NiGEM Overview

NiGEM is an estimated model, which uses a ‘New-Keynesian’ framework in that agents are presumed to be forward-looking but nominal rigidities slow the process of adjustment to external events.

A policy-advice model, NIGEM is also designed to be flexible where assumption on behaviour and policy can be changed. Agents can be assumed to look forward in some scenarios, but not in others. Financial markets are normally assumed to look forward and consumers are normally assumed to be myopic but react to changes in their (forward looking) financial wealth. Monetary policy is set according to rules, with defaults designed for speed. However, interest rate feedback rules can be changed, and their parameters adjusted.

Hence there is no such thing as ‘the NiGEM simulation results suggest ’ but rather, ‘under these assumption the NiGEM simulation results suggest ‘. This is perhaps different from the options given by others in their models, and it reflects the widespread use of the model for policy analysis.

The structure of the NIGEM is designed to correspond to macroeconomic policy needs. NiGEM is a structured around the national income identity, can accommodate forward looking consumer behaviour and has many of the characteristics of a Dynamic Stochastic General Equilibrium (DSGE) model. Unlike a pure DSGE model, NiGEM is based on estimation using historical data. It thus strikes a balance between theory and data and enables using the NIGEM both for policy analysis and forecasting.

Although New Keynesian and DSGE models are frequently assumed to be the same, they incorporate distinct approaches. New Keynesian models often involve a small number of equations, estimated in a VAR and specified in logarithms. A good recent example being that used by Gali and Moncelli (2005). They describe output, price formation, the monetary feedback rule, the trade balance and the exchange rate and include forward looking behaviour. DSGE models, such as those stemming from Rotemberg and Woodford (1997) are based on the national income identity, which links the optimising behaviour of individuals.

In New Keynesian models, fiscal multipliers are inherently constant over time unless of the model are forced to be time dependent. More complete DSGE style models link logarithmic equations through linear identities, multipliers do not directly link to parameters but also depend on levels of openness and financial sophistication.

Model Coverage

Overview

Most countries in the OECD are modeled separately. The rest of the world is modeled through regional blocks: Latin America, Africa, East Asia, Developing Europe, OPEC and a Miscellaneous group mainly in West Asia. All models contain the determinants of domestic demand, export and import volumes, prices, current accounts and net assets, and the OECD countries are more complex than those of the non-OECD countries.

The core of each of these country models consists of a production function determining output in the long term; a wage-price block; a description of the government sector; consumption, personal income and wealth; international trade; and financial markets. We use a dynamic error-correction structure on the estimated equations, which allows the model to adjust gradually towards equilibrium in response to a shock. In some cases the speed of adjustment will depend on expectations as well as distance from equilibrium

Linkages

Linkages in NiGEM take place through trade and competitiveness, interacting financial markets and international stocks of assets. The model is homogeneous in exchange rates, and exports demand equals imports across the world. Competitiveness acts as an important stabilising feedback on the model, as shifts in the domestic price level or the exchange rate feed into relative trade prices, allowing net trade to offset shifts in domestic demand.

There are also links between countries in their financial markets as the model describes the structure and composition of wealth, emphasizing the role and origin of foreign assets and liabilities as well as the distinction between equity, bond and bank based assets, all of which are covered. Equilibrium output depends on the production function underlying the model, and the output gap is the deviation of actual from equilibrium output

Expectations

The NiGEM model allows forward-looking expectations in wages, consumption, exchange rates, bond and equity prices and in monetary policy making. We assume forward-looking behaviour by default in most cases, except in the case of consumption where the evidence of forward-looking behaviour is less clear.

Bond prices affect wealth and depend on long-term interest rates, which are the forward convolution of short-term interest rates, and equity prices, which depend on expected future profits, also affect wealth. A solution method is, therefore, needed that allows us to solve for their current and future values.

We use the Extended Path Method of Fair and Taylor to obtain values for the future and current expectations and iterate along solution paths. Expectations are repeatedly recalculated until convergence is achieved. The model is solved far enough into the future so that the results are not affected by the terminal date. Terminal conditions are standard, and embed steady state properties where appropriate.

