Optimal capital stock in building and construction. Derived from optimal capital/output ratio based on the factor demand system (Bradley, FitzGerald, Kearney; 1991)
74	Short run unit cost of production in building and construction. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993)
75	Long run unit cost of production in building and construction. Derived from the factor demand system (Bradley, FitzGerald, Kearney; 1993)
76	Investment in building and construction, volume. A 15% rate of geometric depreciation is assumed.
77	Gross Output, volume, in the building and construction sector is identical to the volume of investment in building and construction.
78	Gross Output, value, in the building and construction sector is identical to the value of investment in building and construction.
79	Deflator for gross output in building and construction.
80	Material inputs into building and construction, value.
81	Wage bill in building and construction.
82	Net output in building and construction, value.
83	Profits in building and construction, volume.
84	Investment by the building sector, current prices
85	Cost of capital in building and construction.
86	Cost of capital in building and construction, 5-year moving average.
87	Price deflator for material inputs into building and construction.
88	Value added in building and construction, volume.
89	Value added in building and construction, value.
90	Price deflator for value added in building and construction.
	Industry: Utilities
91	Gross output in utilities.
92	Price deflator for gross output in utilities.
93	Energy input into utilities.
94	Labour share of gross output in utilities.
95	Materials share of gross output in utilities.
96	Average earnings in utilities relative to non-agricultural wages.
97	Weighted final demand in utilities.
98	Grpss output in utilities, value.
99	Price deflator for energy input into utilities.
100	Price deflator for raw materials (excl. energy) in utilities.
101	Wage bill in utilities.
102	Energy input in utilities, value.
103	Raw materials (excl. energy) input into utilities.
104	Material inputs into utilities, value.
105	Material inputs into utilities, volume.
106	Price deflator for material inputs into utilities.
107	Net output in utilities, value.
108	Net output in utilities, volume.
109	Price deflator for net output in utilities.
110	Value added in utilities, value.
111	Value added in utilities, volume.
112	Price deflator for value added in utilities.
113	Investment in utilities, value.
114	Capital stock in utilities.

	Total Manufacturing & Total Industry
115	Depreciation in industry.
116	Gross output in total manufacturing, volume.
117	Gross output in total manufacturing, value.
118	Price deflator for gross output in total manufacturing.
119	Material inputs into total manufacturing, value.
120	Material inputs into total manufacturing, volume.
121	Price deflator for material inputs into total manufacturing.
122	Net output in total manufacturing, volume.
123	Net output in total manufacturing, value.
124	Wage bill in total manufacturing.
125	Value added in total manufacturing, value.
126	Value added in total manufacturing, volume.
127	Price deflator for value added in total manufacturing.
128	Investment in total manufacturing, value.
129	Investment in total manufacturing, volume.
130	Capital stock in total manufacturing.
131	Employment in total manufacturing.
132	Average earnings in total manufacturing.
133	Profits in total manufacturing.
134	Labour productivity in total manufacturing.
135	Average unit labour cost in total manufacturing.
136	Gross value added in industry, volume.
137	Gross value added in industry, value.
138	Price deflator for gross value added in industry.
139	Employment in industry.
140	Investment in industry, volume.
141	Investment in industry, value.
142	Price deflator for investment in industry.
143	Capital stock in industry.
144	Wage bill in industry.
145	Average earnings in industry.
146	Profits in industry.
147	Labour productivity in industry.
148	Average unit labour costs in industry.
149	Profit repatriations in industry.
	Agriculture
150	Total intermediate consumption of agricultural input as a share in gross agricultural output, volume.
151	Domestic absorption of domestically produced agricultural produce as a share of gross output in agriculture and food processing (excl. material inputs in food processing), volume.
152	Employment in agriculture.
153	Long run capital stock in agriculture as a share of gross value added in agriculture.
154	Short run capital stock in agriculture.
155	Depreciation in agriculture.
156	Value added in agriculture, volume.
157	Gross value added in agriculture, volume.
158	Price deflator for gross value added in agriculture.

