An international comparison of employment in recovery

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While the global economic recovery remains fragile, output in most of the major advanced economies has been rising since mid-2009. Employment, however, tends to lag production, and unemployment continued to rise well into 2010 in many countries. The ILO estimates that the level of unemployment remains elevated by 30 million worldwide relative to 2007 (ILO-IMF, 2010). After taking into account global population developments, this points to a rise in the global unemployment rate of about ¾ percentage point. As the advanced economies have been faced with the brunt of the global downturn, unemployment rates have risen far more significantly within the OECD area. The unemployment rate in this region remains 3 percentage points higher than at the beginning of 2008.

This note updates a previous study of labour market behaviour during the global recovery (Holland, Kirby and Whitworth, 2010a) and extends two earlier studies of labour market responses to the global economic crisis (Holland, Kirby and Whitworth, 2009 and 2010b). While the first two notes discussed employment responses to the downturn, this note focuses on employment responses to the recovery. For comparative purposes we restrict our analysis to the countries studied in the previous two notes, covering thirteen advanced economies.

In Holland, Kirby and Whitworth (2009) we demonstrated a simple rule of thumb between output growth and the unemployment rate in the OECD as a whole, based on Okun's approach. Using a dataset that spans from 1988–2008, this suggests that on average if output rises by 1 percentage point more than trend growth of 0.6 per cent per quarter, this is associated with a decline of 0.6 percentage points in the unemployment rate across the OECD economies. In our analysis of July 2009, at the depth of the global recession, unemployment at the OECD level had risen by somewhat less than anticipated by this simple rule of thumb.

The most recent figures for OECD output and unemployment in the final quarter of 2010 indicate that the level of GDP remains 0.7 per cent below the level in the first quarter of 2008, while the unemployment rate has risen by 3 percentage points. If we narrow our analysis to the period of recovery, output rose by 4.7 per cent in the OECD between the first quarter of 2009 and the fourth quarter of 2010, while the unemployment rate rose by a further 1 percentage point. Figures 1 and 2 put these numbers into context with developments in individual economies and with our rule of thumb.

Figure 1 illustrates the change in output from its pre-recession peak to the fourth quarter of 2010 against the change in the unemployment rate over the same period in a selection of countries. We include the regression line from the rule of thumb equation reported in Holland, Kirby and Whitworth (2009) to give an indication of which countries have over- and under-performed relative to expectations based on this rule. When assessing labour market performance by Okun's rule of thumb, it is important to bear in mind that there is likely to be a permanent loss of output associated with the financial crisis. Financial crises do not necessarily lead to a permanent loss of output. Barrell *et al*. (2010) emphasise that only one in four crises in the OECD have left permanent scars on the level of output. However, we assume that the current crisis will induce a permanent adjustment to risk perceptions and appetite, and expect a long-run loss in the level of output of about 3 per cent on average in the OECD (Barrell, 2009). We allow for this adjustment to the rule of thumb regression line illustrated in figure 1.[1]

