THE CBR MACRO-ECONOMIC MODEL OF THE UK ECONOMY (UKMOD)

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Abstract

This working paper provides a detailed exposition of the assumptions, structure and statistical evidence that support a new macroeconomic forecasting and simulation model of the UK Economy. The model is based on an annual dataset that produces conditional forecasts or simulations over a five to ten year horizon. The model enables us to discuss issues of policy in quantitative terms so that the orders of magnitude of the economic consequences can be assessed. Readers of our forecast reports will find in this paper the information that justifies the modelling methodology and the empirical evidence supporting the key behavioural relationships of the model.

JEL codes: E12; E17; E27; E44; E47

Keywords: Macroeconomic policy; fiscal and monetary policy; macroeconomic forecasts; macroeconomic models

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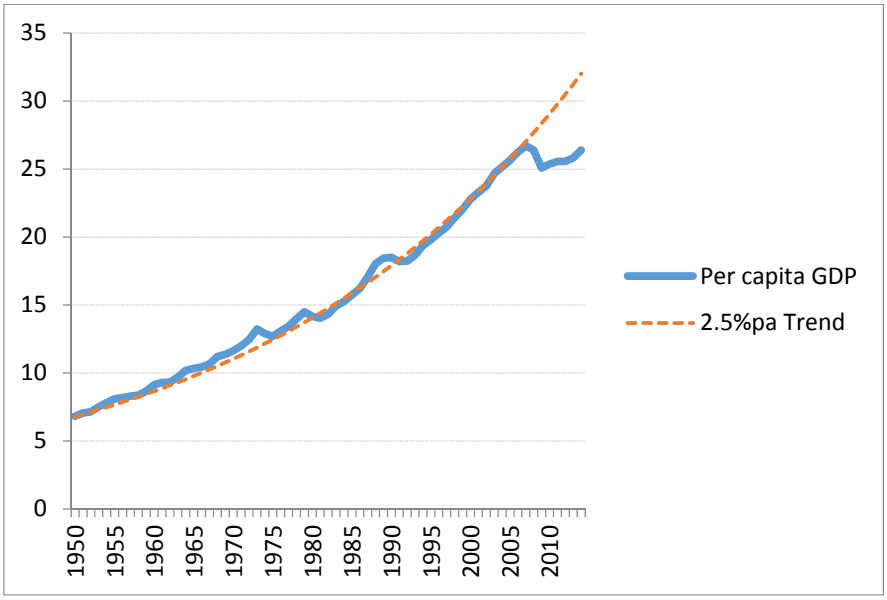
1. Introduction

The CBR model of the UK economy (UKMOD) has been developed as a guide to macro-economic policy-making at a very difficult time in the evolution of the UK economy. After more than 60 post-war years in which the real GDP per head seldom deviated much from a growth path of 2.5% per annum it suddenly slumped after 2007. GDP in 2007 was only 4% below the long-term trend, but by 2014 per capita GDP had unprecedentedly fallen to 21% below this trend (chart 1), and by 2014 involved a huge cumulative loss of 105% of GDP. Even though employment has held up better than anyone expected, unemployment nevertheless rose by close to a million between 2007 and 2011 before falling back by half a million. The cost of a relatively benign jobs performance has been to reduce labour productivity which in 2014 is now 16% below its previous trend. The gap in GDP per hour between the UK and the USA has widened by 8% from its pre-crisis level. If productivity returns at some point to its former relationship with the USA we can expect future pressure on employment unless the economy begins to grow rapidly (and more rapidly than the USA).

Chart 1 Real GDP per Head (2011 prices)



Perhaps not surprisingly, all forecasting models, whether government, academic or commercial, failed to forecast this unprecedented failure of the economy. The timing of financial collapses is inherently difficult to predict but less excusable was the failure of forecasters to warn that a collapse was even likely given the huge previous build-up of debt in the household sector and more particularly within banks.[1] We

might reasonably have expected that Bank of England forecasters for instance would have had insights into the fragility of the UK banking sector. Moreover, almost all UK models then over-predicted the post-2009 recovery. They also under-predicted inflation, which rose to over 5% in the midst of recession, and failed to foresee the rise in employment as the economy stagnated after 2009.

This catalogue of failure suggests that something is badly wrong with the state of forecasting models. The modellers themselves appear to have shrugged off these failures. The recession of 2008/9 has been widely viewed as an unpredictable shock, and the (unforeseen) subsequent slow growth as an unusual but not unprecedented consequence of a severe banking crisis. The forecasting failures however have a cause in an emphasis within conventional models on supply-side factors, in face of what has proved to be a large failure of demand. The Government's OBR model, for example, starts by projecting a trend path for potential output and then assumes that monetary policy will guide the economy toward that path. Any off-path point due to shocks leads to a return to trend within 3 to 4 years.[2] Other forecasters, including the OECD, IMF, and several commercial forecasters, use an approach based on similar principles. This approach can appear reasonable in normal times but will fail in face of a major shock as in 2008. The approach becomes particularly misleading in what Keynes called a 'liquidity trap', when monetary policy becomes ineffective in the face of a deficiency of demand.[3]

Failures in forecasting of this magnitude exhibited since 2008 suggest that some modesty may be required in guiding future macro-economic policy in the UK. In practice, policy advice has continued as if little has happened. The Government asserts that reducing the size of the government debt must be a key priority if the UK economy is to return to economic health, and that major public spending cuts are required to reduce the debt. There has been relatively little modelling work to investigate whether such a strategy is either necessary or practicable. Indeed the nature of the OBR model (and similar OECD and IMF models) means that they cannot be directly used to investigate such questions. The OBR's neo-classical assumption that the economy follows a consistent long-term trend, and will return to this trend relatively quickly after any shock, means that forecasts beyond two or three years ahead are dominated by this assumption and not by fiscal policy or other issues. We believe that this approach to forecasting is especially problematic at a time when government fiscal policy remains restrictive.

The academic economics profession is equally unworldly. The mainstream approach is now to use so-called DSGE (dynamic stochastic general equilibrium) models. These are based on Walrasian general equilibrium principles assuming that market forces will bring the economy back to its full capacity operation subject to certain frictions caused among other things by government regulations. We agree with Keynes's view that neo-classical ideas are of little relevance to the macro-economic behaviour of real economies in major recessions. We also agree with Gregory Mankiw[4] in viewing the development of macro-economic theory over the last several decades in these terms: 'from the standpoint of macro-economic engineering [i.e. practical economic policy-making] the work of the last several decades looks like an unfortunate wrong turn'. Most Central Bank forecasters, including the Bank of England, use a direct DSGE approach with, in the BoE's case, generally poor results.

We reject Walrasian principles as an unhelpful and overly theoretical approach to macro-economic modelling. The attempt to construct macro-economic theory on micro-economic foundations is an interesting exercise worthy of some attention within the wider discipline, but its limited practical application means that it should only ever be a minority interest. Instead we have returned to basic Keynesian principles guided by the further development of Keynesian concepts by Godley and Lavoie in their book *Monetary Economics*.[5] In this approach the level of output in an economy will be determined by effective demand for its goods and services. There is, in this view, no exogenous long term trend in capacity. Instead capital stock and labour supply (including skills) are endogenous. Capital investment depends on expected output which in turn depends on demand. Labour supply in the UK is also increasingly endogenous within an EU area with free movement of labour. Since productivity depends heavily on capital-labour ratios, this is also endogenous and does not have the independent life of its own assumed in many conventional models. Even the very long-term tendency for labour productivity to converge on the technologically most advanced economy has broken down in recent decades as productivity in the UK (and other EU economies) has diverged from the US level.

The UKMOD model is strongly empirical. It consists of series of econometric equations describing how important macro-economic indicators are related to one another in both the long-term and short-term. All equations consist of statistically significant relationships estimated from UK data over recent decades. A Keynesian view of the economic world influences the relationships selected for inclusion in these equations, but ultimately it is the data that determines what precisely is included in each equation and with what weights. There is no overt attempt to insert profit-maximising behaviour into the model except in as far as it is implicit in the

equations for such things as company investment or private-sector employment. Nor is the model precise about the formation of expectations. Since it is assumed that most expectations are based on the recent history of the economy these become subsumed within econometric equations. Importantly, there is no explicit NAIRU (non-accelerating inflation rate of unemployment). Instead we estimate equations for various key aggregate price terms based on past behaviour. In practice these show that price inflation reflects changes in wage and import costs. Wage inflation in return reflects price inflation and the employment rate. Interest rates also influence inflation with a two year lag (mainly via their influence on the sterling exchange rate) but there is no strong tendency in the data for recent decades for inflation to accelerate at any fixed level of unemployment as assumed in many forecasting models. Forecasts and simulations generated with UKMOD indicate that rises in wage inflation associated with low unemployment (or high employment rates) can be contained with relatively small increases in short-term interest rates.

The key exogenous drivers of demand in the UKMOD model are:

- demand for exports (and hence growth in world trade)
- government spending
- household borrowing.

Both government and household spending are determined by a willingness and ability to take on additional debt. Household borrowing reflects the financial regime in place at any given time. For much of the period since the early 1980s banks made it increasingly easy for household sector borrowers to raise the stock of debt, but since the 2008 financial crisis banks have been heavily constrained by a need to repair their balance sheets. The balance between public and private debt plays a key role in our forecasts following Godley's emphasis on the observation that the current balances of the public and private sectors, together with the external balance must sum to zero. The model is also essentially monetary in that the financing of expenditure plays a key role. In this respect it contrasts strongly with neo-classical approaches in real business cycles and similar theories.

2. The UK Macro-Economic model (UKMOD)

UKMOD is an econometric (or structural) model. It describes how sets of exogenous variables (i.e. determined outside the model, such as world trade or the oil price), policy instruments and economic shocks, determine a set of endogenous variables (e.g. GDP or price inflation). It provides a formal representation of how the economy works, based on the ways in which different aspects of economic behaviour have been related in the past, thus providing a guide to future economic change.

The model is Keynesian in that it is largely concerned with determining demand. The structure of the model is conventional within the Keynesian tradition with aggregate demand determined as the sum of household consumption, investment, government consumption, exports and imports. Supply side variables such as capital stock and labour supply are determined endogenously, (or semi-endogenously in the case of labour). It is thus substantially different from the Government's OBR model, and similar models, which are based on forecasting the trend in the UK economy's potential output and the economy's path back to that trend from any given starting point.

The UKMOD model recognises the Godley-Lavoie post-Keynesian principle of stock-flow consistency in that ratios of wealth to income tend to return to a stable level in the long-term. This is implicit in the inclusion of wealth terms in the consumption function rather than having any explicit target for the income to wealth ratio. We have abstracted from Keynes and Godley-Lavoie treatments of the financial sector and asset allocation by treating short-term interest rates as an exogenous policy variable and treating credit for house-holds as semi-exogenous. Long-term interest rates are endogenous and reflect (exogenous) short-term rates among other influences. Wage and price setting is post-Keynesian. Consumer prices are determined by a mark-up on wage and import costs offset by labour productivity. Wages are implicitly set by bargaining to maintain employees' share of firm's value-added, subject to labour market conditions. Wages rise when prices rise and are affected by the level of employment. As indicated above, we find no evidence for a vertical long-run Phillips curve and none for the notion that inflation will accelerate at low levels of unemployment as suggested by much contemporary theory.

The model is based on relationships and interrelationships econometrically estimated on past annual data. Although we accept in principle the Lucas critique that past relationships can change if new policies are introduced, we take the view that this will only apply in unusual or extreme circumstances and is not a sufficiently general fear to vitiate econometric macro-economic modelling.

Most existing models focus on generating short-term forecasts and use a range of contemporary monthly or quarterly indicators and judgements as a guide to where the economy is and to its imminent movements. Since our focus is on policy simulation using annual data we make no use of such indicators or judgements[6]. This allows our equations to work unaltered in generating policy scenarios, but could mean that very short-term 'baseline' forecasts over a single year may be less accurate than other forecast models.

The model consists of:

- 250 variables with data from 1950 to 2014[7]
- 80 econometric equations
- 145 identities

The model is based on the post-Keynesian approach of Wynne Godley described in Monetary Economics by Godley and Lavoie 2007:

- 4 sector approach: households, companies, government and foreign (importantly Godley/Lavoie also has a separate monetary/banking sector which is not yet developed in this model)
- Stock-flow consistent with tendency for ratios of assets to incomes not to diverge too far from long-term averages
- Consumer spending depends on borrowing as well as income, assets and liabilities
- Mark-up pricing (i.e. consumer prices rise with wage and other costs of production)
- Wages determined as attempts to gain a traditional share of value-added but constrained by changes in the employment rate.