159	Gross output in agriculture, value.
160	Total intermediate consumption of agricultural input, value.
161	Value added in agriculture, value.
162	Gross value added in agriculture, value.
163	Income in agriculture.
164	Investment in agriculture, volume.
	Market Services: Distribution
165	Value added in distribution, volume.
166	Wage bill in distribution as a share of value added in the sector. Modelled based on the translog cost function with two factors and value added.
167	Employment in distribution, long run.
168	Employment in distribution, short run.
169	Capital stock in distribution, long run.
170	Capital stock in distribution, short run.
171	Deflator for value added in distribution.
172	Average earnings in distribution relative to non-agricultural wage rate.
173	Investment in distribution, volume.
174	Investment in distribution, value.
175	Value added in distribution, value.
176	Wage bill in distribution.
177	Profits in distribution.
178	Cost of capital in distribution.
179	Labour productivity in distribution.
180	Average unit labour costs in distribution.
181	Weighted final demand in distribution.
	Market Services: Business and Financial Services
182	Value added in business and financial services, volume.
183	Employment in business and financial services, long run.
184	Employment in business and financial services, short run.
185	Capital stock in business and financial services, long run.
186	Capital stock in business and financial services, short run.
187	Deflator for value added in business and financial services. This is a behavioural equation. Because the deflator for this sector is residually determined (making the output and expenditure sides add up) it is very noisy out of sample. This equation is used as an "instrument" where this variable appears as an explanatory variable in other equations.
188	Average earnings in business and financial services relative to non-agricultural wage rate.
189	Wage bill in business and financial services as a share of value added in the sector. Modelled based on the translog cost function with two factors and value added.
190	Investment in business and financial services, volume.
191	Investment in business and financial services, value.
192	Value added in business and financial services, value.
193	Deflator for value added in business and financial services. This item is a residual in the model so it captures all the errors in other equations for the output and expenditure sides of the national accounts.
194	Profits in business and financial services.
195	Cost of capital in business and financial services.
196	Labour productivity in business and financial services.
197	Average unit labour costs in business and financial services.

198	Weighted final demand in business and financial services.
	Market Services: Transport & Communications
199	Value added in transport & communications services, volume.
200	Employment in transport & communications services.
201	Capital stock in transport & communications services, long run.
202	Capital stock in transport & communications services, short run.
203	Deflator for value added in transport & communications services.
204	Average earnings in transport & communications services relative to non-agricultural wage rate.
205	Wage bill in transport & communications services as a share of value added in the sector. Modelled based on the translog cost function with two factors and value added.
206	Investment in transport & communications services, volume.
207	Investment in transport & communications services, value.
208	Value added in transport & communications services, value.
209	Deflator for value added in transport & communications services adjusted for subsidies.
210	Profits in transport & communications services.
211	Cost of capital in transport & communications services.
212	Labour productivity in transport & communications services.
213	Average unit labour costs in transport & communications services.
214	Weighted final demand in transport & communications services.
	Aggregating Market Services Sector
215	Depreciation in services.
216	Value added in market services, volume.
217	Value added in market services, value.
218	Deflator for value added in market services.
219	Investment in market services, volume.
220	Capital stock in government market services.
221	Capital stock in public administration and defence.
222	Capital stock in health and education.
223	Capital stock in market services.
224	Capital stock in non-market services.
225	Capital stock in services.
226	Employment in market services
227	Wage bill in market services.
228	Profits in market services.
229	Labour productivity in market services.
230	Average earnings in market services.
231	Average unit labour costs in market services.
232	Value added in health and education, volume.
233	Value added in health and education, value.
234	Profits in health and education.
235	Value added in public administration and defence, volume.
236	Value added in public administration and defence, value.
237	Value added in non-market services, value.
238	Value added in non-market services, volume.
239	Deflator for value added in non-market services.
240	Deflator for value added in public administration and defence.
	Imports and the Balance of Payments

241	Imports of goods and services excl. energy, constant prices. This variable is not used in the model. However, it can be used to check the behaviour of the residually determined MNE, which ensures that the output and expenditure sides of the national accounts add up in volume terms.
242	Imports SITC 3
243	Imports of goods and services excl. energy, volume. This is residually determined ensuring that the volume of GDP from the output side equals the volume on the expenditure side.
244	Imports of goods and services excl. energy, value.
245	Imports of tourism services, volume.
246	Imports of goods and services, volume.
247	Imports of goods and services, value.
248	Deflator for imports of goods and services.
249	Balance of trade.
250	Balance of payments - private capital flows.
251	Accumulated stock of private capital outflows at current prices.
252	Accumulated stock of private capital outflows at current prices excl. non-resident net financial liabilities of Credit Institutions
253	Other net factor income from abroad.
254	Price deflator for profit repatriations.
255	Net factor income from rest of the world, value.
256	Net factor income from rest of the world, volume.
	Demographics
257	Number of males aged 0 - 14 years.
258	Number of females aged 0 - 14 years.
259	Number of males aged 15 - 24 years.
260	Number of females aged 15 - 24 years.
261	Number of males aged 25 - 64 years.
262	Number of females aged 25 - 64 years.
263	Number of males aged 65+ years.
264	Number of females aged 65+ years.
265	The long-run stock of emigrants
266	Net emigration.
267	The stock of emigrants
268	Real after-tax average wage rate in Ireland relative to the UK
269	Net emigration of females.
270	Net emigration of males.
	Labour Supply
271	**Labour force participation rate of females aged 25 - 64 - long run.**
272	**Labour force participation rate of females aged 25 - 64 - short run.**
273	Labour force participation rate of males aged 25 - 64 - long run.
274	Labour force participation rate of males aged 25 - 64 - short run.
275	Labour force participation rate of females aged 15 - 24 - long run.
276	Labour force participation rate of females aged 15 - 24 - short run.
277	Labour force participation rate of males aged 15 - 24 - long run.
278	Labour force participation rate of males aged 15 - 24 - short run.
279	Labour force: females ages 25 - 64
280	Labour force: females aged 15 - 24

