An Overview of Recent Progress in Macroeconomic Modelling in the Central Bank

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ABSTRACT

The Bank's Macro-Econometric model has recently been revised. This paper outlines the context within which the model was initially built and the reasons for the revision and re-estimation. Compilation of the data used was a key component of the revision and this is described and the general structure of the model outlined. The main components of the model are then reviewed. The paper concludes with a discussion of how future work on the model might evolve.

1. Introduction

The econometric model of the Irish economy developed and maintained within the Economic Analysis, Research and Publications Department of the Central Bank and Financial Services Authority of Ireland (CBFSAI), was originally developed to form the basis for the Irish component of the ESCB's Multi-Country Model (MCM) project. The goal of this project is to develop a quarterly model for each EU country which will allow cross-country comparability and the analysis of shocks or simulations pertaining to the euro area. The development of the first version of this model was described in McGuire and Ryan (2000). The model is currently used for a variety of purposes within the Bank including domestic and euro-area forecasting exercises, scenario analysis and policy simulation and has been used as a tool in the stress-testing of the financial sector.

Over time, a need to revise the model became clear, for several reasons. Among these were the need to incorporate more up-to-date data and to achieve an improved simulation performance in certain areas. As a result, the model was recently re-estimated[2] and significant improvements have been made, notably the introduction of a housing block and changed specifications of the production function and consumption function. The aim of this paper is to outline the resulting new model.

1 The author is an Economist in the Economic Analysis, Research and Publications Department. With thanks to Maurice McGuire, Kieran McQuinn, Mary Ryan and Karl Whelan for helpful comments. The views expressed in this article are not intended to represent those of the Central Bank and Financial Services Authority of Ireland or the Eurosystem.

2 The modelling team were Kieran McQuinn, Nuala O'Donnell and Mary Ryan. The team were greatly aided by advice and input from Maurice McGuire. A forthcoming Technical Paper by the modelling team will provide a more technical description of the re-estimation and will present simulation results.

The paper is structured as follows: Section 2 describes the background to the model and the need for re-estimation. Section 3 deals with data issues while Section 4 describes the general structure of the model. Section 5 describes the model in more detail. Section 6 concludes with a discussion of the scope for improvement and how future work might evolve.

2. Background

The ESCB Context

The motivation for the development of the Central Bank and Financial Services Authority of Ireland's first edition of the macro-model lay largely with the ESCB's Multi-Country Model (MCM) project. This project began in 1997 as the need became clear to have models with a euro-area focus as tools to assist decision making by the future ECB Governing Council. The aim of this project is to develop a quarterly model for each Eurosystem country to facilitate cross-country comparability and the analysis of shocks or simulations pertaining to the euro area. This project necessitates a common theoretical framework across countries. Given the euro-area focus, the models may differ from other national models designed without such a focus. The country models have a relatively high degree of aggregation to minimise complexity and thus may appear small when compared with other highly detailed country models. The new second edition model will be forwarded for inclusion in the euro-system MCM project.

Due to the desire for linkages between individual country models and the need to compare or aggregate model-based results for different countries, a common theoretical framework across countries is necessary. Ideally, each country model should converge to a stable long-run solution, implying stability of the linked system and the possibility of incorporating model-consistent forward-looking expectations. The models are estimated with quarterly data to facilitate regular monitoring and forecasting.

The resulting models should be capable of being linked together. Models from 12 ESCB countries can currently be operated in a linked format through their trade blocks, thus providing a mechanism for assessing policy responses and projections of the group of countries as a whole. The Irish model was linked in 2001. In non-linked or 'stand-alone' mode, the model is used as an input into the Irish contribution to the ESCB Macroeconomic Projection Exercises, for policy analysis within various ESCB fora and for domestic policy analysis within the Bank[3]. The linked MCM models are, of course, only one of the set of modelling tools available at the euro-area level to support policy making.