The forecasts generated by the model are conditional on a number of exogenous variables chiefly reflecting government fiscal policy and economic conditions outside the UK. A full list of exogenous variables is given in annex B. Key exogenous variables are:

- World trade (weighted by UK markets)
- Government fiscal policy plans (tax rates and *nominal* spending plans).
- Short-term interest rate (used as a policy variable to target consumer price inflation)
- Interest rates in USA

- Global price of oil and other raw materials

In its present form the model does not have a banking sector, although lending to households *is* modelled. Household borrowing is semi-exogenous determined by an equation reflecting past experience in the demand for housing loans but with a partial adjustment mechanism to move from the current situation in which bank lending is constrained by impaired balance sheets to a relatively unconstrained position.

2.1 Estimation of the model equations

Ten key equations are appended to this paper, and a full list of economy econometric equations will be published on the Cambridge Economics website (www.cambridgeeconomics.com). The principles used in deriving the econometric equations are as follows:

- Econometric equations are almost all of the Error Correction Method (ECM) type with long-term and short term components.

- Econometric equations are constructed to be:

    - Theoretically sound in a Keynesian sense and using knowledge of the institutional setting of the UK economy and behaviour of households and firms.
    - Statistically significant terms, and passing other econometric tests (see annex A, key equations).
    - Provide a good fit for a within-sample dynamic simulation
    - Give plausible long term projections to 2025 with key ratios remaining within historical bounds (except where assumptions about household borrowing lead to extremes in both debt ratios and in the ratio of house prices to household incomes).

- Forecasts tested by in-sample testing for using equations estimated over only previous periods with actual values for exogenous variables. Forecasts fit well for 2013-15 using only equations estimated up to 2014, subject to actual exogenous variables (see below for details). Longer period in-sample simulations also perform reasonably, again with actual values for exogenous variables including world trade (in which there was a major recession in 2009) and housing loans (which halved in number in 2008), and also how the UK fiscal and monetary authorities reacted to these shocks.

- No fixes. Equations are allowed to determine forecasts with no adjustment of residuals. No account is thus taken of current indicators beyond the latest ONS Blue Book data in setting forecasts.

- Current forecasts are from 2015 to 2025 with data only up to 2014. No data beyond 2014 is used except for fully exogenous variables.

2.2 Structure of the Model

2.2.1 Exogenous Variables

The key exogenous variables relate to UK fiscal and monetary policy, US monetary policy, world oil and raw material prices and North Sea oil and gas production:

UK Fiscal & Monetary Policy

- Government nominal current and constant price capital spending on goods and services, constant prices (CN_GG, DKV_GG and DIV_GG). Note that real current spending (CV_GG) is determined within the model using an identity to project the government current deflator.
- UK tax rates; income tax, national insurance, corporation tax and North Sea tax and VAT (TAX_INC_RATE, NIC_RATES, TAX_CTRATE, VATRATES)
- Government plans for public sector pay increases and benefits rates (COMPHN_GG_RATES & SBFN_GG_RATES)
- Short-term interest rates, UK bank rate (BR) and volume of quantitative easing (QE)

US Monetary Policy and Inflation

- USA federal funds rate and 10 year government bond rate (BR_USA and LR_USA)
- US Consumer Price inflation rates, (USA_CPI)

World Trade

- Index of world trade in goods weighted by UK export markets[8]

- Oil Production and Prices and Raw Material prices
- World oil price; Brent crude in $ per barrel, annual average
- World raw materials price index
- North Sea oil and gas production, exports and imports, volumes

Demography

- UK rates of natural increase for total and working-age population, and population aged over 65. Note that net migration into the UK is determined by an equation within the model.

In addition there are a number of semi-exogenous variables. These have econometric equations but the forecast is adjusted in some way or is regarded as merely a guide which can be altered for simulation purposes.

- Number of loans for housing. A partial adjustment mechanism, reflecting constraints on bank lending, gives a path over a number of years from the current level of loans to a level fully determined by the econometric equation based on demand for loans.

- Some transfer flows are determined as a proportion of sector income. These include private sector 'other current net transfers'.

2.2.2 Simulations

A key purpose of the model is to undertake simulations of alternative economic policies. For the immediate future these are likely to focus on the potential consequences of fiscal reflation. Simulations are straightforward to generate and the model is set up to generate complete sets of consequences. The procedure involves changing values of exogenous variables such as projections for government spending, tax rates, or UK (or foreign) short-term interest rates. Most external (non-UK) influences are exogenous and can be changed, importantly including the world oil price (in US dollars). The sterling effective and dollar exchange rates are endogenous since they form important feed-back influences for almost any other change. Such endogenous variables could be exogenised, for instance to simulate a fixed exchange rate.

2.3 Out-of-Sample and Within-Sample Testing

The model is not primarily designed to generate short-term forecasts but needs to produce reasonably accurate forecasts in order to give confidence that it suitably represents the working of the modern UK economy. The model has been tested by comparing in-sample forecasts with ONS data (outturns) or with the latest available consensus forecasts (currently for 2015). The results shown in Table 1 were obtained from a version of the model in which all of the equations were estimated up to 2012 and forecasts made for 2013-2015. These are conditional forecasts generated with the correct (i.e. latest available official estimates) values for exogenous variables. The exogenous variables are those listed above, including the four key drivers of economic change; i.e. world trade, government nominal spending and tax rates and the number of loans for house purchase. With these exogenous variables the model predicts changes of GDP and its components, employment, unemployment and inflation relatively well. This is achieved despite the model being annual rather than quarterly and not using any short-term indicators. The conditional forecasts are even closer to reality if government current spending is included in real terms. However we take the view that government spending targets are set in cash terms and that the government current spending deflator depends on public sector wages, public sector productivity and the inflation rate of government non-wage purchases.

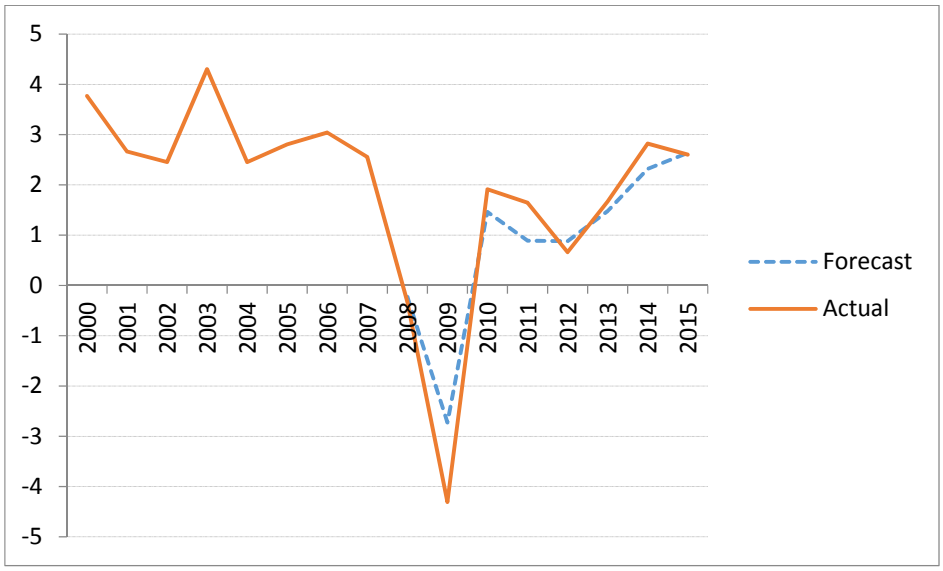
Table 1 Model Forecast Compared with Outturns (% pa except where specified)

	2013		2014		2015	
	Predicted	Actual	Predicted	Actual	Predicted	Consensus
GDP	1.9	1.7	2.9	3.0	2.8	2.5
Household Consumption	2.1	1.7	2.5	2.5	3.0	2.7
Household Investment	3.6	7.0	9.8	8.7	6.3	4.3*
Business Investment	2.0	4.5	9.0	8.0	3.8	4.3*
Government Consumption	1.0	-0.3	1.7	1.6	-0.4	0.9
Net Trade (volume)	1.1	1.0	1.3	1.2	1.0	-0.1
Inflation (Consumer deflator)	2.2	1.9	1.7	1.5	0.5	0.6
Employed persons	1.5	1.2	2.3	2.3	1.2	1.4
Unemployed rate (%)	6.9	7.6	5.3	6.2	4.7	5.2

*Sources: UKMOD_2012 (i.e. UKMOD with econometric equations estimated up to 2012), ONS National Accounts July 2015, HM Treasury Independent Forecasts June 2015. Note * indicates all fixed investment*

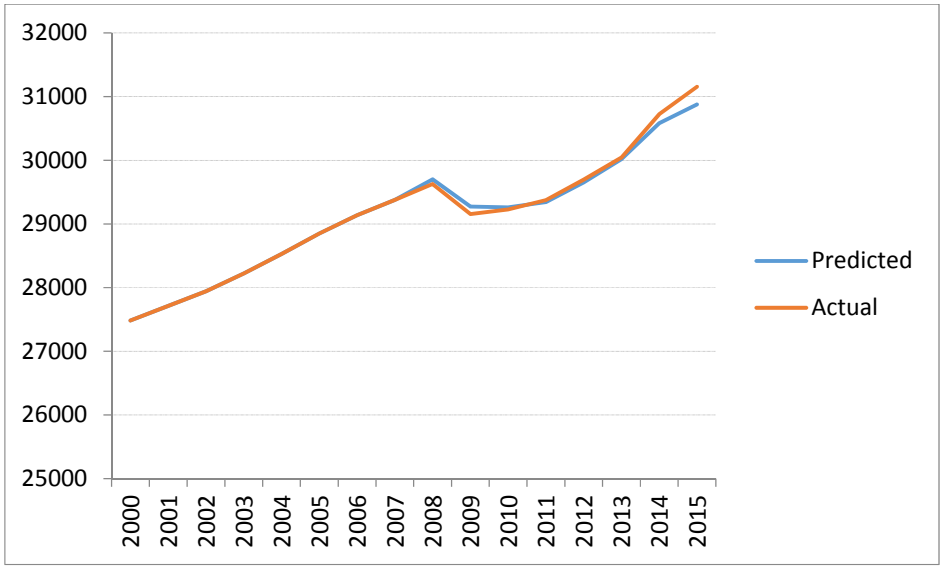
As a longer period test the same model (i.e. with equations estimated on data up to 2012) is used to generate conditional forecasts for the period 2007-15. The results for annual growth in real GDP are shown in chart 2.

Chart 2 GDP in constant prices (% pa)



This is a challenging period since it included both the deepest recession in the UK for a century, an unusually slow recovery and a much more rapid growth of employment than generally expected. The reasonably good fit between predicted and actual GDP is largely generated by the exogenous variables. These include Bank and Building Society loans for housing (which fell by half in 2008), the world trade index (which fell by 13% in 2009 and recovered by the same amount in 2010). The model shows that conditional on these shocks the predictions for GDP were reasonable. Of course, this is not at all the same thing as being able to forecast the exogenous variables themselves, i.e. the financial crash and its consequences for world trade. These are beyond the scope of the present model. However, the number of employed people has been less easy for traditional models to predict even knowing the main exogenous variables. The number of jobs lost in 2008/9 was less than widely expected for a serious financial crash and the gains after 2009 were so large as to constitute a productivity puzzle for most commentators. The model estimated to 2012 is able to forecast employment relatively accurately (chart 3), again conditional on knowing the path of the exogenous variables.

Chart 3 Employed persons (000s)



3. Forecasting the Economy

3.1 Introduction

This section explains how the model is used to forecast the economy. At several points we compare or contrast our approach with that of the OBR in order to highlight differences. In some ways the two models are similar, but UKMOD aims to examine the medium term and to simulate alternative policies. It is an annual rather than quarterly model and is thus less focussed on the immediate short-term than is the OBR. As a result UKMOD makes almost no use of off-model short-term economic indicators, unlike the OBR. There are also no 'fixes' to forecasts in UKMOD. Instead the equations are allowed to generate forecasts unaltered, subject only to conditioning to exogenous variables. On the other hand UKMOD contains much less detail than the OBR model about the structure of taxes and government spending.