281	Labour force: males aged 25 - 64
282	labour force: males aged 15 - 24
283	Number of females aged 15 - 64
284	Number of males aged 15 -64
285	Population aged 0 - 14 years
286	Population aged 15 - 64 years
287	Population aged 65+ years
288	Total population.
289	Total female labour force.
290	Total male labour force.
291	Female labour force participation rate.
292	Male labour force participation rate.
293	Total labour force participation rate.
294	Total labour force.
295	Employment in non-market services.
296	Employment in services.
297	Total employment.
298	Non-agricultural employment.
299	Employment in market services, industry and agriculture.
300	Total number of unemployed.
301	Unemployment rate.
	Consumption and the consumption function
302	Personal consumption, long-run: Keynesian consumption function. This consumption function describes the case where all consumers are credit constrained in the long-run.
303	Personal consumption, long-run: Consumption function including wealth effects. This consumption function describes the case where consumers are not credit constrained in the long-run.
304	Personal consumption, short-run. The choice of the consumption function depends on the assumption about the degree of credit constraints faced by households, and this is implemented by setting the parameter $0 \leq Z\_SAVRAT \leq 2$.
305	Personal consumption of electricity, volume.
306	Consumption of fuel and power excl. electricity, volume.
307	Personal consumption of petrol, volume.
308	Deflator for consumption of electricity.
309	Deflator for consumption of fuel and power excl. electricity.
310	Deflator for consumption of petrol.
311	Deflator for consumption of goods and services excl. fuel and power and petrol
312	Personal savings rate.
313	Personal consumption of fuel and power and petrol, volume.
314	Weighted index of non-electricity prices
315	Personal consumption of electricity, value.
316	Consumption of fuel and power excl. electricity, value.
317	Personal consumption of petrol, value.
318	Personal consumption of fuel and power and petrol, value.
319	Deflator for consumption of fuel and power and petrol.
320	Consumption of goods and services excl. fuel and power and petrol, volume.
321	Weighted average of the cost inputs for the consumption deflator for a subcomponent of personal consumption.

322	Consumption of goods and services excl. fuel and power and petrol, value.
323	Personal consumption, value.
324	Price deflator for personal consumption.
325	Net expenditure by central & local government on current goods and services, value.
326	Non-pay related government current expenditure on goods and services, volume.
327	Net expenditure by central & local government on current goods and services, volume.
328	Government current expenditure on pay excluding public administration, value.
329	Government current expenditure on pay excluding public administration, volume.
330	Deflator for non pay related government current expenditure.
331	Net financial wealth of households.
	The housing market
332	Real price of a new house - long run.
333	Real price of a new house - short run.
334	Housing completions.
335	Real price of a second-hand house.
336	Housing stock.
337	Investment in housing, value.
338	Private investment in housing, volume.
339	Private investment in housing, value.
340	Government investment in housing, volume.
	Other expenditure (I, X)
341	Investment in machinery and equipment, volume.
342	Physical changes in other stocks, volume.
343	Industrial exports as a share of gross output in high-tech and traditional manufacturing.
344	Exports of tourism services, long run.
345	Exports of tourism services, short run.
346	Exports of other services, long run.
347	Exports of other services, short run.
348	Investment in machinery and equipment, value.
349	Investment in agriculture, value
350	Investment in services, volume
351	Investment in services, value
352	Investment in non-market services, volume
353	Investment in non-market services, value
354	Deflator for investment in non-market services
355	Deflator for investment in public administration
356	Deflator for investment in health and education
357	Deflator for investment in government market services (roads, water etc)
358	Total investment, volume.
359	Investment in building and construction, non-housing, volume.
360	Investment in building and construction, non-housing, value
361	Deflator for investment in building and construction, non-housing
362	Investment in building and construction, volume
363	Investment in building and construction, value
364	Deflator for investment in building and construction, total
365	Total investment, value.
366	Total investment in market services, value