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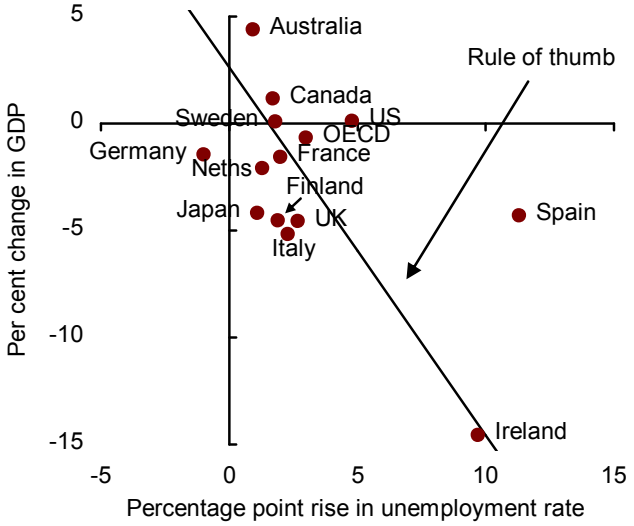
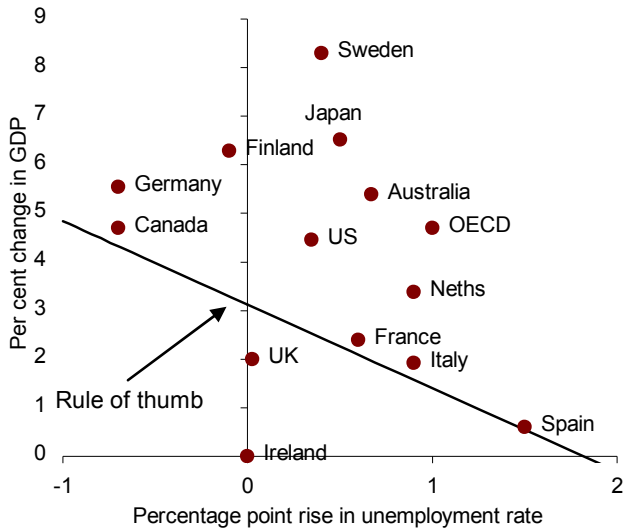
[1] We make no such adjustment to figure 2, as the bulk of the output adjustment is assumed to have been completed by the time the economy starts growing again.

Figure 1. Unemployment rate against output loss



Pre-recession peak to 2010Q4

Figure 2. Unemployment rate against output loss



Recession trough to 2010Q4

Countries that lie below the rule of thumb line, such as Finland, Italy, Japan and Germany, have exhibited a relatively small rise in the unemployment rate given their output loss, whereas those that lie above the line have exhibited a greater rise in unemployment than expected. Notably, Australia, the US and Spain have all experienced what might be considered excessive rises in unemployment given their output declines. Ireland, Canada, France, Sweden and the OECD as a whole are all clustered closely around the rule of thumb line. This suggests that the unemployment rates in these countries are broadly in line with our estimate of their output gaps.

Figure 2 focuses on the period of recovery, showing the changes in output and unemployment from the trough of the recession in each country to the final quarter of 2010. Most countries in our sample lie above the rule of thumb line, indicating that the labour market recovery has not kept pace with the output recovery. The exceptions are Spain, Ireland and the UK. However, at least in the cases of Ireland and Spain, this is largely a reflection of the weakness of the output recovery rather than a sign of a strong labour market. Output in both countries continued to decline until the end of 2009, and edged up only slightly in the first half of 2010. Employment continued to decline in both countries into the third quarter of 2010.

While the unemployment rate is a useful conventional measure of labour market slack in the economy, a rise in the unemployment rate can indicate either job losses, or it can reflect new entrants into the labour force who have yet to find employment. The two have very different implications for the productive capacity of the economy. Any adjustment in working time will also not be reflected in the unemployment rate, but does affect both income levels and potential output. In order to assess these important labour market developments, it is useful to monitor total labour input as well as the rate of unemployment. We define labour input as the total number of hours worked, or employment multiplied by the average hours worked per employed person in the economy.

Figures 3 and 4 plot the percentage change in output and labour input since the onset of the recession and since the onset of the recovery, respectively. The shading of the labour input columns allows us to distinguish between shifts in the level of employment and shifts in average working time. Output and labour input both remain below their pre-recession peaks in almost all the countries in our sample. Australia and Canada are the two exceptions. Australia suffered very little in the way of output loss during the global downturn, while Canada has already regained its pre-crisis level of output and surpassed its pre-crisis level of employment. Ireland has experienced the sharpest fall in both output and employment in our sample. Both remain depressed by more than 14 per cent since the onset of the recession.

As we discussed in the previous studies, some countries have shown a stronger bias towards cutting employment, while others have favoured adjustment in average hours of work. Germany exhibited very little employment adjustment throughout the course of the downturn despite a very sharp contraction in output, and the level of employment now stands slightly higher than at the onset of the recession. Average hours have declined by more than employment in Australia, the Netherlands, Germany and Japan, whereas the decline in labour input in Spain is entirely down to employment losses. Average hours of work have actually increased slightly in Spain since the start of the recession, while employment has declined by more than 10 per cent.