One very important difference between UKMOD and the OBR model concerns the supply side. The OBR model forecasts begin by constructing a long-term supply capacity, and the forecast continues by assuming that the economy will revert to this trend over a few years from whatever off-trend position it is judged to have in the initial year. In contrast, UKMOD makes no attempt to forecast supply capacity in this sense, nor is there any assessment of the economy's initial position relative to

any trend. The OBR's approach is based on an essentially neo-classical view that the economy will tend to make full use of available resources subject to monetary policy signals. We reject this view partly because the future capacity of the economy depends on investment, both physical and in knowledge, and is thus endogenous. The level of output, and supply capacity depend, in our Keynesian view, on the level of demand, both existing and expected.

Our forecasts are essentially projections for the UK private sector. Much of the economic behaviour of the UK government and the rest of the world is taken as exogenous (and based on OBR Economic and Fiscal Outlook Reports). The forecasts are thus conditional upon our assumptions about this behaviour. We start this section with an explanation of how we forecast asset prices and interest rates. This is followed by a description of how expenditure and income forecasts are constructed, after which we discuss our approach to forecasting inflation and the nominal side of the economy. Following this we set out how we forecast the labour market, demography, housing and finally trade, and the balance of payments.

3.2 Asset Prices, Interest Rates and Exchange Rates

Unlike the OBR we do not use short-term indicators to forecast asset prices and interest rates. Nor in most cases do we follow the OBR in making assumptions for the medium term future of these variables although for foreign variables we have to do so. Instead we try to use equations where stable and significant relationships can be identified from annual data over recent decades. Although we do view asset prices and interest rates as inherently volatile, and buffeted by a wide range of unpredictable political and other factors, it is helpful to have equations to act as guidelines, and to underpin simulation scenarios. We do not expect forecasts for such things as UK equity prices or bond prices to be accurate (we could become very rich if they were), but some relationships are quite strong at least for annual data. Government bond prices and yields are for instance quite strongly related to short-term interest rates, exchange rates strongly reflect differences in UK and US real interest rates and UK equity prices reflect company profits. It would be a mistake in our view not to exploit such relationships in estimating both baseline forecasts and policy simulations.

- UK short-term interest rates are one case where we rely on assumptions and we do not use equations such as a Taylor rule (which jointly targets inflation and unemployment). We are not trying to guess the future path of interest rates. Instead we wish to use them as a key policy control variable. Interest rates are set in the baseline forecast to keep consumer inflation close to 2% per annum. In fiscal reflation scenarios they are currently set to keep inflation below 4% and government debt levels from rising. All of our forecasts and simulations are thus conditional on the values adopted for short-term interest rates. Having said this, if the Bank of England Monetary Committee actively pursues their remit of maintaining consumer price inflation at close to 2%, our baseline forecasts should provide a guide to the actual path of future interest rates.

- UK long-term interest rates (10 year gilt yields) are projected by an equation. The equation depends on current consumer price inflation rates, UK short-term interest rates and long term bond rates in the USA.

- The exchange rate (trade-weighted sterling effective exchange rate) is forecasted by an equation. In the equation (see key equation 7 below) the effective exchange rate reflects uncovered interest rate parity with the USA. The key long-term variables are real interest rates in the UK and USA and UK exports. The OBR have a similar procedure based on maintaining uncovered interest rate parity with the USA.

- Foreign interest rates and inflation. US variables are set by assumption. At present, US short-term interest rates are assumed to remain low until 2016 when they rise initially to 0.8% before settling to a sustained level of 3% from 2019. US 10 Treasury bond yields are assumed to be 3% from 2015. US consumer price inflation is assumed to be close to 2% per annum from 2015.

- World oil and commodity prices. Future oil and commodity prices are unpredictable and are set by assumption. Once again the UK forecasts should be regarded as conditional on the assumptions adopted[9].

- At present the assumption is that the Brent Crude oil price returns slowly over ten years towards a ceiling of $90 per barrel (set by the currently assumed profitability of fracking in the USA).

- UK equity prices are inherently volatile, but over the long-term are proportional to nominal company profits in the UK. Because of their importance in policy simulations we use an equation to set UK equity prices (FTSE All share index). The main independent variables are real UK company profits and the change in the annual average 10 year UK Gilt rate.

- UK House prices (DCLG house price index) are projected with a house price equation. In the equation house prices are related to nominal household incomes, the rate of consumer price inflation, the long-term interest rate and lending to the household sector.

3.3 Gross Domestic Product

Real GDP is projected in this model as the sum of the expenditure components of GDP. It is the sum of real consumers' expenditure, real investment, real government current spending on goods and services and real exports less real imports. The deflators for each of these components are projected separately and the nominal value of these GDP components is calculated as the product of the real values and the deflators. Nominal GDP is then calculated as the sum of the nominal components.

This procedure is straightforward and the forecasting method for each of the GDP components is described below. It is quite different from the complex approach used by the OBR. The OBR first calculates a trend growth path, dependent on assumptions about productivity and employment growth (and only indirectly on the stock of capital). It then assesses the size of the current output gap between actual and potential output, and follows this by assuming a path over which the output gap is closed usually over the forecast period of 4 to 5 years. The components of real GDP are projected separately by OBR, who state that, 'considerable time is spent moving back and forth between the individual forecasts for the expenditure and income components of GDP and the forecast of the aggregate measure of GDP' (OBR, *Forecasting The Economy*,[10] para 3.24).

Because UKMOD is an annual model, we also do not adopt OBR's practice of separately calculating short-term GDP forecasts based on current indicators of economic activity. As stated above, OBR's method for the medium term is based on the assumption (para 3.31) that in a flexible market economy a wide output gap would close over a period of a few years. OBR also assume that monetary policy would be used to support the closing of a gap. In UKMOD no such assumptions are

made. Instead the path of GDP is determined wholly by past relationships as estimated in the equations for the components of GDP and their deflators, and by assumptions about a limited set of exogenous variables including Government fiscal policy and external growth and prices. Interest rates are used only to guide consumer price inflation towards its 2% per annum target.

We might note in passing that the OBR lean heavily on the output gap as a measure of the pressure of demand and hence as an indicator of likely future inflation. In UKMOD we depend directly on the unemployment rate or employment rate as such a measure, and outline below how this features in our equations for prices and inflation. In addition, we include the existing capital stock in our equations for fixed investment by companies.

3.4 Consumption

Real consumers' expenditure is forecast using the single consumption function described in key equation 1 below. Again, there is no attempt to use current indicators (such as retail sales data) to influence short-term forecasts as in the OBR forecasts. The determinants of consumption in the UKMOD equation are chiefly household income and wealth. This is relatively conventional. The OBR describe this approach as 'within the spirit of the permanent income/life cycle model' (*Forecasting the Economy*, para 3.39[11]). Our equation can be thought of in the same way, and the coefficients are determined directly from past UK annual data over the period 1987-2014. Our theoretical framework is rather that of Godley and Lavoie (2007) is which households aim at a stable wealth to income ratio in the long-term. They save for pensions and house purchase but do not wish to accumulate financial assets above the target level.

The inclusion of housing wealth alongside net financial wealth is somewhat controversial. We take the view that most home-owners in the UK (i.e. two-thirds of households) are acutely aware of the current value of their homes, and it is sensible to assume that this will influence decisions about levels of saving out of current income. However, it is the empirical evidence that matters most and as can be seen from key equation 1 below, annual changes in real house prices (along with annual changes in UK equity prices) are statistically significant long-term variables within an equation with good statistical properties.

A less conventional aspect of the UKMOD consumption function is the importance of borrowing. This includes a variable for new long-term borrowing secured on housing (NUMLOANS*HMEANADV)[12]. Around 75% of all household liabilities

are long-term secured debt, i.e. home mortgages. Our view is that net new debt (i.e. new borrowing) has a positive impact on consumer spending. House purchase results in removal services and potentially purchases of household and electrical goods, with each new mortgage potentially underpinning several home moves[13]. In addition all mortgages for second-hand homes result in most of the additional money ending up in the bank accounts of the last household in the chain, a household that for some reason is not buying a new house (e.g. those inheriting a house from deceased parents), or at least is trading down to a lower cost house. The likelihood is that some of this windfall cash will be spent on consumption within a short period. Furthermore some new mortgage debt is taken out directly to release equity from the home, and most of this new debt is likely to finance consumption. The equation below suggests that 33% of net new financial liabilities result in consumer spending in the short-term. This is offset by repayment of existing loans secured on housing (REPAY_RATE). The average repayment rate is around 6% per annum, although this varies across the economic cycle. When repayments are high the effect is to reduce consumer spending. It should be noted that the direction of causation is relatively clear at least for new mortgage debt. The debt is not acquired to finance target consumption. Rather it is taken out to finance a capital purchase (housing). It is the secondary leakage of this new debt into consumption that we are concerned with and not the original motivation for taking on the debt.

The impact of short-term debt (DEBT_HI_ST) is more ambiguous. There is a clear negative impact from the lagged stock of short-term debt. The higher the debt the lower is consumer spending, reflecting the need to finance debt repayments. The short-term interest rate (BR) is not significant here. The annual *change* in debt, reflecting the level of new short-term borrowing, is also not statistically significant (and is omitted from the equation). Even though most short-term borrowing finances consumption, much borrowing is defensive in the sense that it finances existing levels of consumption or even repayments of existing debt.

3.5 Business Investment

Business investment is forecast using two equations. One is for non-financial corporations and public corporations taken together. These are taken together to overcome changing sector definitions due to nationalisation and privatisation. The other is for financial corporations. As in all cases there is no use of short-term economic indicators as used by the OBR.

The equation for non-financial companies and public corporations assumes that firms invest in new capital on the basis of their current profitability net of corporation

tax, expectations of future demand for their products and services, relative factor prices and capacity utilisation (see key equation 2 below). Expectations of future demand are taken as reflecting the rate of growth of private-sector GDP in the current year. Capacity utilisation is measured as the ratio of real capital stock to real GDP. When this ratio is high (indicating low utilisation of capital) business investment is depressed, and vice versa. The capital stock of businesses is in turn projected by depreciating the previous year's stock by 8% and adding real investment in the current year. Three indicators of the cost of capital are also included. The current long-term real interest rate (10 year gilt rate), is included as a negative influence, as is the real cost of capital goods. Finally the write-down rate for capital tax allowances is also a statistically significant influence.

This equation shares similarities with the equivalent OBR equation, except for the inclusion here of a term for real company profits net of tax. The OBR modellers follow the Modigliani-Miller theorem in assuming that the means of financing business investment is irrelevant. We take the view that capital markets are not perfect in this sense. Retained profits are important for two reasons. Firstly, they are available to firms when constraints in lending may make other forms of capital difficult to access. Constraints include existing high levels of leverage which deter further lending. Secondly, high levels of debt make firms more vulnerable to financial stress and failure, and retained profits may be the preferred source of finance for this reason. We can add that high current profitability influences firm's expectations for future profitability of the same activities. For all of these reasons we include net profits in our equations, and as can be seen below it is a statistically significant influence in the equation.

Investment by financial companies comprises only around 5% of business investment. We use an equation to generate forecasts although it would make relatively little difference to forecasts if we were to fix it at 5% of future business investment. We assume that investment levels reflect inflows and outflows of property income and prices of investment assets. The equation relates long-term investment positively to expected property income in the sector (interest and dividends), and negatively to short-term interest rates. Investment is also projected as higher when property prices are low reflecting a tendency to buy property when it is cheap, but higher when the relative price of capital goods is high since investment in computer systems etc. is less discretionary.

3.6 Residential Investment

Residential investment consists of investment in both new houses and home improvements. Forecasts are generated by a single equation (key equation 3). There

is a long-run (co-integrating) relationship between annual data for residential investment, real household incomes and the number of loans for house purchase. This differs from the OBR equation which has a long-run relationship between residential investment, real interest rates and real house prices. Part of the difference depends on which stage of causation is included. In our equation we focus on housing loans which themselves depend on population of working age, real house prices and nominal interest rates. We interpret our forecasts for the number of housing loans as a demand for loans. The actual number of loans made depends on any supply constraints on bank or building society lending. Supply constraints have been important since 2008

3.7 Change in Inventories

Stock building is not normally an important component of expenditure but can be large in recessions when firms find themselves with larger inventories than they expect to need. We forecast stock building with an equation in which stock building is a function of the change in real GDP and short term interest rates reflecting the costs of holding stock. There is also a negative time trend to capture the tendency for inventories to decline relative to output due to just-in-time operations and other efficiencies.
The stock of inventories in constant prices is equal to stock building plus the previous year's stock deflated by the GDP deflator. The nominal value of stocks is then projected as the real value multiplied by the GDP deflator.