367	Physical changes in other stocks, value.
368	Non-agricultural stocks, volume.
369	Non-agricultural stocks, value.
370	Change in stocks, volume.
371	Change in stocks, value.
372	Agricultural exports, volume.
373	Agricultural exports, value.
374	Industrial exports, value.
375	Services exports, volume.
376	Services exports, value.
377	Non-agricultural exports, volume.
378	Non-agricultural exports, value.
379	Exports of goods and services, volume.
380	Exports of goods and services, value.
381	Personal savings.
382	Company sector savings.
383	Total savings.
384	Total domestic savings adjusted for stock appreciation.
385	Government savings.
386	Gross domestic absorption, volume.
387	Gross domestic absorption, value.
388	Final demand, volume.
389	Final demand, value.
	Deflators
390	Deflator for imports (SITC 3) where PM3F is in foreign currency terms - before adjusting for the real effective exchange rate.
391	Deflator for energy, instrument to include carbon taxes
392	Deflator for imports of goods and services excl. energy.
393	Deflator for material inputs in agriculture
394	Deflator for investment in machinery and equipment.
395	Deflator for investment in distribution sector
396	Deflator for investment in transport and communication sector
397	Deflator for industrial exports.
398	Deflator for GDP at factor cost
399	Weighted average of coats factors affecting the deflator for physical changes in other stocks: weighted average of price for inputs into non-agricultural stocks.
400	
401	Deflator on personal consumption, inflation rate
402	Deflator for net expenditure by central & local government.
403	Deflator for government current expenditure on pay excluding public administration.
404	Deflator for investment in health and education sector
405	Deflator for investment in public administration sector
406	Deflator for investment in government market services sector
407	Deflator for investment in building sector
408	Deflator for investment in utilities sector
409	Deflator for manufacturing investment.
410	Deflator for high tech manufacturing investment.
411	Deflator for food manufacturing investment.

412	Deflator for traditional manufacturing investment.
413	Deflator for investment in business and financial market services
414	Deflator for market services investment
415	Deflator for services investment
416	Deflator for agricultural investment
417	Deflator for total investment
418	Deflator for agricultural exports.
419	Deflator for services exports.
420	Deflator for non-agricultural exports.
421	Deflator for exports of goods and services.
422	Price deflator for change in non-agricultural stocks
423	Price deflator for non-agricultural stocks.
424	Price deflator for change in stocks.
425	Deflator for indirect taxes.
426	Deflator for subsidies.
	Wage equation
427	Wage equation, long run
428	Wage equation, short run
429	Average rate of tax on disposable income
430	Average wage in public administration
431	Average wage in health and education
	The Government Sector
432	Government current revenue from excise taxes.
433	Government revenue from VAT.
434	Government revenue from other expenditure taxes.
435	Employment in public administration and defence, PES basis
436	Government current expenditure on goods and services, non-pay
437	Rate of subsidy GCSAS - indexation rule.
438	Rate of subsidy GCSANS - indexation rule.
439	Rate of subsidy GCSONA - indexation rule.
440	Government current expenditure on other consumer subsidies.
441	Government current expenditure on transfers abroad excl. EU
442	Rate of subsidy GCSCT - indexation rule.
443	Average rate of unemployment transfers.
444	Investment in public administration, value
445	Investment in health and education, value
446	Investment in government market services, value
447	Government investment in housing, value.
448	Other government capital expenditure - indexation rule.
449	Indexation rate for EEC Budgetary contributions
450	Indexation rate for EEC subsidies
451	Indexation rate for EEC tax - component EECTG
452	Indexation rate for EEC tax - component EECTO
453	Vat rate on housing
454	Weighted index of excise taxes.
455	Index of rate of motor vehicle duties.
456	Index of rates of other indirect taxes.