Trade

The trade equations depend upon demand and relative competitiveness effects, and the latter are defined in similar ways across countries. It is assumed that exporters compete against others who export to the same market via relative prices and demand is given by the imports in the markets to which the country has previously exported while imports depend upon import prices relative to domestic prices and on demand. As exports depend on imports, they will rise together in the model. Systems of trade equations are 'closed' to ensure that the world balance of trade adds up, at least to its normal degree of accuracy, in any simulation.

The equations are estimated in equilibrium correction form, with panel data techniques being used in recent research. The model covers trade in goods and services, with export prices and import prices being linked for consistency using Armington matrices for demand and prices. Trade competitiveness depends upon relative prices, and after any shock the model should return to a long run real equilibrium exchange rate pattern of its own accord.

Financial Markets

Interest rates and exchange rates are set differently in forecast and simulation mode, as in a forecast the markets contain information, and we would normally only depart from market paths for interest rates and exchange rates when we feel we have specific model based information. Forecasts are generally based on judgments about interest rates and exchange rates. These judgements depend both on model outturns, the implications of small forecasting models, and the discussion of prospects amongst the group. Once interest rates and exchange rates are set financial market developments follow, with an evaluation of potential profits based on the model forecast and hence the construction of a forecast for equity prices. These model based exercises influence forecast outcomes significantly

In scenario mode, forward looking nominal long rates and long real rates are a forward convolution using expected short-term nominal and real interest rates respectively Forward looking exchange rates have to look one period forward along the arbitrage relation involving domestic and foreign short term interest rates, with expected exchange rates next period being solved for in the same way to produce a forward recursion. Forward looking equity prices are solved out from the discounted sum of expected discounted profits. The discount factor is made up of the nominal interest rate and the risk premium on equity holding decisions. There are equations for long rates and equity prices in backward scenarios.

MODEL STRUCTURE

OVERVIEW

For a macro-econometric model to be useful for policy analyses, particular attention must be paid to its long-term equilibrium properties. At the same time, we need to ensure that short-term dynamic properties and underlying estimated properties are consistent with data and well-determined. As far as possible the same theoretical structure has been adopted for each of the major industrial countries, except where clear institutional or other factors prevent this. As a result, variations in the properties of each country model reflect genuine differences in data ratios and estimated parameters, rather than different theoretical approaches. The behavioural equations have been mostly estimated individually, although key equations have been estimated in a panel framework.

PRODUCTION

The major country models rely on an underlying constant-returns-to-scale CES production function with labour-augmenting technical progress.

$$Y_t = \gamma\left[\delta\left(K_t\right)^{-\rho} + \left(1-\delta\right)\left(L_t e^{\lambda t}\right)^{-\rho}\right]^{-1/\rho}$$

where is Q is real output, K is the total capital stock, L is total hours worked and t is an index of labour-augmenting technical progress. This constitutes the theoretical background for the specifications of the factor demand equations, forms the basis for unit total costs and provides a measure of capacity utilization, which then feed into the price system. The approach to the estimation of the production function is set out in Barrell and Pain (1997). The elasticity of substitution is estimated from the labour demand equation, and in general it is around 0.5. This estimate is used in the calibration of the other parameters of the production function, and an estimate of technical progress is calculated. Similar results can also be produced with systems estimation s Barrell, Guillemineau and Holland (2007) show.

$$\ln(L) = \left[\sigma\ln\left\{\beta\left(1-s\right)\right\} - \left(1-\sigma\right)\ln\left(\gamma\right)\right] + \ln\left(Q\right) - \left(1-\sigma\right)\lambda i - \sigma\ln\left(w/p\right)$$

$$\ln(K) = \left[\sigma\ln\left(\beta s\right) - \left(1-\sigma\right)\ln\left(\gamma\right)\right] + \ln\left(Q\right) - \sigma\ln\left(c/p\right)$$