3.8 Government Consumption and Investment

Government consumption in nominal terms is exogenous, but can be set at any level for simulation purposes. For the baseline forecast we use OBR figures on the Government's plans for general government expenditure on public services and administration - known as Resource Departmental Expenditure Limits (RDEL). These are obtained separately for current DEL and capital DEL. Government current expenditure plans are set in nominal terms and are converted to real terms by the OBR using a series of deflators. In our case we start with the OBR nominal terms estimates and convert these into real terms using assumptions about public sector wage costs, procurement costs and productivity. The Government's plans for public sector wages are used in the baseline forecasts. Once again these can be varied for simulation purposes. Our forecasts for real government expenditure can differ significantly from those of the OBR despite our use of the OBR's nominal figures and wage increase assumptions. The main difference comes in assumptions about government sector productivity. We simply project past trends in productivity

whereas the OBR tend to assume that large cuts in nominal spending will be associated with large increases in productivity. Government investment is taken from OBR projections as exogenous variables in both real and nominal terms. Other elements of aggregate government spending are transfers and these are described below in the Income and Transfers section.

3.9 Export Volumes

Export volumes are projected in aggregate through a single export volume equation (key equation 4). The OBR construct separate forecasts for exports of goods, services and oil, and our intention is to introduce this level of disaggregation of trade into this macro-economic model in future. At present the single export volume equation has a long-term relationship between export volumes, a world trade index, the sterling effective exchange rate and oil export volumes.

The data and exogenous forecasts for the world trade index are from Oxford Economics and are weighted for UK non-oil goods export markets, making the entire macro-economic forecast conditional on the path adopted for the growth of world trade[14]. There is a separate equation for the sterling effective exchange rate (key equation 7). Oil export volumes are exogenous and are projected as a constant share of the DECC estimates of oil production volumes.

The export volume equation suggests that a one percentage point decline in relative unit labour costs would boost export volumes by 0.25% in the long term. Relative unit costs vary with the effective exchange rate. A one percentage point rise in the effective exchange rate leads to a rise of 1.33% in relative unit labour costs. This implies that a one percentage point decline in the effective exchange rate will boost export volumes by 0.33% in the long-term. The 22% devaluation of sterling in 2008/9 would thus have boosted long-term UK exports by 7%. The equation also contains a negative trend which predicts a continuing decline of the UK share of weighted world trade by around 0.7% per annum. The equation also contains a number of dummy variables chiefly reflecting VAT missing-trader intra-community fraud issues which led to distortions in export data in some years.

3.10 Import Volumes

As with exports we forecast import volumes using a single equation (key equation 5). The OBR point out correctly that individual components of expenditure have different import propensities. Our equation reflects this logic and includes most of the individual components of domestic and export expenditure as separate terms. The long-term relations in the single equation link import volumes with household consumption and export volumes. Import volumes are also linked to changes in import prices relative to domestic producer prices. In response to a decline in the price of imports relative to local prices we should expect firms and consumers to switch to more cheaply produced domestic goods. In the case of exporters, it is likely to take some time for firms to adjust to the change in relative prices with less readily substitutable goods and services (the estimated adjustment of import volumes to export volumes in our model is very sluggish as is the case in the OBR model).

3.11 Income Measure of GDP

The income side in the model largely follows the National Accounts which is broken down into five sectors. We use four sectors (reduced from five by aggregating financial and non-financial corporations).The largest sector is the household sector, followed by the public, private company and external sectors. Income in each sector consists of income from production (i.e. earnings and profits), property income, social benefits and other transfers. Set against these are pension contributions, direct taxation, and debt servicing costs, leaving household disposable income. Most of these components are forecast using equations, however we make use of the high level identity in which the income of the private, government and external sectors sums to total GVA, and in which tax receipts, pension and benefits payments, property income flows and other transfers must sum to zero across the three sectors.

The household sector is enumerated in a relatively detailed way but corporate sector variables are forecast at a high level of aggregation. Around 60% of primary incomes (i.e. incomes earned directly from production) are distributed as income from employment (including employers' national insurance contributions) and 40% as profits (gross operating surpluses and mixed income). Because household incomes are forecast in detail, and private sector aggregates partly determined via identities, corporate incomes are partly determined as residuals between the private sector total and the household sector estimates.

Primary income is Gross Value Added (GVA) which is equal to GDP less indirect taxes on production net of production subsidies. Indirect tax revenues and subsidies on production are projected with equations. For indirect taxes the equation has long-term variables in consumer expenditure at current prices, the oil price (in dollars) and VAT rates. Subsidies (in constant prices) depend in the long-term on real GDP and the stock exchange all-share index at constant prices. Subsidies tend to be higher relative to GDP when unemployment is rising and when the stock exchange index is low. Private sector GVA is equal to total GVA less public sector GVA, where the latter is equal to the general government wage bill plus depreciation (projected as a trend). Household sector GVA is forecast using a simple equation which relates household sector GVA to private sector GVA as a whole.

3.11.1 Household and NPISH[15] Sector

The main component of household income is income from employment which is projected using equations for average wages and salaries in the public and private sectors. The latter is key equation 6 and is discussed below in the inflation section. These equations are then multiplied by employment in each sector to obtain the aggregate wage bill. The treatment of public sector income from employment is semi-exogenous, depending on projected public sector employment and average wages in the public sector. Average wages in the public sector reflect stated government policy in the short term. Over the medium and longer terms we assume that average public sector wages and salaries revert steadily to traditional relationships relative to the private sector (mainly reflecting differences in occupational structure with higher proportions of professionals in the public sector). This approach is unlike the OBR model where the income from employment forecast is conducted off-model. The OBR's trend growth framework anchors the forecast for employment and this, combined with judgements on wage growth and average hours, gives total wages and salaries.

The combined household and NPISH sector also derives primary incomes from operating surpluses (profits) and mixed income. The latter is defined as earnings from production in small businesses which are difficult to define as either self-employed income or profits. Profits and mixed income are forecast using an identity for market sector GVA less company GVA less the market sector wage bill. Household sector GVA has been a rising proportion of private sector GVA, and is projected as an extrapolation of the trend. Private sector GVA is in turn calculated as total GVA less the GVA of general government[16].

Households also accrue secondary income in the form of property incomes, pensions and benefits and other transfers (which include net claims receipts from insurance companies). Property income receipts are projected using an equation in which the long-term relationships are with the stock of financial assets, long term interest rates (10-year gilt rates) and the effective exchange rate. Property interest payments are projected as the long-term interest rate multiplied by household sector liabilities. Net current transfers are forecast using a simple equation with GDP and interest rates as arguments. This maintains net current transfers at close to 2% of nominal GDP. Net capital transfers are much smaller. The model assumes 6% per annum growth in nominal transfers. This maintains net capital transfers at close to 0.3% of nominal GDP.

The final element of household incomes is social benefits. These include government pensions and social security benefits, plus payments of private pensions and pay-outs from life and other insurance policies. Government social payments consist of four elements. Two of these are pensions: retirement pensions projected relative to numbers of people over retirement age and average wages, and public sector occupational pensions (projected relative to public sector employees and public sector wages). The other two are social security benefits payments. Most of these fall within the Government's Welfare Cap which is taken as exogenous from the OBR. Jobseeker's Allowance payments are treated separately with a levels equation depending on unemployment levels and average wages. Payments of private pensions and life insurance are projected again using an equation in which the long-term influences are average private sector wages, the number of people aged 65 or over and the Stock Exchange All-Share Index.

The main deductions from household incomes are taxes, national insurance and private pension contributions and interest payments. The OBR use detailed information from the Government in forecasting tax payments, and this is a major focus of their economic projections. We do not have access to this information and so use a less detailed approach. Tax payments in our model are forecast using separate equations for income tax, council tax, other current taxes, and capital taxes (mainly inheritance tax). The most important of these is income tax. The equation in this case contains long-term variables for the total wage bill, real average wages, basic rate of income tax, personal tax allowances and the basic rate tax limit. The basic rate of income tax is assumed to remain at 20% in baseline projections, while the tax allowance and basic rate limit are set according to existing government plans as far as these are known, with change in line with consumer prices thereafter. This equation predicts a continuation of the ratio of income tax revenue to nominal GDP at a little above 9%. Smaller current tax revenues from the household sector are set

to grow in line with consumer prices. However, council tax revenue is adjusted to follow OBR projections up to 2020. Revenues from capital (inheritance) taxes are forecast with an equation in which the main variables are house prices and the stock market (all-share) index.

The second most important direct tax is national insurance contributions. These are estimated by an equation in which the long-term relationships are with the number of people employed and the national insurance rate (the sum of the employees' main rate and the employers' rate). An equation is also used to project contributions to private pension schemes and life insurance policies. In this the long-term influences on nominal contributions are nominal disposable income and real wealth. These private contributions part of household sector savings and in the National Accounts are added back into disposable income to calculate a savings ratio. The final deduction from household sector income is interest payments. These are forecast as the long-term interest (10 year gilt) rate multiplied by the previous end-year stock of household sector liabilities.

Gross saving is defined as disposable income less consumer spending. As in the OBR model the savings ratio is observed as a memo item and is not targeted or directly projected. The OBR will sometimes revise consumer spending forecasts to obtain a savings ratio 'consistent with their view of household behaviour'. In our model the ratio could play a similar role but no adjustments have yet been needed.

Subtracting household investment in fixed assets (mainly housing) from gross saving, and adjusting for changes in pension reserve equity, gives the household financial balance (net lending). This represents the amount households have borrowed or lent once all uses are subtracted from their total resources. As the OBR state this serves as a useful diagnostic tool for both the consumption and household investment forecasts and distils a number of key judgements into one tractable projection. One important identity is that the net lending of the private, government and foreign sectors must sum to zero. Each sector's lending must be another sectors borrowing. Hence we need to only calculate two of the three in order to get the third. If the government deficit and the balance of payments current account deficits were both zero then private sector net lending would also be zero. However, this does not constrain the net lending of the household sector. Household net lending plus company sector net borrowing sums to private sector net lending. Even if the private sector were in balance (i.e. zero net lending) the household deficit could be any value, except that it would be equal and opposite to company net lending. In practice, household sector net lending (borrowing) has almost always been in the range of plus or minus 4% of GDP.

Household net lending contributes to the accumulation of the sector's stock of financial wealth, but it is not the only factor since capital gains are also involved. In the UKMOD model we forecast the stock of financial assets separately from the stock of financial liabilities, and net assets are the difference between the two. We use an equation to provide the weights for the contribution of net lending, the value of equities, bonds and deposits. The long-term variables in the equation are cumulative net lending, the UK (all share) stock market index, the (10 year) gilt rate and the level of household debt (since bank lending to households leads to the creation of household deposits).

Household liabilities are calculated as the sum of long-term and short-term debt and other liabilities (including trade credit of incorporated businesses). Long-term (mainly mortgage) debt is projected using an identity reflecting the number of new housing loans (NUMLOANS), and the other for the value of dwellings. The method for forecasting the number of housing loans is described below in the section on credit creation. This equation leads to an implicit forecast for the repayment of long-term loans. The repayment rate (% of the value of long-term loans) has normally been in the range 3-10%, falling to close to 3% in 2008 and averaging 6% since then. Short-term debt is much smaller in value than long-term debt and in 2014 stood at only one eighth of long-term debt. Its value has fluctuated in the range 14-20% of household disposable income, and in 2014 was at the low end of this range. An equation is used to forecast short-term debt. This equation depends on the long-term interest rate, credit conditions (using the number of housing loans as an indicator), and real household disposable income. Finally, other debt is a little lower in value than short-term debt. We have assumed that it remains at 17% of household disposable income.

Unlike the OBR we make no attempt to model holdings of different types of financial asset. In particular there are no stocks of money, equities or bonds on the model. We are implicitly assuming that although the value of household wealth is an important influence on consumption, the composition of that wealth is not important. This does not apply to housing assets which are forecasted separately and which also influence consumer spending although only via changes in house prices.

3.11.2 Corporate Sector

The corporate sector is not modelled in the same level of detail as the household or external sectors and is split into two subsectors: financial and non-financial

companies. We aggregate together private non-financial corporations and public corporations in order to circumvent problems of sector definition connected with nationalization and privatisation. The corporate sector is treated as a residual in several important respects. As in the OBR model the non-financial corporate sector (NFC) acts as the residual that balances the income account in our model.

To arrive at NFC income (i.e. gross operating surplus) we use an equation in which the long-term arguments are gross value added of the market sector(i.e. GDP less indirect taxes net of subsidies less public sector GVA), the compensation of employees in the private sector and the employment rate. The income of the financial sector is projected separately in a simple equation in which the gross operating surplus moves with whole-economy GVA in the long-term and is influenced by changes in the difference between long and short-term interest rates in the short-term.