3 For example, see Mawdsley, McGuire and O'Donnell (2004) for an application of the model to stress-testing the financial sector, or Box A, Section 1 of CBFSAI Quarterly Bulletin, 1 2005 for its use in an assessment of oil price increases.

This set also includes the Area-Wide model[4], and various models of both the euro-area and individual economies developed by national central banks.

Why Re-estimation is Needed

The first version of the Bank's model was estimated in 1999 (see McGuire and Ryan, 2000). The dataset for that first version ended in 1996 for most variables or 1995 for some variables. It is now necessary to re-estimate with an extended dataset to allow the model to be based more on the economy of the 1990s than was the case with the previous version. The new dataset runs until 1999. With the latter half of the 1990s being a period of considerable economic expansion and structural change, it was expected that incorporating this period in the econometric estimation could prove problematic and this was indeed the case for a small minority of equations, notably the exports and wages equations. These are discussed in more detail below.

Other reasons also pointed towards the need for re-estimation and revision. The Central Statistics Office (CSO) has made significant revisions to its National Accounts Data which could be incorporated in an extended database. An improved version of the Chow-Lin procedure used for interpolation is also available (Frain, 2004). Furthermore, problems remained with the first version which it is hoped can be ironed out second time round. Among these were the performance of investment in simulations where an overly strong response to movements in GDP was obvious and so alternative specifications were considered. Thus, the total capital stock was disaggregated into housing and non-housing capital, allowing for the separate modelling of housing and non-housing investment.

Other difficulties in the first version of the model related to longer-run simulations, where results were considered somewhat less reliable. Specifically, issues relating to convergence to a steady-state still remain to be addressed.

3. Data

The data used come from a specially constructed quarterly dataset which was interpolated from annual National Accounts data[5] supplied by the CSO. This was necessary as official quarterly National Accounts are only available from the mid 1990s onward. Due to the need for a long consistent time series, the data are based on the 1979 version of the European System of Accounts[6] (ESA 1979). At the time of construction, data on an

4 See Fagan, Henry and Mestre (2005).

5 For details, refer to McGuire, M., O'Donnell, N., and Ryan, M. (2002). The assistance of the CSO in providing suitable annual data is gratefully acknowledged.

6 The European System of Accounts is an internationally compatible accounting framework for a systematic and detailed description of an economy, its components and its relations with other economies.

ESA 1995 basis were only available from the CSO from 1990 onwards.

The data were interpolated from an annual to a quarterly basis, with quarterly indicators, using a procedure based on that of Chow and Lin (1971). For details, see Frain (2004). The interpolation method aimed to incorporate the considerable amount of higher frequency (quarterly) information available on the economy over the sample, e.g. retail sales, consumer price inflation, exchequer flows etc. Care was taken to only select variables that have an arithmetic, rather than a behavioural, link with the relevant aggregate, so as to avoid incorporating behavioural links into the interpolated data. Otherwise, the subsequent estimation phase could have been compromised. Most of the indicators used were taken from the CSO databank, with the exceptions of the cash-based exchequer data[7].

The indicator data was first examined for seasonality using the TRAMO/SEATS seasonal adjustment programme (Gómez and Maravall, 1996). In most cases, the seasonally adjusted indicator series supplied by the seasonal adjustment package was used in the interpolation procedure. However, in the cases of the real exports and imports volumes series, the level of noise in the series was thought to be high, especially when the two series were considered together. This led to sharp quarterly movements in GDP from net trade effects. Therefore, a decision was made to use the underlying trend in these quarterly series as the indicators for the interpolation procedure, i.e. the original series minus both the seasonal and short-term noise components, as estimated by TRAMO/SEATS.

Not all national accounts series required interpolation. If series are related by an identity, e.g. a value, volume and deflator series, only two of the three series can be interpolated, since typically the identity will not hold between the three higher frequency series after the interpolation procedure. The identity relationship can then be used to eliminate the series with the weakest indicators from the interpolation process.