The bias towards reducing labour input through average working time partially reflects subsidised short-time worker programmes in Japan, Finland, Italy and Germany. However, Boysen-Hogrefe and Groll point out in their article in this issue of the *Review* that the short-time worker scheme in Germany can only explain a small share in the decline in average hours of work since the onset of the global crisis. The majority of the change is explained by greater flexibility in working time in all firms, which has increased considerably over the past ten years, rather than just the short-time work institutions, which have been available in Germany for 100 years.

Figure 3. Change in GDP and labour input from pre-crisis peak

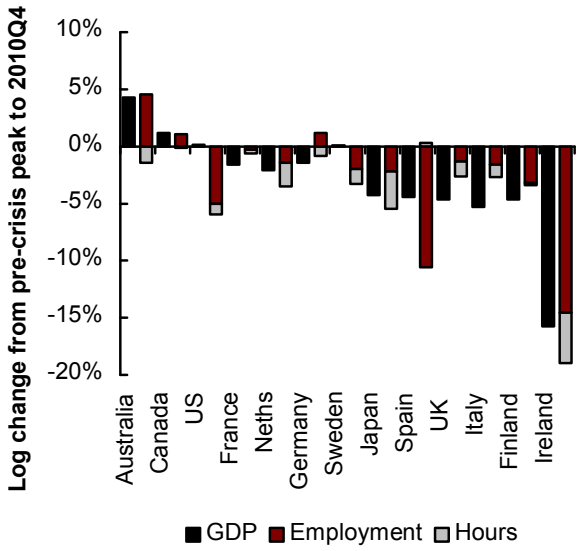


Figure 4. Change in GDP and labour input from recession trough

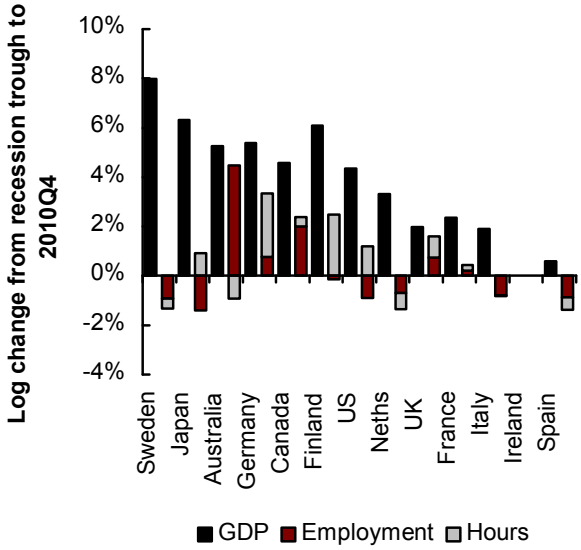
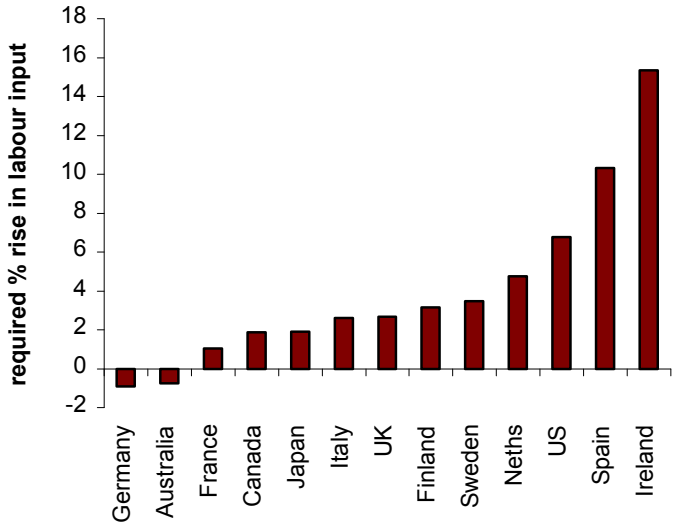