457	Other government capital receipts.
458	Public authorities agricultural levy.
459	Indexation rate for Rates
460	Indexation rate for government receipts of transfers from abroad
461	Indexation rate for government trading and investment income
462	Indexation rate for tax on wealth GTWL
463	Indexation rate for income tax paid by farmers
464	Indexation rate for DIRT tax paid by households
465	Average rate of customs duties.
466	Rate of energy tax.
467	Indexation rate for carbon tax
468	Indexation rate for carbon tax paid by emissions trading sector
469	Average rate of employee social insurance contributions.
470	Rate of corporation tax for firms in the business and financial services
471	Rate of corporation tax for firms in manufacturing
472	Rate of corporation tax for firms in sectors other than the business and financial services sector (Including IFSC) and manufacturing
473	Rate of corporation tax for companies outside the industrial sector.
474	Rate of corporation tax for companies in the industrial sector: weighted average of tax rates to exporters and non-exporters.
475	Rate of corporation tax for companies in the industrial sector.
476	Rate of corporation tax for companies outside the industrial sector.
477	Rate of capital grants to industry.
478	Rate of capital grants to personal sector for housing.
479	Average rate of income tax.
480	Weighted average VAT rate.
481	Indexation rate for GTWL
482	Indexation rate for lump sum tax on companies GTYCL
483	Average rate of employers' social insurance contributions.
484	Indexation rule for employment in health and education
485	Government current expenditure on personal transfers to education excluding unemployment payments.
486	EU budgetary contribution.
487	EU subsidies
488	EU taxes.
489	Other EU taxes on expenditure.
490	Taxes on expenditure - Rates.
491	Current receipts: Transfers from the rest of the world.
492	Net trading and investment income.
493	Government current revenue from taxes on agricultural income.
494	Government current revenue from the deposit interest retention tax paid by the private sector.
495	Government current revenue from motor vehicle duties.
496	Public authorities protective customs duties.
497	Motor vehicle duties paid by businesses.
498	Government current revenue from taxes on energy.
499	Government current revenue from expenditure tax on carbon emissions.
500	Revenue from carbon tax on the sector not subject to emissions trading
501	Revenue from carbon tax on the sector subject to emissions trading

502	Government total current revenue from domestic expenditure taxes.
503	Total indirect taxes.
504	Government current revenue from taxes on personal income excluding social insurance.
505	Average rate of social insurance contributions.
506	Social insurance contributions, total
507	Social insurance contributions, employer
508	Social insurance contributions, employee
509	Average rate of personal taxation including social insurance contributions paid by employees.
510	Government revenue from corporation tax
511	Government revenue from taxes on profits of the manufacturing sector.
512	Government revenue from taxes on profits from business and financial services sector.
513	Government revenue from taxes on profits of firms in sectors other than business and financial services sector (Including IFSC) and manufacturing.
514	Government revenue from taxes on profits of the industrial sectors.
515	Total taxes on profits, including DIRT
516	Motor vehicle duties paid by households.
517	Dirt tax - yield net of refunds.
518	Government current revenue from taxes on income.
519	Wealth tax on households
520	Total government current revenue.
521	Total wage bill in health and education
522	Total wage bill in public administration
523	Government current expenditure on agricultural subsidies not related to sales.
524	Government current expenditure on agricultural subsidies related to sales.
525	Government current expenditure on other non-agricultural subsidies.
526	Government subsidies: Current payments to CIE and PO Deficit.
527	Government current expenditure on consumer subsidies.
528	Government current expenditure on agricultural subsidies.
529	Government current expenditure on other subsidies.
530	Total government expenditure on subsidies.
531	Total subsidies and capital grants to enterprises.
532	Government current expenditure on transfers to education.
533	Government current expenditure on transfers for unemployment.
534	Government current expenditure on transfers to the personal sector.
535	EU taxes.
536	Government current expenditure on transfers abroad: non-tax contribution to the EU budget.
537	Government current expenditure: transfer payments to the rest of the world.
538	Total government current expenditure.
539	Government capital expenditure: transfers to industry.
540	Government capital expenditure: transfers for housing.
541	Total government capital expenditure.
542	Total government capital revenue.
543	Public authorities surplus on a national accounts basis.
544	Exchequer borrowing requirement.
545	Exchequer borrowing requirement as % of GNP in current prices.
546	General government deficit on EU basis.
547	Public authorities savings on a national accounts basis.