Besides the national accounts data obtained from the CSO, data was supplied by other sources, such as the Bank’s Monetary Policy and Statistics department (data on interest rates and government debt/lending), the ECB (energy prices, world demand, competitors’ prices) and the Department of the Environment (housing data).

4. Model Structure

As with the previous version, the model has a dual structure in that relationships between variables differ over different time horizons. There is assumed to be an equilibrium structure to the

7 Where no suitable indicator was available to perform the interpolation, the RATS procedure DISTRIB was used. This relies on standard time series models, such as random walks, autoregressive models and ARIMA models to incorporate series to a higher frequency.

economy that determines the relationships between variables in the long-run. This structure is derived from economic theory but is generally not imposed on the data without testing, i.e. if a particular relationship is rejected by the data then it is not included in the model. The short-run relationships in the model are generated with less recourse to economic theory. All the relevant variables are initially included in the short-term dynamics with a wide range of lags but only the statistically significant ones are retained (this is known as the General to Specific (GTS) approach associated with Hendry, (see e.g. Hendry, (1993))). In a few instances in this version, relationships had to be imposed rather than freely estimated, in the interests of model functioning and coherence. This will be discussed in more detail below.

The long-run relationships

The general finding is that most economic variables are non-stationary in levels. This means that the variables tend to drift over time and do not return to a specific value, i.e. they do not have a fixed mean. This is clearly true of variables such as consumption, investment, output, the capital stock, consumer prices, etc. The assumption of those trying to construct a structural model, however, is that this drift is not a completely random process but that there are links between the variables, called cointegrating relationships, which re-establish themselves over time. This means that the variables have common trends. It is the identification of these links and common trends that constitutes the modelling of the long run structure of the economy[8].

As with the first version of the model, the approach adopted to uncovering these relationships in the data is to use one of the methods specifically designed to deal with non-stationary series[9]. These include the Johansen procedure, (Johansen (1988), Johansen and Juselius (1990)), the Phillips-Hansen Fully Modified Ordinary Least Squares (FM-OLS) approach (Phillips and Hansen (1990), Phillips (1991) and Phillips (1994)) and the Auto-Regressive Distributed Lag (ARDL) approach. These have some limitations, however, in that they only allow for the estimation of very small systems or single relationships. The supply-side of the model has instead been estimated as a system using Multivariate Non-Linear Least Squares[10].

8 The idea might be illustrated by the law of one price. This suggests that the price of a certain good tends to be the same in different markets if these markets are open and the good is easily traded. If this is true then the prices in both markets will cointegrate, i.e. the difference between the two prices will tend to revert to zero over time, even though both prices may tend to drift upwards. This link or cointegration will produce common trends in the two prices since both variables must in some sense follow each other.

9 The sensitivity of more standard statistical techniques such as ordinary least squares to the assumption of stationarity makes them inappropriate as estimation techniques.

10 Using the non-linear systems estimator (NLSYSTEM) in WinRats-32 5.0.

The short-run relationships

The long-run relationships are entered into the model as error-correction terms in equations for the short-run development of variables. These equations relate the current change in a variable to changes in other variables, its own history and to the lagged deviation of the variable from its long-run equilibrium level, i.e. the ECM term. The statistical significance of the coefficient on the error-correction term indicates whether it is appropriate to have the long-run relationship in the equation[11]. The short-term dynamics of the relationship are, generally, freely estimated and are not heavily influenced by theory. As already noted, they start from a very general specification of the equation including a number of lags of variables that might be considered relevant. Then there is a gradual process of elimination of variables until only the statistically significant ones remain. It is worth noting that all the variables in the short-run equations have been differenced or appear in a cointegrating combination, i.e. the long-run relationship. This means that they will generally be stationary and ordinary least squares estimation can be applied.