The OBR state that their non-oil PNFC profit forecast receives a great deal of attention at each forecast round and acts as a diagnostic for the coherence of the income forecast. They closely scrutinise all determinants and compare the profits projection to a benchmark equation, considering both current trends and qualitative evidence. Should they decide that the profitability profile implied by the rest of the forecast is inconsistent with their other judgments, this would give them cause to revisit other areas of the forecast. We tend to rely on our equations without further adjustment, but do assess the plausibility of forecasts, especially forecast ratios such as the ratio of company profits to GDP, in deciding whether equations are adequate.

Since post-tax profits are used in our equation for company investment we need also to forecast profits taxes. Company tax (corporation tax) receipts are estimated with an equation for private non-financial companies (excluding North Sea Oil operators) in which the long-term influences are company profits (gross operating surplus), the corporation tax rate and the exchange rate. Tax receipts from financial companies and North Sea Oil operators are projected as the corporation tax rate multiplied by profits. For public corporations they are projected as 1% of profits reflecting the low level of taxes paid since 2009. For other North Sea Oil taxes (petroleum revenue taxes) revenues are projected as a declining trend proportion of Oil GDP to reflect the increasing costs of retrieving remaining North Sea reserves.

Other aspects of company income are not used to forecast investment but can be obtained as residuals. Companies' social contributions are equal and opposite to the

sum of those received by government, foreign and household sectors. Net property income and net other transfers for companies can be obtained in the same way. Our model does not have a detailed representation of the financial sector balance sheet but the stock of company financial assets can also be obtained as a residual, and the ratio to GDP can be monitored. No attempt is made to forecast stocks of financial assets and liabilities separately. We are interested in lending to the household sector but this is projected partly by assumption in a semi-exogenous equation. The corporate sector financial balance sheet is also not represented by the OBR with the same sophistication as it does for households. Less use is made of the net lending constraint; instead, total acquisition of liabilities is driven by a simple equation that depends on the business investment forecast.

3.11.3 Government Sector

Expenditure

The OBR macroeconomic model represents the public sector in a high level of detail but most variables are populated by forecasts made off-model as part of the wider public finances forecast. Since the OBR have examined government spending plans in detail, over the existing planning period of 5 years into the future, we have adopted OBR projections of *nominal* government current and capital spending on goods and services. Beyond the initial 5 years we assume that nominal spending on goods and services is constrained to meet the present Government's desire to reduce public debt to zero.

Real current spending by government is forecast by deflating the exogenous projections for nominal spending. The current expenditure deflator is projected as an identity with terms for public sector wages, other costs and public sector productivity. Other costs are assumed to rise in line with consumer price inflation. Public sector productivity (i.e. public sector employment relative to government current spending in real terms) is assumed to rise at its past trend rate of 1.8% per annum. Alternatively, an equation is used for government sector employment to track annual changes in productivity, but at present we prefer a simple productivity assumption. As noted above, the OBR treat government productivity differently and appear to assume that large spending cuts will be associated with large increases in productivity.

The OBR also make assumptions about public sector wage increases reflecting Government's policy on the growth in public sector wages. We share OBR's

assumptions about public sector wages in baseline forecasts but can alter them for scenarios. Average public sector wages per employee are currently assumed to grow at 1% per annum until 2019, and after that begin to converge back to the level of private sector wages (achieving convergence by 2025).

Government expenditure on transfers, including pensions, social security benefits and other transfers are partly demand-led and hence outside tight control by government. We project these using equations that reflect relevant economic conditions, and cannot simply adopt OBR projections since key influences such as unemployment will tend to differ between our forecasts and those of the OBR. Social security benefits are projected in two parts. The first includes those within the Government's 'Welfare Cap'. These are projected to reflect OBR assumptions on the evolution of the Cap. Secondly, benefits outside the Welfare Cap are mainly Job Seekers Allowance and these are projected using an equation in which the main terms are the level of unemployment and average wages.

Property Income payments from general government are interest payments on government debt. These are projected as the long-term interest rate (10 year gilt yield) plus 0.5% multiplied by the stock of debt at the beginning of the year. A deduction is made for re-imbursement of interest on £375bn bonds bought under the quantitative easing policy and held by held by the Asset Purchase Facility. The OBR assume reduction of APF holdings of bonds due to redemptions of £125bn by 2020 (OBR EFO Dec 2014 p170).

Other current transfers consist mainly of grants to non-profit organisations including housing associations plus overseas aid and payments to the EU. These currently amount to 3% of nominal GDP and are projected as a gently rising proportion of GDP. Capital transfers consist of investment grants (mainly to housing associations) and other capital transfers (e.g. to banks during the recent economic crisis). Investment grants are projected using a simple equation in which the main variables are nominal GDP and construction by housing associations (see housing section below). Other capital transfers are set flat at £2 billion a year.

Income

On the government income side we make assumptions about tax rates and tax bands. Tax rates are generally held at existing rates for the baseline forecasts,

while tax bands increase with consumer price inflation. Where changes have already been announced these are built in. This includes the corporation tax rate which the Coalition Government has announced will fall to 18% by 2020. This rate is held at 18% after 2020. Revenues from direct and indirect taxes are estimated by equations already described in previous sections. Direct tax revenues for Government can be obtained as the sum of private sector payments less net payments to the Rest of the World (set flat at £200 million per annum). Social contribution receipts are projected as the sum of private sector National Insurance contributions plus payments into public sector pension schemes. The latter are projected as a trend proportion of the public sector wage bill.

Other sources of government income are projected simply. Property income receipts (dividends and interest) are projected as the long-term interest rate (less 1%) multiplied by the previous stock of financial assets. Other current transfer receipts (mainly from abroad) are projected as 0.35% of nominal GDP. Capital tax receipts (mainly inheritance tax) are forecast using an equation in which the long-term influences are house prices and equity prices. Finally, capital transfer receipts are set flat at £10 billion per annum to reflect the repayment of loans and grants made to the private sector in connection with the banking collapses of 2008 and 2009.

The government deficit (general government net lending/borrowing) is calculated as government income less expenditure. We project financial stocks relatively simply. In practice stocks of government assets and liabilities are considerably affected by changes in definitions (such as bringing the Post Office pension fund within the scope of government finances) and by policy decisions on finance such as the decision to bail out banks in 2008/9. Future definitional and policy changes are unknowable. In our case we project changes in the stock of government liabilities as equal to the government deficit plus other changes in debt. The latter is projected to decline by £5 billion each year as loans to banks are repaid over the forecast period. Similarly the government's stock of financial assets is assumed to decline by the same amount. The net stock of assets is simply the difference between assets and liabilities.

3.11.4 Rest of the World (RoW): Income

Forecasts for trade flows (export and import volumes and prices) have been described in other sections. Most aspects of income flows to and from the Rest of the World are small and are set flat at their latest value. This includes compensation

of employees, direct and indirect taxes, social contributions and social benefit payments. Net current 'other' transfers are obtained as the inverse of government plus private sector net other transfers. Net capital transfers are projected to grow in line with consumer prices.

The much larger property income flows are more difficult to project. Both in-flows and outflows are normally equivalent to around 12% of GDP, but between 2004 and 2007 surged to 20% of GDP followed equally rapidly by a collapse back to 12%. The UK's balance of property income has deteriorated by 2% of GDP since 2011, accounting for virtually all of the deterioration in the balance of payments current account since 2011. Forecasts are generated by two equations; one for rest of the world (RoW) property income liabilities (UK credits) and the other for RoW credits (UK liabilities). The RoW liabilities equation has long-term variables for US GDP, US 10 year Treasury yield, the dollar-sterling exchange rate and the UK corporation tax rate. An equation for RoW credits (UK debits) would have the same long-term variables, except for corporation tax which is insignificant. However, credits and debits usually move together and have rarely differed in value by much more than 10%, perhaps reflecting a need by financial institutions to maintain a balance of domestic and foreign assets to minimise exchange rate risk. For this reason we have estimated a simple equation for RoW credits. This is an ECM equation with only the level and change in RoW liabilities as independent variables.

3.12 Inflation and Nominal GDP

The OBR describe the government's inflation target as the anchor for the inflation forecast and hence for nominal values. As usual, the OBR use current indicators to set short-term inflation forecasts. In the longer term their main drivers are the degree of spare capacity, import prices, unit wage costs and developments in retail margins. The Bank of England is assumed to set monetary policy to meet the 2%pa inflation target in the medium term. Our approach is similar in many respects although more explicit in that the short-term interest rate is set transparently to keep inflation close to 2% per annum in the baseline forecast, but can be used to converge with any inflation target for scenarios.

Equations are used to forecast a series of inter-linked price indices including consumer (CPI), export and import prices. Also included are National Accounts deflators for consumers' expenditure, capital goods, government consumption and for GDP as a whole. Further equations are used to forecast house prices and equity prices. Three linked equations form the core of this system. These are equations for private sector wages, consumer prices and import prices. Once again we make no distinction between the short-term and the longer-term, and unlike the OBR make no use of short-term price indicators.

The system starts with a market sector wages equation (where the market sector includes public corporations). Average wages are measured as the private sector wage bill divided by the number of people employed in the market sector. In the equation (key equation 6) a long-term relationship exists between wages, market sector Gross Value Added (GVA) per employee and the employment rate. Wages thus rise in line with GVA per employee which itself is a product of productivity and price increases. As expected, the wage share of GVA is higher when employment rates are high. The underlying theory is one of wage determination through bargaining by employers and employees to maintain their shares of GVA, with these attempts influenced by the employment rate. This is not the same as wage bargaining to maintain a target growth in real living standards, but is related to it through the link between nominal GVA and prices. It should be noted that this is not an augmented Phillips curve. Wage inflation is not permanently lower when employment rates are low, but instead when employment rates are falling. A stable employment rate (whether high or low) thus has no long-term impact on wage inflation. A further long-term determinant of wages is the real equity value of companies as measured by the FT All-Share index deflated by consumer prices. The theory is that a high share price makes employers less resistant to wage claims by

employees. Changes in working-age migration also influence wage inflation (accelerated migration leads to lower wage inflation) but there is no significant long-term impact.

The consumer price equation (key equation 7) has a long run relationship between consumer prices (the consumer price deflator), private-sector wages, private sector labour productivity, import prices and VAT tax rates. Consumer prices rise proportionately with wage and import costs plus VAT tax rates, and inversely with private sector labour productivity. This equation is consistent with a theory of mark-up pricing in which firms pass on changes in their costs of production.

There is thus a simultaneous relationship between wages and prices, both of which directly influence each other. The long-run versions of the two equations are:

*Wages = 1.09 + 0.54 *GVA + 1.66 * Employment rate + 0.08 * Share price*

*Prices = 0.9 + 0.67 * Wages + 0.6 * Import Prices -0.32 * Productivity*

This gives a composite equation for consumer prices as follows:

*Prices = 1.84 + 0.36 * GVA + 1.10* Emp. Rate + 0.55 * Share price * 0.60 * Import Prices - 0.32 * Productivity*

In the import prices equation (key equation 8) import prices have a long-term relationship with the effective sterling exchange rate and world oil prices (in US dollars). A range of short-term influences include changes in world raw material prices and changes in the volume of world trade. In the export price equation export prices have a long-term relationship with domestic prices (the GDP deflator) and import prices. In practice this means that export prices do not deviate by much from import prices.

Prices for other components of GDP expenditure are set as follows. The price of investment goods is set by an equation in which the long-term relationships are with domestic producer prices and import prices and with VAT rates. In practice this means that in the long term investment goods prices rise at similar rates to the GDP deflator, but with rather more variability from year to year. The price of government consumption is set by an identity in three parts reflecting wages, productivity and other costs. Public sector wages reflect statements of government policy in the short to medium term. Longer-term wages are assumed to converge towards their long-

term ratio to private sector wages. Non-wage costs for government consumption are assumed to rise at the same rates as consumer prices and government sector productivity is assumed to rise at its trend rate of 1.8% per annum.

Nominal values of the components of GDP expenditure are projected as the real values multiplied by the appropriate deflator. Nominal GDP is obtained as the sum of these components and the aggregate GDP deflator is calculated as nominal GDP divided by real GDP.

3.13 Labour Market

Our labour market forecasts include projections of the main Labour Force Survey (LFS) aggregates. The forecast for the number of people in employment is decomposed into general government employment, and market sector employment. These are combined with forecasts for nominal earnings growth to generate a forecast for the growth of total wages and salaries, which is used to forecast personal incomes but also a number of public sector receipts such as those from income tax and national insurance contributions.