548	Current budget deficit.
549	Public authorities surplus on a national accounts basis as percentage of GNP.
550	Annual change in government expenditure on national debt interest on bonds.
551	Government expenditure on national debt interest on small savings.
552	Government current expenditure on national debt interest on loans denominated in foreign currencies.
553	Interest received by government on liquid assets
554	Interest rate on promissory notes
555	Interest paid on EU/IMF loans
556	Promissory notes interest
557	National debt interest paid to the rest of the world.
558	National debt interest paid to domestic agents.
559	Total government current expenditure on national debt interest.
560	National debt denominated in foreign currencies.
561	Government small savings outstanding.
562	Government borrowing abroad in foreign currencies.
563	Government bonds outstanding.
564	Audited national debt.
565	General government debt, EU basis.
566	General government debt, EU basis net of government financial assets
567	Debt to GDP ratio.
568	General government debt to GDP ratio.
569	General government debt, net of financial assets, to GDP ratio.
	Other equations: reconciling output, expenditure and income
570	Undistributed profits of companies after tax as a share of total profits.
571	Gross domestic product at factor cost, value.
572	Gross domestic product at factor cost, volume.
573	Total taxes on expenditure, volume
574	Total subsidies, volume
575	GDP, value.
576	GDP, volume.
577	Growth in real GDP.
578	GDP deflator.
579	Gross national product, value.
580	Gross national product, volume.
581	Growth in real GNP.
582	GNP deflator.
583	Total depreciation.
584	Net value added at factor cost: Adjustment for stock appreciation.
585	Net national product at factor cost, value.
586	Adjustment for stock appreciation
587	Private income
588	Personal income
589	Personal disposable income
590	Real personal disposable income
591	Profits.
592	Adjusted tax base for income tax.
593	Other profits

594	Non-agricultural wage bill
	Flow of Funds
595	Flow of funds, company sector source of funds.
596	Flow of funds, company sector use of funds.
597	Flow of funds, company sector acquisition of financial assets.
598	Flow of funds, household sector source of funds.
599	Flow of funds, household sector use of funds.
600	Flow of funds, household sector acquisition of financial assets.
601	Flow of funds, private sector acquisition of financial assets.
602	Rate of company sector acquisition of financial assets.
603	Rate of household sector acquisition of financial assets.
604	Rate of private sector acquisition of financial assets.
605	Rate of private sector acquisition of government debt.
	Financial variables
606	Weight on the USA in calculating the effective exchange rate
607	Effective exchange rate.
608	Weight on UK in calculating the effective exchange rate.
609	Average rate of exchange for government foreign borrowing.
610	Average interest rate on government borrowing in foreign currencies.
611	Rate of Interest on long-term government securities.
612	Interest rate on Post Office savings.
613	Prime lending rate.
614	Overnight deposit rate for households.
615	Mortgage interest annuity rate.
616	1-3 year AA loans to companies.
617	5-7 year AA loans to companies.
618	Exchange rate: IR£ per USD.
619	Exchange rate: IR£ per sterling.
620	Exchange rate: IR£ per yen.
621	Exchange rate: IR£ per sterling - 4 year moving average.
622	Net foreign capital transfers.
623	This variable is used to index BPTKNG
624	This variable is used to index BPTPRNE
625	Government sector net capital transfers.
626	Private next current transfers from abroad.
627	Balance of payments surplus.
628	Balance of payments surplus as a % of GDP.
	Banking Balance sheet
629	Domestic Credit
630	Bank assets: securities
631	Bank assets: deposits with the CBI
632	Bank assets: Other
633	Bank Assets: Total
634	Bank Liabilities: Borrowing from CBI/ECB
635	Bank Liabilities: Deposits
636	Bank Liabilities: Foreign Liabilities
637	Bank Liabilities: Other

638	Net Foreign Liabilities of Credit Institutions.
639	Net external reserves.
640	Central Bank Assets Other
641	Central Bank Liabilities: Currency
642	Cash balances held by exchequer.
643	Central Bank: Liabilities to government
644	Central Bank Liabilities: Other
645	Central Bank Liabilities: Total
646	Total official external reserves of the banking system.

8 Appendix 2: Fiscal rules in HERMES

Table 19: Indexation Rules in Government Accounts in HERMES (1 of 2)