The long-run steady state solution of the model does not refer to a specific time horizon, rather it represents a set of relationships towards which the model will tend to move at any point in time. It is intended that this long-run equilibrium will be a stable one that will serve as a basis for extension to include the modelling of expectations in a model-consistent or rational manner. If such a stable equilibrium does exist, then standard algorithms, such as that of Fair and Taylor (1983), can be employed to solve the model forward from any point in time, and the results used as the current expectation for the variables in question. This version of the model has not as yet reached the stage of having a long-run steady-state and thus contains no forward-looking elements. Notwithstanding the necessity for further work to ensure complete stability, the long-run properties of the model can still be usefully described in general terms.

The features of the model are essentially similar to the small-scale structural model described in Henry (1999). The level of real output is determined in the model as the interaction of aggregate supply and aggregate demand. Deviations of output from potential and unemployment from the natural rate cause wage and price adjustments to take place which return the model to a long-run neo-classical equilibrium. In the long-run, aggregate supply is limited by the available labour supply and the production function of the economy so that the aggregate supply

11 The absence of significance does not necessarily mean that the variables are not cointegrated but does mean that the variable in question does not respond to disequilibria in the long-run relationship. The variable is in some sense independent or, in technical terms, it is weakly exogenous in the context of the particular long-term relationship. In such a case, it might be more appropriate to include the long-run relationship in the equation for the change in one of the other variables in the relationship.

curve is vertical and the level of inflation is invariant to the equilibrium level of output.

The structure of the model is now described under the headings of aggregate supply, aggregate demand, prices and costs, the fiscal block and trade.

5. Model Description

Aggregate Supply

In the long-run, the relationship between factor inputs and output in the economy is given by a Cobb-Douglas production function. The economy can be off its production function at any point in time. This is because, in the short-term, output is determined by demand but there is only a gradual adjustment of the demand for inputs in response to a particular shock, e.g. if demand is hit by a sharp slowdown then output may contract but it will take some time for labour demand to be affected. The economy will only gradually move back onto the long-run production function. The model responds in this way because the factor demand relationships derived from the production function in the model are embedded as long-run relationships in the short-run factor demand equations. The sluggish adjustment of factor demands is both intuitively appealing and is in line with the typical lagged response of employment to output across a range of economies. A significant change from the previous version of the model is that the total capital stock has been disaggregated into housing and non-housing capital. This allowed for the separate modelling of housing and non-housing investment, as described in the discussion of Aggregate Demand below.

Another feature of the supply-side is the presence of a time-varying structural level of unemployment or natural rate (NAIRU[12]). The gap between the actual level of unemployment and this natural rate of unemployment is an important equilibrating mechanism in the model. This is because this gap enters into the wage equation and through this affects the price equations of the model. If the natural rate is held constant then the Phillips curve, defined as the observed interaction between wage inflation and the actual unemployment rate, will be vertical. The failure to actually observe a vertical Phillips curve within the sample is attributed to movements in the natural rate, i.e. the co-existence of falling unemployment and static wage inflation are explained by reductions in the natural rate.

The Cobb-Douglas production function used is amended from the previous version of the model to allow for a non-linear productivity growth rate in the economy (see McQuinn, 2003). A linear trend may well be inappropriate, in light of the significant changes in the Irish economy over the period 1981-1999.

12 The derivation of the NAIRU is described below under the Prices and Costs heading.

The equations for an output price deflator and labour demand can be derived from the Cobb-Douglas production function as per Allen and Mestre (1997). The output price deflator is derived by inverting the production function and obtaining the dual cost function. First-order conditions yield an expression for marginal cost and output prices and are then set equal to the marginal cost expression scaled by the parameter 'eta', a mark-up over marginal cost, which denotes the economy-wide assumption of imperfect competition, in order to arrive at an expression for long-run prices. The NAIRU is used to calculate the full-employment level of labour and potential output. Total Factor Productivity (TFP)[13] can be calculated as a residual from the estimated parameter values.