Demand for labour and capital are determined by profit maximisation of firms, implying that the long-run labour-output ratio depends on real wage costs and technical progress, while the long-run capital output ratio depends on the real user cost of capital:

where w/p is the real wage and c/p is the real user cost of capital. The user cost of capital is influenced by the forward-looking real long-run interest rate, as well as by corporate taxes and depreciation. The user cost of capital variable is calculated from data for the past, and is a weighted average of the cost of equity finance and the margin adjusted long real rate, with weights that vary with the size of equity markets as compared to the private sector capital stock. These issues are discussed in Barrell and Holland (2007) where the consequences of individual firms taking account of risk on their investments is analysed. The risk premium mark up above the risk free user cost can be varied in scenarios and forecasts, and it affects investment. Investment is determined by the error correction

based relationship between actual and equilibrium capital stocks, where the speed of adjustment, for instance in the US, depends on Tobin's Q and government investment depends upon trend output and the real interest rate in the long run.

Price Setting

Prices are determined as a constant mark-up over marginal costs in the long term. Our core price equations related the producer price to the unit total cost function implied by our production function. Import prices also feed into producer prices, while consumer prices are determined by producer prices, import prices and unit labour costs. The price equations are all statically homogenous. Capacity utilisation is determined by the production function, which gives capacity output, and if output is above capacity producer prices rise more rapidly. We may write capacity output YCAP as dependent on the actual capital stock K, and the steady state level of employment (ES) multiplied by hours per person in employment (HS). In most applications actual rather than steady state employment and hours are used.

$$YCAP_t = \gamma\left[s\left(K_t\right)^{-\rho} + \left(1-s\right)\left(ES_t HS_t e^{\lambda t}\right)^{-\rho}\right]^{-1/\rho}$$

A change in the rate of technical progress will change the capacity output of the economy, and it will change prices. This has been applied to the effects of R&D in the analysis of the impacts of the Lisbon Process for the European Commission's 2007 Competitiveness Report, and the results are available in Barrell and Kirby (2007).

Labour Markets

We assume that employers have a right to manage, and hence the bargain in the labour market is over the real wage. Real wages, therefore, depend on the level of trend labour productivity as well as the rate of unemployment. We assume that labour markets embody rational expectations and that wage bargainers use model consistent expectations. The equations are estimated within a stylized version of the bargaining framework of Layard et al (1991). The dynamics of the wage market depend upon the error correction term in the equation and on the split between lagged inflation and forward inflation as well as on the impact of unemployment on the wage bargain. The sets of panel equations in Barrell and Dury (2003) are dynamically homogenous, and they show that the Italian labour market is reacts more rapidly to nominal shocks than do those in Germany and France, but that there are significant similarities to Spain and Portugal in the long run. The weight on expected inflation in the 1990s is estimated to be around 0.5, well below that estimated for Italy in the 1970s and early 1980s in Anderton and Barrell (1995).

There is no explicit equation for sustainable employment in the model, but as the wage and price system is complete the model delivers equilibrium levels of employment and unemployment. An estimate of the NAIRU can be obtained by substituting the mark-up adjusted unit total cost equation into the wage equation and solving for the unemployment rate1. The labour supply is determined by demographics and an exogenous participation rate. The total population is related to the population of working age by an activity rate which can be varied in scenarios that look at extending working lives with a given expected life, as in Barrell (2007). Barrell and Kirby (2007) investigate the impact of having an endogenous participation rate when evaluating the Lisbon reform process. Increases in labour supply affect real wages, and the can be generated by migration (as in Barrell, Fitzgerald and Riley (2007)) as well as by changes in activity rates and participation rates

CONSUMPTION

Consumption decisions are presumed to depend on real disposable income and real wealth in the long run, and follow the pattern discussed in Barrell and Davis (2007). Total wealth is composed of both financial wealth and tangible (housing) wealth where the latter data is available.

$$\ln(C) = \alpha + \beta \ln(RPDI) + (1-\beta)\ln(RFN + RTW)$$

where C is real consumption, RPDI is real personal disposable income, RFN is real net financial wealth and RTW is real tangible wealth. The impacts of credit constraints and banking sector effects have been investigated in Al Eyd and Barrell (2005) and Barrell, Davis and Pomerantz (2006), where they appear respectively in the dynamics of adjustment and in shift dummies reflecting credit constraints. The role of house prices has been discussed at length in Barrell and Davis (2005) and in Al Eyd, Barrell, Davis and Pomerantz (2005), and where possible housing wealth or house prices are included in the model. However, these effects are not present in all countries, and are absent from the description of consumption behaviour in Italy, for instance. This example shows the advantage of using pooled mean group panels as they allow us to test for structure rather than imposing it, and this allows us to demonstrate significant differences between countries.