Figure 4 shows that only in Australia, Canada and the UK has the level of employment risen since the trough of the recession in output. Jobs continued to be cut for several quarters after output began rising in many countries. While the level of employment edged up slightly in most countries in the first half of 2010, Spain and Ireland continued to suffer further job losses. The recovery in working time has progressed more rapidly, as might be expected. Firms initially raise labour input to meet production demands by allowing retained employees to recover lost working time, and only subsequently expand their workforce. This appears to be happening in Japan, Germany, Finland, the US, the UK and France, while there is less evidence of a recovery in

average hours of work in Sweden, the Netherlands and Ireland.[2] Average working time in Australia has declined in recent quarters. However, this may reflect a shift in preferences towards leisure rather than under-employment, as Australia suffered very little in the way of a recession. Sweden has seen the strongest recovery in output since the low point in the recession, with a rise of 4.8 per cent in the level of output. However, the labour market has not shown an inclination to keep pace with the recovery in output, and both employment and average working time continued to decline in the first half of 2010.

While figure 3 illustrates the rise in labour input needed to restore pre-crisis levels of labour input, labour market conditions also reflect demographic developments that neither unemployment rates nor labour input levels can indicate. The OECD defines a jobs gap as the rise in employment that is needed to restore pre-crisis levels in the ratio of total employment to the working age population. In countries with strong population growth, such as Australia and Canada, faster job creation is needed in order to keep pace with the new entrants to the labour force. They use population levels rather than labour force levels to abstract from any shifts in labour force participation rates. During a recession, labour force participation is likely to fall, as people may withdraw from the labour force if they are unable to find work for an extended period. OECD estimates point to a jobs gap of nearly 18 million in the OECD area, or 3.3 per cent of employment (OECD, 2010).

Figure 5. Labour input gap



Note: Rise in labour input required to restore pre-crisis ratio of total hours worked to working age population.

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[2] Although, as discussed in Barrell, Kirby and Whitworth (2010), there is evidence that firms are not increasing working hours fast enough to meet demand from employees, as indicated by the increase in people working part-time because they have been unable to find full-time work.

We construct a similar measure, based on total labour input. Our labour input gap reflects the percentage rise in labour input required to restore the pre-crisis ratio of total hours worked to the working age population. These estimates are illustrated in figure 5. All countries in our sample require some rise in labour input in order to restore this ratio. In Germany, Australia, Japan, Canada and France the magnitude of the required rise is small, at less than 2 per cent. A rise of more than 5 per cent is needed in Finland, the US, Spain and Ireland, while more moderate rises are required in the UK, Italy, the Netherlands and Sweden.

As we have emphasised in the previous studies, output is not the sole determinant of labour demand. Employment levels may also be maintained if employees are willing to accept wage cuts as an alternative to layoffs. In a downturn, firms bring in lower levels of revenue, and if they cannot find a way to reduce costs many will go bankrupt. There are four routes through which firms can reduce their labour costs: reducing employment levels; reducing average hours worked per employee; reducing average wages; and raising the average productivity level per employee by investing in more productive technology.

In Holland, Kirby and Whitworth (2010), we calibrated an estimate of the expected change in employment, given actual country-specific developments in output, average hours worked and real wages, by running a series of simulations using NIESR's global econometric model, NiGEM.[3] In this note we take a slightly different approach to calibrating the expected change in employment. We use a long-run labour demand relationship, drawing on the framework developed in Barrell and Pain (1997), which hinges around the marginal product condition of a (CES) production function of the form:

$$Q = \gamma\left[\delta K^{-\rho} + (1-\delta)\left(Le^{tech}\right)^{-\rho}\right]^{-\frac{1}{\rho}} \qquad (1)$$

where Q is output, K is the capital stock, L is labour input, *tech* is the rate of labour-augmenting technical progress, γ is a scaling factor, δ is a distribution parameter and the elasticity of substitution, σ, is given by $1/(1+\rho)$. Profit maximising firms will aim to set the marginal product of labour equal to its cost, which is the real wage paid by producers. This first-order condition reduces to a simple log-linear labour demand relationship of the form:

$$\ln(L) = \theta + \ln(Q) - \sigma\ln(W) + (\sigma - 1)tech \qquad (2)$$

where W is the real wage and is a constant term based on a function of the parameters in equation (1). Taking first differences, splitting labour input in employment (E) and hours (H) and assuming an elasticity of substitution of 0.5 leads to the key equation that forms the basis of our analysis.