The full employment level of output is then given as

$$\ln Q_t^* = (1 - beta) \ln X_{1t}^F + beta \ln X_{2t} + TFP$$

where X_1^F is the full employment level of labour, X_2 refers to capital and *beta* is the exponent on the capital stock in the production function. *TFP* is derived as ln(*alpha*) + (1 – *beta*)*gammaT* where *alpha* is the scale factor from the production function and *gamma* is the growth rate of labour-augmenting technical progress *T*.

Thus, the measure of potential output is obtained by simulating the production function using current levels of capital stock and potential labour input, where potential labour input is the full employment level of labour defined above. This level of potential output is not equal to the long-run equilibrium level of output since the capital stock only adjusts slowly to its long-run level. Over time the two measures will converge as this capital stock adjustment takes place. Consequently, the output gap variable is related to the level of unused labour resources in the economy, which helps the model to adjust towards long-run equilibrium but does not represent this equilibrium at any point in time.

There is no inherent mechanism to ensure that there is a stable equilibrium level of output in the long-run. In order to achieve this there must be a stable equilibrium level of capital, which in turn implies that other variables settle down at stable levels, including both the real interest and the real exchange rate. The need for a stable real interest rate is intuitively sensible, but can be seen algebraically by noting that the marginal product condition from the production function results in the following β**GDP*/*capital stock* = ($r + \delta + \nu$). This relates the marginal product of capital to the term in brackets, which is the user cost of capital. This includes r the real interest rate along with the depreciation rate, δ and a risk premium, ν. The latter two

13 The estimate of TFP was filtered with the Hodrick-Prescott filter.

elements are fixed so that for GDP and capital stock to stabilise at their respective equilibrium levels, r must approach a stable value r^*. The requirement for a stable real effective exchange rate comes from the necessity for the components of aggregate demand to stabilise as a proportion of equilibrium output and to add up to equilibrium output in the long run. The net trade balance and consumption will not do so unless the real exchange rate stabilises. The nominal level of the interest rate and the exchange rate are exogenous variables in the model. The adjustment of these real variables, therefore, has to come about through developments in the domestic price level. All interest rates used in the model are exogenously determined and are not currently linked to one another. Thus, for the purposes of any simulation conducted all relevant rates are changed. Short-term real interest rates are adjusted for inflation using the consumption deflator.

The only option as regards the nominal anchor for domestic prices would seem to be a link with external prices given the small and open nature of the economy. The exchange rate is an exogenous variable and is used to translate foreign prices into domestic currency equivalents. These prices then work their way through a system of related price indices. In the final analysis, the level of external prices or inflation determines domestic price developments. If external inflation is set at a stable rate over a long-run simulation, then the real interest rate and the real exchange rate will tend to settle down to equilibrium levels. The level of real output will then approach equilibrium through the mechanisms already described.

Aggregate Demand

Aggregate demand is made up of the usual output expenditure components. While government expenditure in real terms is currently treated as exogenous in the model, the other main elements are explicitly modelled.

Long-run personal consumption is modelled in a fairly standard manner, driven by disposable income and financial wealth (see Ryan, 2003). Short-run consumption is a function of its own lagged changes along with lagged changes of financial wealth, short-term interest rates and the unemployment rate. Surprisingly, the growth rate of credit became insignificant and was not retained in the short-run specification. Credit growth surged in the latter part of the 1990s, much of it driven by residential mortgages, but while loans for housing are included in credit, the subsequent house purchase is included in statistics as investment rather than consumption.

Non-housing investment is determined by the gap between the actual and long-run equilibrium non-housing capital stock, with the latter being derived from the supply-side relationship between the marginal product of capital and the cost of capital. This gap is used in the error-correction term of the non-housing investment function, which also contains lagged changes in the dependent variable and current and lagged changes in output. The latter adds an accelerator feature to the relationship. The level of the non-housing capital stock is obtained by the perpetual inventory method, whereby the current period's level is updated by taking the difference between last years stock and depreciation levels and adding it to the contemporaneous level of gross investment.