INCOME

If we switch the model to forward-looking consumer behaviour, then we need to find a proxy for unobservable permanent income (the income stream from the net present value of human wealth). We assume that RPDI is a good indicator of permanent income in our long run estimation (although measured with error) and in some of our simulations we replace it with the variable for which it was a proxy. If incomes or interest rates change in the future in these specific simulations then the proxy variable will change and consumers will react to their permanent incomes2. We may define permanent income as

$$PI_t = rp_t \left[HW_t \right]$$

$$HW_t = \left[RPDI_t + HW_{t+1} \Big/ \left((1 + rr_t)(1 + cm_t) \right) \right]$$

where rp is the rate of return applied to capitalized income HW, RPDI is current real disposable income and the discount factor is made up of the real interest rate rr and the mark up above rr that is used by consumers, cm. Changes in this latter term change the effective horizon for consumers, and if it is large they become myopic. Solving out the equation for HW gives the expected net present value of all future income.

The dynamics of adjustment to the long run are important in policy analysis and they are largely data based, and differ between countries to take account of differences in the relative importance of types of wealth and of liquidity constraints. Personal incomes are built up from components. Employment income comes from the labour market models. Taxes and transfers come from the public sector models. Rents, dividends and interest incomes are flows on the accumulated stocks of assets, and gross income receipts and payments are modelled as part of other personal incomes. If the wedge between borrowing and lending rates go up then net income falls, and with forward looking

consumers the change in the future flow of income affects behaviour now. Barrell and Davis (2007) discuss the impact of financial liberalisation on the dynamics of adjustment in a group of countries where housing wealth can be utilized for borrowing.

WEALTH

Financial wealth depends on foreign and domestic equity and bond prices and on the accumulation of assets. The evolution of gross financial assets and liabilities are modelled in the wealth blocks of the model, and these are explained in Barrell and in't Veld (1992).

We have followed common modelling practice such as adopted by Masson et al (1990) and assume that the personal sector has ultimate ownership of all domestically held financial assets. Each country on the model has a stock of foreign assets and a stock of liabilities. These are linked to the stock of domestic financial assets and the stock of domestic private sector and public sector liabilities. A proportion of government debt is owned abroad, as are proportions of the national stock of equities and the stock of banking assets. Some national financial wealth is held in foreign equities and bonds as well as banks. Income flows from asset stocks are allocated in relation to ownership, and hence net property income from abroad depends on income receipts and payments on bonds, equity holdings and bank.

The wealth and accumulation system allows for flows of saving onto wealth and for revaluations of existing stocks of assets in line with their prices determined as above. When foreign equity and bond prices change, domestically held assets change in value. Where housing wealth is included, as in the major economies except Italy, we use published data on the stock, and accumulation takes place through the investment flow less depreciation and costs, whilst revaluations follow from change sin house prices. House prices in turn can be forward looking, reacting to the discounted future stream of rental income.

FINANCIAL MARKETS

We generally assume that exchange rates are forward looking, and 'jump' when there is news. The size of the jump depends on the expected future path of interest rates and risk premia, solving an uncovered interest parity condition, and these, in turn, are determined by policy rules adopted by monetary authorities

$$RX_t = RX_{t+1}\left[\left(1+rh\right)\Big/\left(1+ra\right)\right]\left(1+rprx\right)$$

where RX is the exchange rate, rh is the home interest rate, ra is the interest rate abroad and rprx is the risk premium. Relationships of this form are investigated empirically in Al Eyd, Barrell and Holland (2006) and the implications for risk premia for the evolution of current accounts are discussed in Barrell, Holland and Hurst (2007). In most analyses, we assume that the risk premium is exogenous, and hence exchange rate developments follow from changes in expected interest rates at home and abroad.