$$\Delta\ln(E) = \Delta\ln(Q) - 0.5\Delta\ln(W) - 0.5\Delta tech - \Delta\ln(H) \qquad (3)$$

Given equation (3), we can calculate an expected change in employment for a given change in output, real wages, hours and labour augmenting technical progress. For the first three, we use the observed actual changes. The change in labour augmenting technical progress is more difficult to estimate. As a first estimate, we can assume that the average rate of technical progress is unchanged from the pre-recession period. We use the average growth rate of hourly labour

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[3] For further detail on the structure of the NiGEM model, see the Appendix.

productivity over the period 1997–2007. This is reported as $\ln(E)^{e1}$ in the table above. However, if the economies suffer a permanent loss of output as a result of the financial crisis, this would also be reflected in a decline in trend productivity levels. While the bulk of this can be expected to be effected through capital shallowing, there may be a slowdown in the rate of technical progress as well. Our second estimate assumes no change in the level of technical progress over our sample period. This is reported as $\ln(E)^{e2}$ in the table.

Table 1. Actual and expected employment change

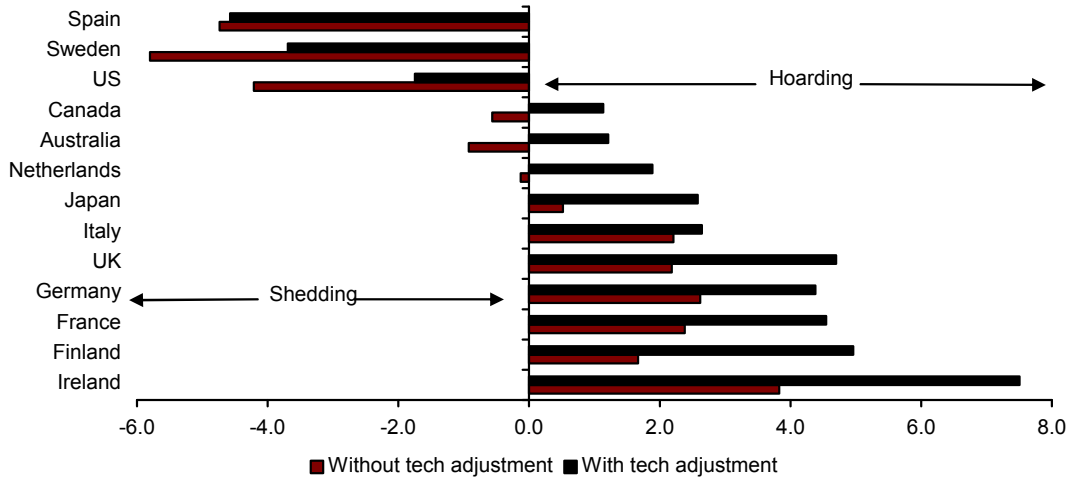
	$\Delta\ln(E)$	$\Delta\ln(E)^{e1}$	$\Delta\ln(E)^{e2}$	$\Delta\ln(H)$	$\Delta\ln(Q)$	$\Delta\ln(W)$	Ave. annual productivity growth 1997-2007
Ireland	-14.5	-22.0	-18.4	-4.4	-15.7	14.1	3.7
Spain	-10.6	-6.0	-5.8	0.3	-4.4	2.2	0.1
US	-5.0	-3.1	-0.8	-0.9	0.1	3.7	2.0
Finland	-3.2	-7.8	-4.8	-0.2	-4.6	0.9	2.6
Japan	-2.2	-4.8	-2.7	-3.3	-4.3	3.3	1.8
Sweden	-2.0	1.1	3.8	-1.3	0.1	-4.8	2.4
Italy	-1.6	-4.2	-3.8	-1.1	-5.3	-0.9	0.4
Netherlands	-1.4	-3.3	-1.3	-2.1	-2.1	2.6	1.5
UK	-1.3	-6.3	-3.5	-1.3	-4.7	0.3	2.2
France	-0.3	-5.1	-2.7	-0.3	-1.6	2.8	1.9
Canada	1.1	0.0	1.6	-0.1	1.2	-0.7	1.4
Germany	1.2	-2.8	-1.4	-0.8	-1.5	1.6	1.6
Australia	4.6	3.6	5.5	-1.4	4.3	0.5	1.7

Note: log changes are multiplied by 100 to approximate percentage changes.
$\Delta\ln(E)^{e1}$ is adjusted for expected labour augmenting technology growth, based on average historical productivity growth.
$\Delta\ln(E)^{e2}$ assumes no change in the state of technology over this period.