Housing Investment

As mentioned above, a significant enhancement of the current model is the inclusion of a housing block (see McQuinn, 2004). As noted above, in the previous version of the model the performance of investment in simulations showed an overly strong response to movements in GDP and so alternative formulations were considered. Thus, the total capital stock was disaggregated into housing and non-housing capital. This allowed for the separate modelling of housing and non-housing investment. Given the rapid increase in house prices and actual housing supply over the past decade, this is a particularly interesting change to the model and will enable an evaluation of the sensitivity of the domestic property sector to changes in macro-economic variables.

Long-run private housing completions are modelled as a function of house prices and this long-run relationship is entered as an ECM term in the short-run completions equation along with lags of the dependent variable and lagged house prices. Total housing completions are modelled as a function of private housing. The user cost of capital in the housing block is modelled as a function of the mortgage interest rate and house prices. Long-run house prices are modelled as a function of the user cost, the housing stock and disposable income. The long-run relationship is entered as an ECM term in the short-run equation along with lags of the variables in the long-run relationship and the lagged dependent variable.

Real housing investment is calculated as an identity from the housing completions and house price variables. Total investment in the model is the sum of housing and non-housing investment. The housing capital stock is again calculated by perpetual inventory. The housing deflator is modelled as a function of its own lags along with the long-run relationship established between completions and house prices in the ECM term. Nominal housing investment is calculated from its real counterpart and the housing deflator.

The trade components of aggregate demand are described separately below.

Prices and Costs

Given the small and open nature of the economy, the nominal anchor for domestic prices is a link with external prices. The exchange rate is an exogenous variable and is used to translate foreign prices into domestic currency equivalents. These prices then work their way through a system of related price indices. The nominal level of interest rates is also exogenous. In the final analysis, the level of external prices or inflation determines domestic price developments. If external inflation is set at a stable rate over a long-run simulation, then the real interest rate and the real exchange rate should tend to settle down to equilibrium levels which, in turn, determine equilibrium output.

The three principal domestic wage and price equations in the model relate to wages per person employed, the GDP deflator and the consumption deflator. Other deflators relating to investment and government spending are derived from these and, where relevant, the import deflator within an ECM framework. Unlike other demand component deflators, the stock changes deflator is not separately determined, but rather is a residual item to ensure that the evolution of the individual deflators is consistent in the aggregate with the GDP deflator so as to avoid 'adding-up' problems for nominal GDP and its components.

As wages and prices are the adjustment mechanism of the model in moving towards equilibrium, their long-run relationships and the degree of disequilibrium in the economy feature in their short-run behavioural equations. Long-run wages (total wages and salaries divided by total employment) are modelled using a wage mark-up model. Long-run wages are set equal to output prices (GDP deflator) plus productivity (output per worker). The productivity term is adjusted to correct for possible distortions due to transfer pricing, and so is measured as real GNP per worker as opposed to GDP per worker. A dummy from 1995q1 onwards is included to account for the declining share of labour income as a proportion of output from this point. This pattern reflects increased labour productivity without associated rapid wage increases (see Cassidy, 2004).

In the short-run, wage dynamics are modelled as a function of lagged wages, the deviation from the long-run and the unemployment gap, i.e. the deviation of the actual unemployment rate from the time-varying NAIRU outlined in the supply side of the model. In general it was difficult to model the short-run dynamics of Irish wage inflation. This may, in part, be due to the national rounds of wage bargaining in Ireland, which have been in place since 1988. These result in wage increases being agreed across most of the public and private sectors for a specified period of time (usually up to three years). An additional reason for the difficulties may be to do with the close links between the Irish and UK labour markets.