The employment forecasts feed into a number of labour market indicators and demographic variables. These include unemployment, employment rates and migration (and hence population both in total and working age). We also project the number of people aged 65 and over who are in employment and hence define the potential labour force as the number of people of working age (16-64) plus those over 64 who are working. This definition is used in the calculation of employment rates. Unemployment rates are defined as the LFS measure of unemployed people divided by the numbers employed (LFS) and unemployed. The hours worked per employed person is forecast using an equation (EQHOURS_PER) and the total number of hours worked is obtained as the product of the number of people employed and the average hours worked per person.

Unlike the OBR (which uses assumptions) we use an econometric equation to forecast the number of people employed in the market sector (key equation 9). The equation has a long-term relationship between employment in the market sector and GDP, the capital-labour ratio, real average wages in the market sector, the level of house building and interest rates. There is also a term for the real value of company shares. This equation has some unconventional features, including a strong long-term influence from interest rates. Market sector employment has a substantial impact on the over-all macro-economic forecast and is sensitive to precise

specification. The important thing has been to estimate an equation capable of predicting the strong and generally unexpected upsurge in employment since 2009 which increased the number of people employed by 1.9% up until 2014. This equation, estimated up to 2012 gives accurate predictions of the numbers employed in 2013 and 2014.

The equation includes terms for labour demand (GDP) and supply (real wage). Employment rises with increases in demand but is lower when real wages are high. This is in line with neo-classical theories of employment, in which shifts in the demand schedule would raise employment, and increases in the supply schedule would lead to lower wages and higher employment. Average real wages are statistically significant in our employment equations in the form of both levels and annual changes. This reflects the increased flexibility of the UK labour market since the 1980s. Equations estimated over earlier periods do not have statistically significant terms for real wages or have a counterintuitive sign.

Other long-term influences in the equation are the capital-labour ratio and the interest rate. The capital-labour ratio has a negative coefficient indicating that when capital replaces labour, employment will be lower for any given level of GDP. The inclusion of an interest rate term reflects the repayment cost of existing debt. When this is high post-interest profits are reduced and pressure to cut costs, including labour, is increased. This is an important factor in the unexpectedly high level of job creation during the period of unprecedentedly low interest rates since 2008. It also underlies our forecast that employment will grow more slowly once interest rates begin to rise again.

We cannot compare the equation with that of the OBR because the OBR forecasts market sector employment beyond the short-term through assumptions about the speed of return of the employment rate to its underlying trend level. The OBR state that over the medium term the level of market sector employment is: ‘expected to return gradually to a level consistent with the projected trend level of total employment and projections of general government employment’.

Our forecast for employment in general government is constructed by projecting a trend in the ratio of government employees to current spending by general government. This trend has been declining at a rate of 1.8% per annum and is projected to continue doing so. This ratio is then applied to the projected level of real general government current spending. The forecast is complicated by the fact that real government current spending is itself dependent on the assumed growth rate

for government sector productivity. We take OBR projection of nominal government spending and then apply a deflator to calculate real government current spending. It is this deflator that depends on government sector productivity. Real government spending, government sector employment and hence productivity are thus all obtained simultaneously.

The LFS measure of the number of people unemployed and available for work is also forecast using an equation (key equation 10). In this equation the long-term influences on the number of unemployed people are: GDP, the number of people employed, the size of the working-age population and the number of people aged over 64 in employment. The latter are likely to displace more people of working age into unemployment for any given level of jobs. The number of new firms formed each year also appears to have a direct impact on unemployment, over and above its impact on jobs. We forecast the number of over-64s in employment as a trend. This is predicted to increase from around 1 million to 2 million over ten years. International migration of working-age people into the UK has short-term influences on unemployment through its impact on the working-age population. In the long term the rise in unemployment is offset by higher employment induced via lower wages caused by the higher migration.

3.14 Housing Market

The housing block in the model includes equations for house prices, house building and housing stocks, and for mortgage advances and mortgage repayments. The house price equation has long-term variables in average wages, long-term interest rates, and house-building by housing associations. House prices move positively with wages and negatively with interest rates and the building of housing association dwellings.

The model has separate equations for house building in the private, local authority and housing association sectors. For private house-building there is an econometric equation in which the level of house-building moves positively in the long-term with population and negatively with house-prices, the size of the private housing stock relative to population and the level of house-building in the public and housing association sectors. House-building in the large housing association sector is projected using an identity in which the number of new houses is equal to 16% of government capital spending in nominal terms deflated by the average house prices. House-building by local authorities is now at a low level and is projected to continue at the current level. Changes in the stock of housing in each of these three sectors

are set equal to the level of house-building. However the slow sell-off local authority dwellings is projected to continue to both the private and housing association sectors.

Housing finance is dealt with through equations for the number of loans for housing, the average size of mortgage advance and the repayment rate of mortgages. The number of loans for housing is an important variable in this model, influencing household consumption and investment. It is partly determined by credit conditions in the banking sector and is described below in the credit conditions section. In the equation for the average value of mortgage advances, the long-term value of advances depends on the average house prices and also on the number of housing loans (as an indicator of credit conditions).

Changes in long-term secured debt depend on the paying-down of existing debt as well as the value of new loans for housing. The repayment rate fluctuates from year to year between zero and ten per cent. It is projected as the difference between the change in the secured debt of households and new loans expressed as a percentage of lagged secured household debt. The terms in this identity are obtained from the equations described above in the Household Income section.

3.15 Credit Conditions

The model does not have a fully articulated financial sector at present. However, we believe that the flow of credit to households is a key influence on consumer spending and residential investment and hence on aggregate demand. As indicated above we find statistically significant relationships between consumer spending and new borrowing. A similar relationship is not identified for company fixed investment, presumably because much investment is funded via retained profits while companies borrow for other purposes such as financing inventories, mergers and share buy-backs.

The flow of credit to households is treated as a semi-exogenous variable. That is to say, demand for loans is estimated through equations but credit supply constraints are imposed upon demand to arrive at forecasts for the actual value of loans. Two equations are used. The first projects the value of loans and depends on the number of loans for housing and house prices. The second equation projects the number of housing loans. The latter has long-term influences in the population, house prices, debt to income ratios and interest rates. This is estimated up to 2007 and hence avoids the financial crisis and credit crunch of 2008 and subsequent years. The number of housing loans fell by 50% in 2008 and even by 2014 remained over a

third below the 2007 level. To model these extreme circumstances we use a partial adjustment approach. This assumes that the volume of loans will slowly recover to fully reflect demand. The experience of 2013 and 2014 suggests that convergence is slow at a rate of 25% per annum. Since we expect that demand for housing loans will peak in 2017 and turn down there-after once interest rates begin to recover, the slow convergence implies that the number of loans will not rise to its 2007 level within a decade or more. There is some logic in expecting that after the 2017 demand rather than supply will be the constraint on the number of loans issued. In the model it is possible to switch between supply and demand constraints from 2017, but at present this has only a small impact on the forecasts.

3.16 Demography

Population is determined from natural increase plus migration for working-age and total population. Natural increase is treated as exogenous and taken from ONS population projections (2011-based) but is adjusted to allow for any difference in migration between the model-based forecasts and ONS projections. Migration is estimated by equations including UK employment and unemployment terms but can be modified by assumptions about immigration policy. There is a feedback between unemployment and migration and migration will differ between simulations depending on UK job creation and unemployment.

4. Conclusions

Although some macro-economic modellers take the view that models without medium or long-term anchors are unlikely to be stable, we do not find this to be the case. UKMOD performs reasonably well in out of sample and within-sample tests and generates ten-year forecasts that are plausible and within the range of historic fluctuations. We thus do not use any notion of a stable medium or long-term growth of productive capacity. The external controls in UKMOD are provided by the main exogenous variables, i.e. world trade, government spending and tax rates and credit conditions for housing loans. A further control is the short-term interest rate which is used to keep consumer price inflation close to 2% per annum in baseline forecasts. The wide use of ECM equations which include long-term and short-term explanatory variables greatly helps to build stability into the system. The model also has an equation for private sector employment which predicts the strong rise in employment after 2009 and hence predicts the subdued rise in labour productivity (the so-called ‘productivity puzzle’).

The model is strongly Keynesian in that demand is all-important. Since there is no independent long-term trend in economic capacity, there is no assumption that output reverts to such a trend. Instead economic capacity (i.e. capital stock and labour supply) is endogenous to the model. Business investment depends on profitability and cost of capital, each of which is heavily influenced by public policy on tax rates and allowances, and on interest rates. However, private sector employment is influenced by real wages (in the long and short-terms) and to this extent the model has neo-classical features. This reflects the profound changes in wage bargaining arrangements in the UK since the 1970s.

The model contains little in the way of expectations, except in-as-far as expectations reflect current changes in GDP. Attempts to include leading values of explanatory variables were usually unsuccessful. This is to be expected in an annual model since the ability of business leaders to anticipate economic changes a year or more in advance is unlikely to be high. The one exception is the anticipation of future government investment in our equation for business investment. In this case large public infrastructure projects must be planned years in advance and contracts can be negotiated well in advance of work starting.

The main strength of the model is in its ability to generate alternative scenarios in response to variant assumptions about government policy, credit conditions or assumptions on such things as world trade. Conventional models with medium-term anchors in assumed trends in economic capacity cannot be easily utilised in this way since output is assumed to revert to the long-term trend almost irrespective of what happens to government policy, world trade or credit conditions etc. Since the main reason for building a new model was to generate such scenarios it has been important not to constrain the forecasts in this way.

The model will be used for forecasting and policy simulations with regular forecast reports published either on the CBR website or on www.cambridgeeconomics.com. We also plan to publish a full listing of the model on the latter website with details of further model updates including the addition of more detailed trade and financial sectors.

Notes

[1] Mervyn King, Governor of the Bank of England from 2003-13, wrote in 1994, 'in the early 1990s the most severe recessions occurred in those countries which had experienced the largest increases in private debt burdens': 'Debt, deflation: theory and evidence' *European Economic Review*, 38 (1994), 419-34. Jorda, Schularic and Taylor (2011) later showed that in 200 international recessions since 1870, banking crises are usually preceded by large build-ups in private debt, and result in deeper than normal recessions. O. Jorda, M. Schularic and A.M. Taylor, 'When Credit Bites Back. Leverage, Business Cycles and Crisis', NBER Working Paper 17621 (2011).

[2] Office for Budget Responsibility Briefing Paper no.3, *Forecasting The Economy*, October 2011. For example on p, 2 'supply potential' is described as 'a medium-term anchor for the forecast'. It is worth noting that in order to make this approach consistent with business surveys on capacity utilisation the OBR have had to assume huge 'write-offs' in capacity but have been unable to explain convincingly how these write-offs occurred, see W. Martin and R. Rowthorn R I*s the UK Economy Supply Constrained II? A Renewed Critique of Productivity Pessimism. Special Report* Centre for Business Research, University of Cambridge (2012).

[3] J.M. Keynes, *The General Theory of Employment, Interest and Money* (London: Macmillan, 1936) at p. 207. It is not fully obvious why the OBR assume that monetary policy will address an output gap when the Bank of England's prime responsibility is to maintain price stability.

[4] N.G. Mankiw, 'The Macro-economist as Scientist and Engineer' *Journal of Economic Perspectives* 2094 (2006). See also the evidence of Robert Solow to the July 2010 US Congress hearings on the failure of macro-economic models to predict the financial crisis of 2008-10. He said: 'I do not think that currently popular DGSE models pass the smell test. They take it for granted that the whole economy can be thought of as if it were a single person or dynasty carrying out a rationally designed long-term plan, occasionally disturbed by unexpected shocks but adapting to them in a rational consistent way…The protagonists of this idea make a claim to respectability by asserting that it is founded upon what we know about micro-economic behaviour, but I think this claim is generally phoney. The advocates no doubt believe what they say, but they seem to have stopped sniffing or to have lost their sense of smell altogether'. See also B. de Long (2013), 'When the Crisis stuck [i.e.in 2008], we had half a generation of economists who not only had no model that could make sense of the crisis but who blithely reproduced classic errors of the past'. *http://delong.typepad.com/delong_long_form/2013/10/you-dont-need-a-*

rigorous-microfoundationeer-to-know-which-way-the-well-to-know-much-of-anything-really.html

[5] W. Godley and M. Lavoie, *Monetary Economics. An Integrated Approach to Money, Credit, Income, Production and Wealth* (Basingstoke: Palgrave, 2006).

[6] For instance, in describing their approach to forecasting the OBR paper *Forecasting the Economy* uses the word 'judgement' 53 times in 45 pages.