Table 1 reports the actual change in employment between the onset of the recession and the fourth quarter of 2010, followed by our two estimates of the expected change in employment derived from equation (3), using the changes in hours, output and real wages reported alongside. To estimate $\ln(E)^{e1}$ we convert the average annual productivity growth to an average quarterly rate, and adjust by the number of quarters between the pre-crisis peak and the fourth quarter of 2010 in each country.

Figure 6 illustrates our estimates of labour hoarding and labour shedding over this period. This is calculated as the difference between the actual change in employment and our two estimates of the expected change in employment from table 1. The bar labelled 'without tech adjustment' is derived from $\ln(E)^{e2}$ while 'with tech adjustment' is based on $\ln(E)^{e1}$.

Figure 6. Labour hoarding and labour shedding since pre-recession peak



According to our indicator, most of the countries in this sample have been hoarding labour since the onset of the recession. Labour hoarding in Finland has been more significant than elsewhere. The exceptions are the US, Australia and Spain, where labour shedding predominates. This is consistent with our findings illustrated in figure 1 above. The evidence is less clear for Sweden and Ireland. After allowing for technological advancement at the same average rate as in the preceding decade, it appears that firms in these countries may have been hoarding labour on average rather than shedding it. Allowing for technology advancement has the effect of increasing the estimate of labour hoarding, or reducing the estimate of labour shedding, as a more productive technology requires less labour input to produce the same amount of output.

The results reported in this paper differ somewhat from those in figure 9 of Holland, Kirby and Whitworth (2010), which indicated a greater tendency towards labour shedding in our sample of countries. There are two key differences to bear in mind when comparing the two approaches. While both studies are based around the long-run labour demand relationship described in equation (2) above, the earlier study allowed for estimated short-term dynamics around this equation within a full macroeconometric model. If dynamics of adjustment tend to be slow, firms will hoard labour over the short term, but begin to shed labour as they adjust to their long-run equilibrium production path. The approach adopted in this note shows us where the economy is relative to its long-term equilibrium, rather than where the economy is relative to where we would expect it to be given the normal dynamic patterns of adjustment within the economy. The other key difference to bear in mind is the time frame. With three quarters of additional information, the adjustment towards equilibrium has progressed from where it appeared to be in January 2010.

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Appendix: The Structure and Use of the NiGEM Model

The National Institute has been developing its global econometric model, NiGEM, since 1987. NiGEM is used internally for forecasting and policy analysis, and is also used by an external group of about 40 model subscribers, mainly in the policy community, including the ECB, the IMF, the FSA, the Bank of England, and the central banks of France, Italy, Netherlands, Spain, Portugal and Sweden. The Institute produces four forecasts a year with NiGEM. These projections are published in the *National Institute Economic Review* each quarter, along with a discussion of alternative scenarios around the central forecast and short notes based on recent model-based research. This work is also presented at several conferences each year, is widely reported in the press and is made available on NIESR's web-based product, NiGEMWEB (http://nimodel.niesr.ac.uk).

NiGEM is a global model, and most countries in the OECD are modelled individually. There are also separate models of China, India, Russia, Hong Kong, Taiwan, Brazil, South Africa, Estonia, Latvia, Lithuania, Slovenia, Romania and Bulgaria, while the rest of the world is modelled through regional blocks. All country models contain the determinants of domestic demand, export and import volumes, prices, current accounts and net assets. Economies are linked through trade, competitiveness and financial markets and are fully simultaneous.