After considering many alternative specifications and different measures of the NAIRU[14], a fully imposed or calibrated equation was finally selected, with results from estimation of the variations considered and the equation from the previous version of the model used as a benchmark, along with the performance of the equation in the model context. The wage equation is a key equilibrating mechanism in the model, with the unemployment gap bringing wages, short-run marginal costs and prices into line. While it would have been preferable to have been in a position to use a freely estimated equation, in the interests of model coherence and functioning, calibration was necessary.

GDP deflator

As noted above, the long-run output price deflator is derived by inverting the production function and obtaining the dual cost function. First order conditions yield an expression for marginal cost and output prices and are then set equal to the marginal cost expression scaled by the parameter 'eta', a mark-up over marginal cost, which denotes the economy-wide assumption of imperfect competition, in order to arrive at an expression for long-run prices. The short-run movements in the GDP deflator depend principally on the ECM term, with lagged changes of the dependent variable included.

The main concern of the long-run specification of consumer prices is to provide a means of capturing both internally generated price pressures as well as import price pass-through factors. The long-run specification is based on a weighted average of domestic and foreign prices. Changes to foreign prices, arising from either trading partners prices or the exchange rate, will feed into consumer prices via the import deflator and from there to the GDP deflator[15]. Short-run dynamics are represented in the usual ECM format.

Other deflators modelled include expressions for exports and imports, government consumption and capital formation and private capital formation. All of these are modelled as error correction models with relevant deviations from long-run equilibrium terms. The presence of the housing block requires a housing investment deflator as noted above. Unlike other demand component deflators, the stock changes deflator is not

14 The NAIRU used was kindly provided by Aidan Meyler, ECB, and is based on Meyler (1999). Four alternative measures of the NAIRU were provided, based on overall HICP inflation, services inflation, manufacturing wage inflation and ''domestically generated'' inflation. The latter is defined as the gap between services and goods inflation and is recommended by Meyler as a proxy for capturing excess domestic inflation arising from labour market disequilibrium. This is the version which was used. The unemployment gap is then extracted using the Kalman filter technique from the price data.

15 There can be some role for domestic developments influencing the domestic price level such as a change in the NAIRU. This does not cut across the idea that external prices form a nominal anchor in the sense that in a very long run simulation with the exogenous variables held constant, or growing at a realistic rate, the domestic rate of inflation will be determined by external developments.

separately determined, but rather is a residual item to ensure that the evolution of the individual deflators is consistent in aggregate with the GDP deflator so as to avoid ‘‘adding-up’’ problems for nominal GDP and its components.

The import deflator equation has changed since the previous version of the model. The long-run relationship in the first version was a function solely of competitors prices whereas the GDP deflator and energy prices were retained in this version. The short-run equation in this new version includes the ECM term, lags of the dependent variable and changes in competitors prices and energy prices.

Fiscal Block

A basic fiscal block is included in the Irish model. The general government block is mainly made up of identities for variables such as public consumption, budget balance, public savings, net government lending and consolidated debt of the government. The interest payments on government debt are also exogenous in the model.

The only behavioural equation estimated in the government block is that for transfers to households. The change in transfers is specified as a function of lagged changes in transfers, the change in the unemployment level and the lagged change in nominal GDP.

Indirect taxes in nominal terms are modelled as a product of an exogenous indirect tax rate and an indirect tax base. The tax base is composed of expenditure by households, the government, firms’ investment and exports. Direct taxes in nominal terms are modelled as the product of an exogenous direct tax rate and a direct tax base. The direct tax base depends on the total remuneration of employees, nominal transfers to households and other income. While direct and indirect tax rates are, at present, exogenous in the fiscal block, later extensions of the model may include some sort of fiscal reaction function involving tax rates to help stabilise the model in long-run simulations.

Trade

The foreign trade block of the Irish model comprises long and short-run equations for real imports and exports. Nominal imports and exports are identities obtained by multiplying the real variables by their respective deflators. Long-run relationships are established between trade volumes and measures of external demand and weighted domestic demand along with appropriate relative price measures. Short-run dynamics are represented by the standard ECM formulation, including the ECM term and lagged changes in the variables.