Item	Indexation Rule
CURRENT REVENUE	
EXPENDITURE TAXES	
Excise Tax	Previous year's average tax rate, indexed to personal consumption deflator
VAT	Previous year's average tax rate
Carbon Taxes	Previous year's average tax rate
Stamp Duties, Fees, etc.	Previous year's average tax rate, indexed to personal consumption deflator
Motor Vehicle Duties-Companies	Previous year's average tax rate, indexed to personal consumption deflator
Customs Duties	Previous year's average tax rate
Rates	Previous year's tax take indexed to growth in nominal GNP
Agricultural Levies	Previous year's tax take indexed to growth in agricultural output prices
Contribution to EC Budget (-)	Previous year's contribution indexed to growth in OECD GDP
TAXES ON INCOME	
Personal Income Tax	Previous year's average tax rate
Social Insurance Contributions	Previous year's average rate for both employee and employer
Company Taxes: Corporation Tax	Previous year's average tax rate
Motor Vehicle Duties-Personal	Previous year's average tax rate, indexed to Personal consumption deflator
Farmers' Income Tax	Previous year's tax take indexed to growth in agricultural incomes
DIRT	Previous year's tax take indexed to growth in average deposit interest from GNP
NON-TAX INCOME	
Trading & Investment Income	Previous year's level indexed to growth in nominal GNP
Transfers From Abroad	Previous year's level indexed to growth in nominal GNP
Other Taxes	Previous year's level indexed to growth in nominal GNP
CAPITAL REVENUE	**Previous year's level indexed to growth in GDP deflator**

Table 19: Indexation Rules in Government Accounts in HERMES contd. (2 of 2)

Item	Indexation Rule
CURRENT EXPENDITURE	
PUBLIC CONSUMPTION	
Wage bill - Public Admin.	Long-run volume growth rate* times actual change in wages.
Wage bill - Other	Long-run volume growth rate* times actual change in wages.
Non-Pay	Long-run volume growth rate* times actual change in wages.
Subsidies	
Consumer subsidies	Split in two: transport subsidies indexed to growth in output in transport and communications sector, other subsidies indexed to growth in nominal consumption.
Agricultural subsidies	Growth in gross output in agricultural sector
Non-agricultural subsidies	Growth in GDP at factor cost
PERSONAL TRANSFERS	
Unemployment	Average rate indexed to either wages or prices (normally wages but in this paper prices)
Pensions etc.	Previous year indexed to change in dependent population (under 14 and over 65) and growth in either wages or prices (in practice wages)
Debt Interest	
Transfers to Rest of World	Contribution to EU budget indexed to growth in OECD GDP; other government transfers indexed to growth in nominal GNP.
CAPITAL EXPENDITURE	
INVESTMENT	
Housing	Long-run volume growth rate* times actual change in price deflator.
Public Admin.	Long-run volume growth rate* times actual change in price deflator.
Health & Education	Long-run volume growth rate* times actual change in price deflator.
Other	Long-run volume growth rate* times actual change in price deflator.
CAPITAL TRANSFERS	
to Industry	Unchanged rate
to Households	Unchanged rate
Other Capital expenditure	Long-run volume growth rate* times actual change in price deflator (GDP deflator).

* The long-run volume growth rate in “normal times” is calculated as a nine-year centred moving average growth rate. This is intended to capture a measure of non-cyclical growth in each individual expenditure item, smoothing out cyclical changes.

Table 20: Detailed HERMES code used to implement indexation rules (1of 3)

	Mnemonic	Base	Rate and Indexation Rule
GENERAL GOVERNMENT BALANCE	GBR	GBR=GTTOT+GR-GC-GK	
TOTAL CURRENT REVENUE	GTTOT	GTTOT=GTE+GTY+GTTI+GTTABR+GTW	
Excise Tax	GTEXT	Personal Consumption volume (C), Tourism Exports volume (XTO) and the personal consumption deflator (PC)	Rate Indexed to PC
VAT	GTEVAT	C, PC, Private Housing Investment (IHPV), Tourism Exports (XTOV) and Government Consumption of Goods and Services Non-Pay (GCGNPV)	Rate Unchanged
Carbon Taxes	GTECA	Carbon Emissions (CO2)	Rate Unchanged
Stamp Duties, Fees, etc.	GTEO	C, PC, and Building Investment (IBV)	Rate Indexed to PC
Motor Vehicle Duties-Companies	GTEMVDC	Stock of Cars (SCARS)	Indexed to PC
Customs Duties	GTECUSO	Imports of Goods and Services (MGSV)	Rate Unchanged
Rates	GTERATE	GNP in current prices (GNPV)	Indexed to GNPV
Agricultural Levies	GTAGLEV	Indexed to PQGA (Price deflator of Gross Agricultural Output)	
Contribution to EC Budget (-)	EECTG	GNP Price deflator and OECD GDP (PGNP*GDP_OECD)	Indexed to PGNP*GDP_OECD
Total Taxes on Expenditure	GTE	GTE=GTEXT +GTEVAT + GTECA+GTEO+GTEMVDC+GTECUSO+GTERATE+GTAGLEV -EECTG	
Personal Income Tax	GTYPER	Personal Disposable Income (YRPERT)	Rate Unchanged
Social Insurance Contributions	GTYSL	Wage Income (YWI + YWSM)	Rate Unchanged
Corporation Tax	GTYC	Non-Wage Income (YC)	Rate Unchanged
Motor Vehicle Duties-Personal	GTYMVDP	Stock of Cars (SCARS)	Indexed to PC
Farmers' Income Tax	GTYA	Agricultural Income (YAG)	Indexed to YAG
DIRT	GTYDIRT	Indexed to RD*GNPV (RD=deposit interest rate)	
Total Taxes on Income	GTY	GTY=GTYPER+GTYSL+GTYC+GTYMVDP+GTYA+GTYDIRT	
Trading & Investment Income	GTTI	Indexed to GNPV	
Transfers From Abroad	GTTABR	Indexed to GNPV	
Other Taxes	GTW	Indexed to GNPV	
CAPITAL REVENUE	GR	Indexed to GDP price deflator (PGDP)	