A major use of the model is in policy analysis. In policy analyses the model can be switched between forward looking, rational expectations mode and adaptive learning for consumers, firms, labour and financial markets. Policy environments are very flexible, allowing a number of monetary and fiscal policy responses. The model framework can be used by any user to build a bespoke model or to change the existing structure.

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. Output is tied down in the long run by factor inputs and technical progress interacting through production functions. As far as possible, the same long run theoretical structure of NiGEM 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 and estimated parameters, rather than different theoretical approaches.

Over the past twelve months NIESR has made a number of interventions in the policy debate based on its research on the world economy. There has been a strong focus on fiscal policy this year, through evaluations of the policy response to the downturn, a comparison of fiscal multipliers across countries and across models, assessments of the sovereign debt crisis in Europe, and evaluations of the fiscal consolidation programmes put forward in the UK and in the rest of Europe. This work has been published in the *National Institute Economic Review*, and has also been presented at conferences held by the United Nations, Euroframe, the Kiel Institute and Swedbank. Our work on fiscal consolidation plans has received wide coverage in national and international newspapers, trade and more general publications as well as on national and international TV and radio.

Production and price setting

The major country models rely on an underlying constant-returns-to-scale CES production function with labour-augmenting technical progress. This is embedded within a Cobb-Douglas relationship to allow the factors of production to interact with oil usage:

$$Q = \gamma \left\{ \left[s(K)^{-\rho} + (1-s)(Le^{\lambda t})^{-\rho} \right]^{-1/\rho} \right\}^{\alpha} M^{1-\alpha} \qquad (1)$$

where is Q is real output, K is the total capital stock, L is total hours worked, t is an index of labour-augmenting technical progress and M is oil input. 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 feeds into the price system. Barrell and Pain (1997) show that the elasticity of substitution is estimated from the labour demand equation, and in general it is around 0.5. 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

$$\ln(L) = c_1 + \ln(Q) - (1-\sigma)\lambda t - \sigma \ln(w/p) \qquad (2)$$

$$\ln(K) = c_2 + \ln(Q) - \sigma \ln(c/p) \qquad (3)$$

where c_1 and c_2 are constant terms related to the other parameters in the model, w/p is the real wage and c/p is the real user cost of capital. The user cost of capital is influenced by corporate taxes, depreciation and risk premia 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. Business investment is determined by the error correction based relationship between actual and equilibrium capital stocks. Government investment depends upon trend output and the real interest rate in the long run. Prices are determined as a constant mark-up over marginal costs in the long term.

Labour market

NiGEM assumes 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. Labour markets embody rational expectations and wage bargainers use model consistent expectations. 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 (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 rate. Labour supply is determined by demographics, migration and the participation rate.

Consumption, personal income and wealth

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.

$$\ln(\ C\ ) = \alpha + \beta\ \ln(\ RPDI\ \ ) + (1 - \beta\ )\ln(\ RFN\ \ + RTW\ \ ) \tag{4}$$

where C is real consumption, $RPDI$ is real personal disposable income, RFN is real net financial wealth and RTW is real tangible wealth. The dynamics of adjustment to the long run 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.

Table 1. Key consumption equation parameters

	β	$\Delta\ln(RPDI)$	$\Delta\ln(RTW)$	$\Delta\ln(RTW_{-1})$	$\Delta\ln(RNW_{-1})$
US	0.81	0.15		0.154	0.034
Germany	0.78	0.68	0.022		
France	0.71	0.51			0.038
UK	0.93	0.17		0.160	0.029

Note: β gives the long-run weight on income from equation 1, while other parameters indicate the short-run response of consumption to changes in real income and wealth.

The key parameters embedded in our model equations for the US, UK, Germany and France are reported in table 1. The impact of a change in housing wealth is about five times stronger than the impact of a change in financial wealth in the short run in the US and the UK, whereas wealth effects are relatively weak in Germany and France. Al Eyd and Barrell (2005) discuss borrowing constraints, and investigate the role of changes in the number of borrowing constrained households. It is common to associate the severity of borrowing constraints with the coefficient on changes in current income in the equilibrium correction equation for consumption. This suggests relatively few borrowing constraints in the US and the UK, with a greater degree of borrowing constraints in Germany and France.