Long-run exports in the MCM models are specified as a function of world demand and competitiveness[16]. Data on world demand and competitors prices are supplied by the ECB. Within the MCM country blocks, it is necessary that the coefficient on world demand is unity in order to operate the models in linked mode. A value greater than unity implies that a country's exports and therefore output would grow at a faster rate than world demand in the long-run and this would not be feasible.

As is well known, Irish exports have grown enormously in the period under consideration with the majority of this growth fuelled by foreign direct investment (FDI). Capturing this growth in an econometric equation proved problematic. With world demand and competitiveness as the only explanatory variables, the coefficient on world demand could not be constrained to unity. The addition of a time trend did not help. Isolating the effect of the FDI boom on exports is complicated by the lack of suitable data on FDI over the full estimation period. A variable measuring the share of industry in total output was constructed and included in an attempt to proxy for the strong export performance of the foreign-owned sector. Inclusion of this variable and a time trend was necessary in order to constrain the coefficient on world demand to unity.

Incorporation of a correctly signed and significant ECM term in the short-run estimation also proved problematic. The approach taken was to constrain the coefficient on the ECM term in the short-run equation and then proceed with a general to specific approach. However, the resulting equation did not perform satisfactorily when embedded within the model. Therefore, as with the wage equation, the short-run export equation was calibrated using results from estimation of the variations considered and the equation from the previous version of the model used as a benchmark, along with the performance of the equation in the model context. The resulting equation contains lags of the dependent variable, relative prices, world demand and the ECM term.

The long-run imports equation is specified as a function of weighted demand, relative prices and a time trend. The weighted demand variable was constrained to have an elasticity equal to unity and relative prices yielded a relatively inelastic effect. The weighted demand variable is compiled with weights obtained from input-output tables and includes personal consumption, government consumption, investment and exports. The resulting short-run expression for imports includes the ECM term, changes in weighted demand and in relative prices.

16 For more detail on the estimation of the trade block see O'Donnell, (2005).

In terms of the balance of payments, international transfers are an exogenous variable in the model. Given the value of nominal imports and exports, the remaining component of the current account is net factor income. In modelling net factor incomes, we have used a somewhat non-standard specification as, in the past, we found that net factor outflows are closely related to the levels of nominal exports. This is mainly due to the presence of the foreign-owned high-technology sector where export earnings and factor income flows are very closely related. Remaining factor flows such as interest payments on the national debt are quite small in comparison to the outflow of profits from this sector. Thus, net factor income is specified as a function of current and lagged nominal exports.

6. Discussion and Conclusion

The Bank's macro-model has been re-estimated over a longer and more up-to-date sample, covering the period 1980 to 1999. Significant improvements have been made in this version of the model, compared to its predecessor. These include the use of a non-linear productivity growth rate in the production function and the introduction of a housing block. The inclusion of disposable income in addition to wealth in the long-run consumption function can also be noted here as can the richer specification of the import deflator.

Macro-econometric modelling is a dynamic process and plans are already underway for the estimation of the next version of the model. For the first time, this will be estimated on a database based on ESA 95 data and will include official CSO quarterly National Accounts data, which is now available from the mid 1990s onwards. Annual data for the preceding period will be interpolated to a quarterly basis. The use of actual quarterly data will signify a major advancement in terms of data management as new data for principal macro variables for future periods will then be simply appended to the model databank as it becomes available, thus removing the need for major interpolation exercises, as are currently required, to extend the databank.

The use of the most up-to-date data available in the next estimation phase should also mean that a greater weight will be given to the post-1995 period. As described above, the booming economy after this point posed problems in estimation, most notably in the exports and wages equations. It is hoped that the availability of more current data, which will mean that these years will form a greater proportion of the databank, will lead to a model that better reflects the structure of the economy as it currently stands. Future work may also consider the development of a model variant with features more specific to Ireland but which are not necessarily included in the MCM framework.

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