Table 20: Detailed HERMES code used to implement indexation rules contd. (2of 3)

	Mnemonic	Base	Rate and Indexation Rule
CURRENT EXPENDITURE	GC	GC=GCGV+SUB-EECS+GCTPER+GCTNT+GCTABR	
Public Consumption	GCGV	GCGV=OSNPV+GCGOWV+GCGNPV	
Wages - Public Admin.	OSNPV	Value added equals wage bill OSNPV=YWSNP Wage bill = Employment (LSNP) times Wage (WSNP) YWSNP=LSNP*WSNP	Index WSNP to average wages WNA; LSNP unchanged
Wages – Other	GCGOWV	GCGOWV=YWSNHE-GCTW	
Wages – Health and Education	YWSNHE	YWSNHE=LSNHE*WSNHE	Index WSNHE to average wages WNA; LSNHE unchanged
Non-Pay	GCGNPV	Index to PGCGNP (price deflator)	
Subsidies	GCS	GCS=GCSC+GCSO	
Consumer Subsidies	GCSC	GCSC=GCSCO+GCSCT	
Transport	GCSCT	OSMTCV (Value added in Transport and Communications)	Index to OSMTCV
Other	GCSCO	Index to Personal Consumption (CV)	
Other Subsidies	GCSO	GCSO=GCSA+GCSONA	
Agricultural	GCSA	GCSA=GCSANS+GCSAS	
Sales	GCSAS	Gross Output in Agriculture (QGAV)	Index to QGAV
Non-Sales	GCSANS	Gross Output in Agriculture (QGAV)	Index to QGAV
Other Non-agricultural subsidies	GCSONA	GDP at factor cost in current prices (GDPFCV)	Index to GDPFCV
Personal Transfers	GCTPER	GCTPER=GCTU+GCTREST+GCTW	
Unemployment	GCTU	Unemployment (U)	Index to weighted average of WNA and PC**
Pensions etc.	GCTREST	Index population aged under 14 and over 65 to weighted average of WNA and PC	
Debt Interest	GCTNT		
Transfers to Rest of World	GCTABR	GCTABR=GCTAEO+GCTAO	
Non-tax contribution to EU budget	GCTAEO	GCTAEO = EECBUD-EECTG	
Contribution to EU budget	EECBUD	PGNP*GDP_OECD	Indexed to PGNP*GDP_OECD
Other govt transfers abroad	GCTAO	Indexed to GNPV	

**In the HERMES model there is an option to index unemployment and other transfer payments (GCTREST) to either wages or prices or a weighted average of both

Table 20: Detailed HERMES code used to implement indexation rules contd. (3of 3)

	Mnemonic	Base	Rate and Indexation Rule
CAPITAL EXPENDITURE	GK	GK=IHGV+ISNPV+ISNHEV+ISMGV+GKTI+GKTH+GKREST	
Housing	IHGV	Index to PIH	
Public Admin.	ISNPV	Index to PISNP	
Health & Education	ISNHEV	Index to PISNHE	
Other	ISMGV	Index to PISMG	
Capital Transfers to Industry	GKTI	Total Industrial Investment (IIV)	Rate Unchanged
Capital Transfers to Households	GKTH	Private Housing Investment (IHPV)	Rate Unchanged
Other Capital expenditure	GKREST	No Indexation, this is assumed unchanged	

Year	Number	Title/Author(s) ESRI Authors/Co-authors *Italicised*
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