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 exchange rate risk premia, solving an uncovered interest parity condition, so that the expected change in the exchange rate is given by the difference in the interest earned on assets held in local and foreign currencies.

$$e_t = e_{t+1}\left(\frac{1+r_t^*}{1+r_t}\right)(1+rp_t) + w_t \tag{5}$$

where e_t is the bilateral exchange rate at time t (defined as domestic currency per unit of foreign currency), r_t is the short-term nominal interest rate at home set in line with a policy rule, r_t* is the interest rate abroad and rp_t is the exchange rate risk premium.

Interest rates are determined by policy rules adopted by monetary authorities as discussed in Barrell, Hall and Hurst (2006). Nominal short term interest rates are set in relation to a standard forward looking feedback rule. Our default rule follows a 'two-pillar' strategy, targeting a combination of inflation and a nominal aggregate. Forward looking long-term interest rates (LR) are a forward convolution of expected short-term interest rates:

$$(1 + LR_t) = \prod_{j=1}^{T} (1 + r_{t+j})^{1/T} \tag{6}$$

We assume that equity markets are also forward looking, with equity prices determined by the discounted present value of expected profits, adjusted by an equity risk premium.

Public sector

We model corporate (*CTAX*) and personal (*TAX*) direct taxes and indirect taxes (*ITAX*) on spending, along with government spending on investment and on current consumption, and separately identify transfers and government interest payments. Each source of taxes has an equation applying a tax rate (*?TAXR*) to a tax base (profits, personal incomes or consumption). As a default we have government spending on investment (*GI*) and consumption (*GC*) rising in line with trend output in the long run, with delayed adjustment to changes in the trend. They are re-valued in line with the consumers' expenditure deflator (*CED*). Government interest payments (*GIP*) are driven by a perpetual inventory of accumulated debts. Transfers (*TRAN*) to individual are composed of three elements, with those for the inactive of working age and the retired, depending upon observed replacement rates. Spending minus receipts give us the budget deficit (*BUD*):

$$BUD = CED*(GC+GI)+TRAN+GIP-TAX-CTAX-MTAX \tag{7}$$

We have to consider how the government deficit (*BUD*) is financed. We allow either money (*M*) or bond finance (*DEBT*), so that the debt stock is related to historical deficits:

$$BUD = \Delta M + \Delta DEBT \tag{8}$$

rearranging gives:

$$DEBT = DEBT_{t-1} - BUD - \Delta M \tag{9}$$

In all policy analyses we use a tax rule to ensure that Governments remain solvent in the long run (Barrell and Sefton, 1997). This ensures that the deficit and debt stock return to sustainable levels after any shock. A debt stock target can also be implemented. The tax rate equation is of the form:

$$TAXR = f(\text{target deficit ratio - actual deficit ratio}) \tag{10}$$

If the Government budget deficit is greater than the target,(e.g. -3 % of GDP and target is -1% of GDP) then the income tax rate is increased.

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 structure of the trade block ensures overall global consistency of trade volumes by imposing that the growth of import volumes is equal to the growth of export volumes at the global level. Trade volumes and prices are linked by Armington matrices, based on 2003 trade patterns. 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 export demand variable is constructed as a weighted sum of other countries' imports, which ensures approximate balance, and any discrepancy is allocated to exports in proportion to the country's share of world trade. Import prices depend on a weighted average of global export prices, and this ensures that the ratio of the value of exports to the value of imports remains at around its historical level. It is assumed that exporters compete against others who export to the same market as well as domestic producers via relative prices. Imports depend upon import prices relative to domestic prices and on domestic total final expenditure. The overall current balance depends upon the trade balance and net property income from abroad, which comprises flows of income onto gross foreign assets and outgoings on gross foreign liabilities. World flows of property income balance because all assets are matched by liabilities, revaluations of liabilities match those of assets and income flows match payments.

Further details on the NiGEM model are available on http://nimodel.niesr.ac.uk/advert/niesr2nigem.php. Enquiries about NiGEM should be addressed to Ian Hurst: aihurst@niesr.ac.uk