[7] The data is almost wholly sourced from the Office for National Statistics (ONS) and mostly from the National Accounts. Since ONS has not consistently backdated its data as far as 1950 we have estimated some earlier data where necessary, observing national accounts identities based on the approach of W. Martin, 'Resurrecting the UK Historic Sector National Accounts', Centre for Business Research, University of Cambridge, Working Paper 356 (2006).

[8] Currently obtained with kind permission from Oxford Economics.

[9] Currently obtained with kind permission from Oxford Economics.

[10] OBR briefing paper No. 3 Oct. 2011

[11] OBR Briefing paper No.3 Oct 2011

[12] NUMLOANS is the number of new loans for house purchase. HMEANADV is the average value of new housing loans.

[13] For new houses and home extensions the National Accounts include legal and estate agents fees associated with house purchase within investment rather than consumption. This applies to purchases of existing property which account for the majority of home loans, even though these are not part of investment. Such fees then contribute to household incomes. Removal costs and new purchases of durables goods accompanying house moves are included within consumer spending.

[14] An alternative equation for world trade, not currently used, can be regarded as semi-exogenous and can be used as a guide which can be altered for simulation purposes. This equation for world trade has long-term relationships with real GDP in China and the EU (but not the USA which is correlated with the EU). Assumptions are made about future growth in GDP for China and the EU. At present we have GDP growth in China gradually slowing from 7% pa to 6% pa over the next decade.

GDP growth in the EU recovers to 2% pa by 2016 and remains close to this level throughout the forecast period.

[15] Non-Profit Institutions Serving Households. These include universities, technical colleges, charities and unincorporated businesses

[16] Gross Value Added (GVA) is GDP less indirect taxes on production net of subsidies on production.

ANNEX A: Key Equations

A full list of equations will be published on www.cambridgeeconomics.com. For the sake of brevity we have listed only a selection of key equations below. The names of the variables in the equations below are identified in Annex B.

1. Real Consumers Expenditure (eqcv_hi)

OLS Regression Results

Dependent Variable: D((CV_HI))
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample: 1987 2014
Included observations: 28

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9055.509	8630.570	1.049237	0.3088
CV_HI(-1)	-0.315384	0.054853	-5.749630	0.0000
((YDN_HI(-1)))/(CP_M(-1))	28.07257	5.982217	4.692669	0.0002
NFASN_HI(-1)/(CP_M(-1))	1.230832	0.426876	2.883347	0.0103
(NUMLOANS(-1)*(HMEANADV(-1)/1000000))/(CP_M(-1)/100)	0.328930	0.051673	6.365629	0.0000
DEBT_HI_ST(-1)/CP_M(-1)	-23.43821	7.005248	-3.345807	0.0038
REPAY_RATE(-1)	-81401.79	45947.73	-1.771617	0.0944
D(FTSE/CP_M)	1189.913	266.8589	4.458958	0.0003
DLOG(HPI/CP_M)	70836.50	17965.41	3.942939	0.0010
D(YDN_HI/CP_M)	20.88043	8.560303	2.439216	0.0260
D88	21031.13	5898.261	3.565648	0.0024

R-squared	0.962392	Mean dependent var	20601.50
Adjusted R-squared	0.940269	S.D. dependent var	17280.04
S.E. of regression	4223.230	Akaike info criterion	19.82131
Sum squared resid	3.03E+08	Schwarz criterion	20.34468
Log likelihood	-266.4984	Hannan-Quinn criter.	19.98131
F-statistic	43.50266	Durbin-Watson stat	2.403767
Prob(F-statistic)	0.000000		

ADF test on variables

CV_HI	l(2)
YDN_HI/CP_M	l(1)
NFASN_HI/CP_M	l(1)
NUMLOANS *(HMEANADV/1000000)/CP_M/100)	l(1)
DEBT_HI_ST/CP_M	l(1) or l(2)
REPAY_RATE	l(1)

ADF l(1)	Joint	Test

Long run coefficients and t-ratios

Variable	Coefficient	t-ratio
Constant	28712.63	0.96
YDN_HI/CP_M	89.01071	11.85
NFASN_HI/CP_M	3.902644	2.56
NUMLOANS *(HMEANADV/1000000)/CP_M/100)	1.042949	4.96
DEBT_HI_ST/CP_M	-74.3164	-2.77
REPAY_RATE	--258104	-1.89

Pesaran-Shin bounds test

F-statistic	16.07
Critical value at 1% level	4.78

2. Business investment (eqdkv_nfcpc)

OLS Regression Results

Dependent Variable: DLOG(DKV_NFCPC)
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample: 1979 2014
Included observations: 36

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.79498	1.914329	7.206171	0.0000
LOG(DKV_NFCPC(-1))	-0.773967	0.100033	-7.737104	0.0000
LOG(GOSN_NFCPC(-1)/(GDPP(-1)))	0.456101	0.109646	4.159753	0.0004
LOG(KIVLV_NFCPC(-1))	-0.562157	0.089669	-6.269237	0.0000
TAX_CTRATE(-1)	-0.016156	0.002649	-6.099737	0.0000
TAX_CAP_ALLOW_WRITEDOWN(-1)	0.011778	0.004118	2.860010	0.0089
LR(-1)-@PC(GDPP(-1))	-0.008049	0.002617	-3.075850	0.0053
DLOG(DKV_GG(1))	0.128253	0.029026	4.418529	0.0002
LOG(DKIVP_PR(-1)/GDPP(-1))	-0.624236	0.229607	-2.718721	0.0122
D(TAX_CAP_ALLOW_WRITEDOWN(-1))	0.017559	0.007747	2.266603	0.0331
DLOG(GDPV_PRIV)	0.723485	0.401150	1.803525	0.0844
D86	-0.214225	0.031725	-6.752534	0.0000
D2003	-0.066423	0.030552	-2.174099	0.0402

R-squared	0.921967	Mean dependent var	0.017997
Adjusted R-squared	0.881254	S.D. dependent var	0.082291
S.E. of regression	0.028357	Akaike info criterion	-4.013689
Sum squared resid	0.018495	Schwarz criterion	-3.441863
Log likelihood	85.24641	Hannan-Quinn criter.	-3.814107
F-statistic	22.64557	Durbin-Watson stat	2.831161
Prob(F-statistic)	0.000000		

ADF test on variables

LOG (DKV_NFCPC)	l(1)
LOG (GOSN_NFCPC/(GDPP))	l(1)
LOG (KIVLV_NFCPC)	l(1)
LR-@PC(GDP)	l(1)
LOG (DKIVP_PR/GDPP)	l(1)
ADF Joint Test	l(1)

Long run coefficients and t-ratios

Variable	Coefficient	t-ratio
Constant	17.82373	11.25
LOG(GOSN_NFCPC/(GDPP))	0.589303	3.96
LOG(KIVLV_NFCPC)	-0.72633	-6.05
TAX_CTRATE	-0.02088	-7.71
LR-@PC(GDP)	0.015218	3.42
LOG(DKIVP_PR/GDPP)	-0.80654	-3.25
TAX_CAP_ALLOW_WRITEDOWN	0.022687	2.25

Pesaran-Shin bounds test

F-statistic	13.79
Critical value at 1% level	4.5

3. Residential Investment (eqdkv_hi)

OLS Regression Results

Dependent Variable: DLOG(DKV_HI)
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample: 1970 2014
Included observations: 45

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.068529	1.250792	-0.854282	0.3991
LOG(DKV_HI(-1))	-0.506456	0.098649	-5.133919	0.0000
LOG(YDN_HI(-1)/(CP_M(-1)/100))	0.379683	0.128003	2.966204	0.0056
LOG(NUMLOANS(-1))	0.101121	0.062526	1.617264	0.1153
DLOG(DKV_HI(-1))	-0.070107	0.087830	-0.798221	0.4304
DLOG(HPI/(CP_M(-1)/100))	0.472562	0.228460	2.068467	0.0465
D(POPN/1000)	0.352072	0.145643	2.417357	0.0213
D(NUMLOANS)	2.14E-07	9.18E-08	2.326831	0.0263
D73	-0.315212	0.102240	-3.083068	0.0041
D81	-0.302808	0.091613	-3.305308	0.0023
D88	0.177454	0.094043	1.886952	0.0680
D2009	-0.228735	0.098722	-2.316955	0.0269

R-squared	0.790184	Mean dependent var	0.044939
Adjusted R-squared	0.720246	S.D. dependent var	0.163596
S.E. of regression	0.086529	Akaike info criterion	-1.833503
Sum squared resid	0.247078	Schwarz criterion	-1.351726
Log likelihood	53.25381	Hannan-Quinn criter.	-1.653901
F-statistic	11.29827	Durbin-Watson stat	1.154339
Prob(F-statistic)	0.000000		

ADF test on variables

LOG(DKV_HI)	l(1)
LOG(YDN_H)/(CP_M/100)	l(1)
LOG(NUMLOAN)	l(1)

ADJ joint test	l(1)

Long run coefficients and t-ratios

Variable	Coefficient	t-ratio
Constant	-5.49741	-4.18
LOG(YDN_H)/(CP_M)/100)	1.213582	12.44
LOG(NUMLOAN)	-0.061227	-1.76

Pesaran-Shin bounds test

F-statistic	13.52
Critical value at 1% level	7.85

4. Exports (eqxv)

OLS Regression Results

Dependent Variable: DLOG(XV)
Method: Least Squares
Date: 08/06/15 Time: 11:09
Sample: 1980 2014
Included observations: 35

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.589157	0.976160	6.750079	0.0000
LOG(XV(-1))	-0.625782	0.097585	-6.412673	0.0000
LOG(WTI(-1))	0.527756	0.098625	5.351121	0.0000
LOG(RULC(-1))	-0.155277	0.031965	-4.857745	0.0001
LOG(XV_OIL(-1))	0.051605	0.008012	6.441029	0.0000
DLOG(WTI)	0.574125	0.054415	10.55096	0.0000
DLOG(XV_OIL)	0.027477	0.017915	1.533740	0.1393
DLOG(RULC)	-0.071435	0.041532	-1.720010	0.0995
@TREND	-0.004754	0.003110	-1.528839	0.1406
D88	-0.042045	0.011759	-3.575680	0.0017
D91	-0.035991	0.011007	-3.269915	0.0035
D2005	0.039934	0.011469	3.481913	0.0021
D2006	0.089205	0.011359	7.853273	0.0000

R-squared	0.954103	Mean dependent var	0.036919
Adjusted R-squared	0.929068	S.D. dependent var	0.038645
S.E. of regression	0.010292	Akaike info criterion	-6.036268
Sum squared resid	0.002331	Schwarz criterion	-5.458567
Log likelihood	118.6347	Hannan-Quinn criter.	-5.836846
F-statistic	38.11081	Durbin-Watson stat	1.991342
Prob(F-statistic)	0.000000		

ADF test on variables

LOG(XV)	l(0)	
LOG(WTI)	l(0)	
LOG(RULC)	l(1)	
LOG(XV_OIL)		l(1)

ADF joint test l(1)

Long run coefficients and t-ratios

Variable	Coefficient	t-Statistic
Constant	10.52947	48.08
LOG(WTI)	0.843354	11.07
LOG(RULC)	-0.24813	-4.50
LOG(XV_OIL)	0.082465	5.74

Pesaran-Shin bounds test

F-statistic	21.87
Critical value at 1% level	5.62

5. Imports (eqmv)

OLS Regression Results

Dependent Variable: DLOG(MVX)
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample: 1970 2014
Included observations: 45

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.971810	0.625579	-4.750494	0.0000
LOG(MV(-1))	-0.414653	0.084010	-4.935748	0.0000
LOG(CV_HI(-1))	0.483028	0.108341	4.458406	0.0001
LOG(XV(-1))	0.131876	0.050055	2.634637	0.0126
DLOG(GDPV-XV+MV)	1.243910	0.105680	11.77053	0.0000
DLOG(XV)	0.438613	0.071005	6.177170	0.0000
DLOG(MP/GDPP)	-0.129506	0.052270	-2.477631	0.0184
DLOG(MV_OILNGAS)	0.052667	0.030094	1.750100	0.0891
DLOG(OILPRSTPB)	0.020840	0.006783	3.072476	0.0042
D74	0.081289	0.019449	4.179624	0.0002
D84	0.033427	0.015084	2.216121	0.0335