Monetary Rules

There are two classes of monetary rule on the model, and they are discussed in Barrell and Dury (2000a) Barrell Dury and Hurst (2001) and they are investigated further in Barrell, Hall and Hurst (2006). The first class of rules are those that target a nominal magnitude, such as the money stock, nominal GDP or the price level, whilst the second class follows from the Taylor principle, and set deviations from the steady state interest rate in relation to deviations from target inflation with a moderating impact form the output gap. For a nominal aggregate rule it is assumed that the monetary authorities adopt a feedback rule the interest rate, r, of the form

$$r_t = \varphi_1 \left(NOM_t / NOMT_t \right) + \varphi_2 \left(INF_t - INFT_t \right)$$

where NOM is nominal GDP, NOMT is its target, INF is the inflation rate and INFT is the target. We use this rule as a default in Europe. Other nominal rules can be used, but they are of the same form, and replace Nom with the price level for instance. Those following the Taylor principle can be written as

$$rr_t = rs_{t+} \delta_1 \left(INF_{t+j} + INFT_{t+j} \right) + \delta_2 \left(OG_{t+i} \right)$$

where rr is the current real interest rate, rs is the (unknown) steady state interest rate, and OG is the (unobservable) output gap. Forward values of targets and outturns can be used, and we normally implement this class of rule with one period ahead expectations, but expectation over one year from the last observable can be chosen. There are three versions of each class of rule available, and parameters can be changed with ease.

Bond & Equity Markets

We assume that bond and equity markets are also forward looking, and long-term interest rates are a forward convolution of expected short-term interest rates. Forward looking equity prices are determined by the discounted present value of expected profits. The discount factor is made up of the nominal interest rate and the risk premium on equity holding decisions. Equity market contagion is discussed in Barrell and Davis (2007a).

Public Sector

Each country has a set of equations for the public sector. Both direct and indirect taxes depend upon their respective tax bases and on the tax rate. Government spending on current goods and services and investment spending depend in part on current plans, and by default rise with trend output. Transfer payments depend upon unemployment and the dependency ratio as well as on policy. Government interest payments are determined by a perpetual inventory model based on the flow deficit and the stock of debt, with the appropriate structure of short and long-term interest payments on the debt stock.

Aspects of the public sector is discussed in Barrell and Sefton (1997), which concentrates on closure rules, in Barrell et al (2004) which looks at multipliers, as does Barrell, Holland, Liadze and Pomerantz (2007) who also look at cross country spillovers, and in Al Eyd and Barrell (2005) which looks at multipliers from different taxes in Europe.

INCOME TAX

Budget deficits are kept within bounds in the longer term through a targeted adjustment on income tax rates, much as described in Mitchell, Sault, and Wallis (2000)

$$Tax_t = Tax_{t-1} + \phi\left[GBR_t^* - GBR_t\right]$$

Where Tax is the direct income tax rate and GBR is the general government deficit as a share of nominal GDP and * denotes the targeted ratio. This simple feedback rule is important in ensuring the long run stability of the model. Another important feedback is related to the financing of the government deficit (BUD), which can be financed through either money (M) or bond finance (DEBT).

$$Debt_t = Debt_{t-1} - BUD_t - \Delta M_t$$

The debt stock affects interest payments and forms part of private sector wealth. Without a solvency rule or a no Ponzi games assumption there is no necessary solution to a forward-looking model.

EXTERNAL TRADE

International linkages come from patterns of trade, the influence of trade prices on domestic price, the impacts of exchange rates and patterns of asset holding and associated income flows. The volumes of exports and imports of goods and services are determined by foreign or domestic demand, respectively, and by competitiveness as measured by relative prices or relative costs. The estimated relationships also include measures to capture globalization and European integration and sector-specific developments.

It is assumed that exporters compete against others who export to the same market as well as domestic producers via relative prices; and demand is given by a share of imports in the markets to which the country has previously exported. Imports depend upon import prices relative to domestic prices and on domestic total final expenditure. As exports depend on imports, they will rise together in the model. The panel work we have undertaken on imports is discussed in Barrell, Liadze and Pomerantz (2007)

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