R-squared	0.934651	Mean dependent var	0.042920
Adjusted R-squared	0.915431	S.D. dependent var	0.047800
S.E. of regression	0.013900	Akaike info criterion	-5.505198
Sum squared resid	0.006570	Schwarz criterion	-5.063570
Log likelihood	134.8670	Hannan-Quinn criter.	-5.340563
F-statistic	48.62866	Durbin-Watson stat	2.163356
Prob(F-statistic)	0.000000		

ADF test on variables

LOG(MV)	l(1)
LOG(CV_H)	l(1) or l(2)
LOG(XV)	l(1)
ADF joint test	l(1)

Long run coefficients and t-ratios

Variable	Coefficient	t-Statistic
Constant	-7.48512	-15.10
LOG(CV_H)	1.064009	10.72
LOG(XV)	0.411732	5.78

Pesaran-Shin bounds test

F-statistic	11.18
Critical value at 1% level	5.62

6. **Wages (eqearnings_priv))**

OLS Regression Results

Dependent Variable: DLOG(EARNINGS_PRIVX/LFSE_PRIV)
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample: 1979 2014
Included observations: 36

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.343623	0.053803	6.386677	0.0000
LOG(EARNINGS_PRIV(-1)/LFSE_PRIV(-1))	-0.317796	0.060479	-5.254664	0.0000
LOG(GVAN_M(-1)/LFSE_PRIV(-1))	0.194419	0.055909	3.477405	0.0017
LOG(LFSE(-1)/POPW(-1))	0.603701	0.086345	6.991766	0.0000
LOG(FTSE(-1)/CP_M(-1))	0.030605	0.009218	3.320003	0.0025
DLOG(TU_MEMBERS/LFSE)	0.266917	0.095615	2.791597	0.0093
D98	0.025327	0.010002	2.532076	0.0172
LR(-1)	-0.002028	0.001434	-1.413920	0.1684

R-squared	0.952514	Mean dependent var	0.053538
Adjusted R-squared	0.940642	S.D. dependent var	0.037526
S.E. of regression	0.009143	Akaike info criterion	-6.358594
Sum squared resid	0.002340	Schwarz criterion	-6.006701
Log likelihood	122.4547	Hannan-Quinn criter.	-6.235774
F-statistic	80.23477	Durbin-Watson stat	2.272352
Prob(F-statistic)	0.000000		

ADF test on variables

LOG(EARNINGS_PRIV/LFSE_PRIV)	l(0)
LOG(GVAN_M/LFSE_PRIV)	l(1)
LOG(LFS/POPW)	l(0) or l(1)
LOG(FTSE(-1)/CP_M(-1))	l(1)
LR	l(0) or l(1)

ADF joint test	l(0) or l(1)

Long run coefficients and t-ratios

Variable	Coefficient	t-Statistic
Constant	0.834407	2.32
LOG(GVAN_M/LFSE_PRIV)	0.602254	9.70
LOG(LFS/POPW)	1.187586	2.60
LOG(FTSE(-1)/CP_M(-1))	0.122251	2.95
LR	-0.02438	-3.44

Pesaran-Shin bounds test

F-statistic	9.27
Critical value at 1% level	4.78

7. Consumer prices (eqcp_mx)

OLS Regression Results

Dependent Variable: DLOG(CP_M)
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample: 1982 2014
Included observations: 33

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.328231	0.291569	1.125742	0.2719
LOG(CP_M(-1))	-0.363394	0.056928	-6.383416	0.0000
LOG(COMPN_PRIV(-1)/LFSE_PRIV(-1))	0.242898	0.043516	5.581830	0.0000
LOG(MP(-1))	0.217711	0.032092	6.784075	0.0000
LOG(GDPV_PRIV(-1)/LFSE_PRIV(-1))	-0.116171	0.070516	-1.647430	0.1131
DLOG(COMPN_PRIV/LFSE_PRIV)	0.348706	0.084538	4.124857	0.0004
DLOG(OILPR$PB)	0.032639	0.006019	5.422514	0.0000
D(EFXI)	-0.000749	0.000347	-2.160979	0.0414
LR(-1)	0.009219	0.001664	5.540629	0.0000
D88	0.019593	0.007950	2.464500	0.0216

R-squared	0.903977	Mean dependent var	0.032671
Adjusted R-squared	0.866403	S.D. dependent var	0.019174
S.E. of regression	0.007008	Akaike info criterion	-6.838449
Sum squared resid	0.001130	Schwarz criterion	-6.384962
Log likelihood	122.8344	Hannan-Quinn criter.	-6.685864
F-statistic	24.05839	Durbin-Watson stat	1.783012
Prob(F-statistic)	0.000000		

ADF tests on variables

LOG(CP_M)	l(0)
LOG(COMPN_PRIV/LSE_PRIV)	l(1)
LOG(MP)	l(0) or l(1)
LOG(GDPV_PRIV/LFSE_PRIV)	l(0) or l(1)
LR	l(1)
ADF joint test	l(1)

Long run coefficients and t-ratios

Variable	Coefficient	t-Statistic
Constant	0.903237	1.22
LOG(COMPN_PRIV/LFSE_PRIV)	0.668415	10.84
LOG(MP)	0.599105	9.18
LOG(GDPV_PRIV/LFSE_PRIV)	-0.31968	-1.78
LOG(LR)	0.025368	4.09

Pesaran-Shin bounds test

F-statistic	21.65
Critical value at 1% level	4.78

8. Import prices (eqmp)

OLS Regression Results

Dependent Variable: DLOG(MP)
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample: 1982 2014
Included observations: 33

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.535108	0.263486	5.826146	0.0000
LOG(MP(-1))	-0.180642	0.024207	-7.462433	0.0000
LOG(EFXI(-1))	-0.184068	0.037720	-4.879902	0.0001
LOG(OILPR$PB(-1))	0.020520	0.003331	6.159761	0.0000
DLOG(OILPR$PB)	0.046714	0.009091	5.138302	0.0001
DLOG(EFXI)	-0.596476	0.041848	-14.25331	0.0000
DLOG(EFXI(-1))	0.126685	0.040984	3.091083	0.0058
DLOG(WTI)	0.305851	0.048799	6.267532	0.0000
DLOG(MP(-1))	0.286242	0.052410	5.461542	0.0000
D86	-0.069038	0.009840	-7.015902	0.0000
D93	0.042504	0.008748	4.858702	0.0001
D2008	0.043034	0.009410	4.573147	0.0002
D2011	0.021353	0.009206	2.319432	0.0311

R-squared	0.980899	Mean dependent var	0.019423
Adjusted R-squared	0.969438	S.D. dependent var	0.042527
S.E. of regression	0.007435	Akaike info criterion	-6.678238
Sum squared resid	0.001105	Schwarz criterion	-6.088704
Log likelihood	123.1909	Hannan-Quinn criter.	-6.479878
F-statistic	85.58681	Durbin-Watson stat	2.123978
Prob(F-statistic)	0.000000		

ADF test on variables

LOG(MP)	l(0)	
LOG(EFXI)	l(1)	
LOG(OILPR$PB)	l(0) or l(1)	
ADF joint test	l(1)	

Long run coefficients and t-ratios

Variable	Coefficient	t-Statistic
Constant	8.498088	15.87
LOG(EFXI)	-1.01897	-9.16
LOG(OILPR$PB)	0.113595	7.50

Pesaran-Shin bounds test

F-statistic	23.78
Critical value at 1% level	6.31

9. Private sector employment (eqlfse_priv)

OLS Regression Results

Dependent Variable: DLOG(LFSE_PRIV)
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample: 1979 2014
Included observations: 36

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.878398	0.316630	2.774212	0.0108
LOG(LFSE_PRIV(-1))	-0.253262	0.051512	-4.916515	0.0001
LOG(GDPV_PRIV(-1))	0.238106	0.040990	5.808932	0.0000
LOG(KIVLV_COS(-1))	-0.145413	0.016991	-8.558489	0.0000
LOG((COMPN_PRIV(-1)/(GDPP(-1)))/LFSE_PRIV(-1))	-0.235597	0.022948	-10.26660	0.0000
DLOG((COMPN_PRIV/(GDPP/100))/LFSE_PRIV)	-0.162817	0.039868	-4.083860	0.0005
LOG(FTSE(-1)/CP_M(-1))	0.032527	0.005603	5.805060	0.0000
BR(-1)	-0.002878	0.000617	-4.665014	0.0001
LR(-1)	-0.004506	0.001237	-3.641888	0.0014
HB_PR(-1)	1.28E-07	4.16E-08	3.066061	0.0055
D89	0.012098	0.004347	2.782880	0.0106
D92	-0.009618	0.004047	-2.376713	0.0262
D2009	-0.025566	0.003889	-6.574303	0.0000

R-squared	0.974350	Mean dependent var	0.007241
Adjusted R-squared	0.960968	S.D. dependent var	0.017929
S.E. of regression	0.003542	Akaike info criterion	-8.173931
Sum squared resid	0.000289	Schwarz criterion	-7.602104
Log likelihood	160.1308	Hannan-Quinn criter.	-7.974348
F-statistic	72.80789	Durbin-Watson stat	2.224313
Prob(F-statistic)	0.000000		

ADF test on variables

LOG(LFSE_PRIV)	l(0) or l(1)	
LOG(GDPV_PRIV)	l(0) or l(1)	
LOG(KIVLV_COS)	l(0) or l(1)	
LOG((COMPN_PRIV/(GDPP))/LFSE_PRIV)		l(0) or l(1)
LOG(FTSE/CP_M)	l(1)	
BR	l(0) or l(1)	
LR	l(0) or l(1)	
HB_PR	l(1)	

ADF joint test	l(0) or l(1)

Long run coefficients and t-ratios

Variable	Coefficient	t-Statistic
Constant	3.46834	3.37
LOG(GDPV_PRIV)	0.941057	9.39
LOG(KIVLV_COS)	-0.57416	-6.41
LOG(COMPN_PRIV/(GDPP))/LFSE_PRIV)	-0.93025	-4.78
LOG(FTSE/CP_M)	0.128434	3.73
BR	-0.01136	-2.70
LR	-0.01779	-2.90
HB_PR	5.04E-07	2.08

Pesaran-Shin bounds test

F-statistic	75.70
Critical value at 1% level	4.3

10. **Unemployment (eqlfsu**)

OLS Regression Results

Dependent Variable: D(LFSU)
Method: Least Squares
Date: 08/06/15 Time: 11:08
Sample (adjusted): 1963 2014
Included observations: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8866.502	764.7776	-11.59357	0.0000
LFSU(-1)	-0.789222	0.073755	-10.70056	0.0000
LFSE(-1)	-0.655612	0.062334	-10.51777	0.0000
POPW(-1)	0.758577	0.064215	11.81311	0.0000
D(LFSE)	-0.786345	0.026073	-30.15976	0.0000
VAT_REGS(-1)	0.003374	0.000369	9.135627	0.0000
GDPV_PRIV(-1)	-0.001099	0.000127	-8.620759	0.0000
D(POPW)	0.461253	0.086242	5.348377	0.0000
D(TAXWEDGE)	-2028.364	743.9153	-2.726607	0.0096
D75	182.7560	51.08396	3.577561	0.0010
D76	290.6655	56.09713	5.181468	0.0000
D82	-169.8498	54.27738	-3.129293	0.0034
D83	-277.0289	57.15769	-4.846748	0.0000
D2013	183.1860	56.44011	3.245671	0.0024

R-squared	0.968505	Mean dependent var	24.68684
Adjusted R-squared	0.957731	S.D. dependent var	238.4958
S.E. of regression	49.03338	Akaike info criterion	10.84768
Sum squared resid	91362.36	Schwarz criterion	11.37302
Log likelihood	-268.0398	Hannan-Quinn criter.	11.04908
F-statistic	89.88903	Durbin-Watson stat	2.174718
Prob(F-statistic)	0.000000		

ADF test on variables

LFSU	l(1)
LFSE	l(1)
POPW	l(1) or l(2)
VAT_REGS	l(1)
GDPV_PRIV	l(1)
ADF joint test	l(1)

Long run coefficients and t-ratios

Variable	Coefficient	t-Statistic
Constant	-11234.5	-15.33
LFSE	-0.83071	-56.02
POPW	0.961171	41.84
VAT_REGS	0.004275	16.51
GDPV_PRIV	-0.00139	-8.15

Pesaran-Shin bounds test

F-statistic	30.08
Critical value at 1% level	5.12

ANNEX B: Equation Variables Glossary

A full list of the model variables will be given on www.cambridgeeconomics.com. The abbreviated list below includes only variables included in the key equations of Annex A.

Variable formula:	Variable title
CP_M	Consumption deflator (households)
CV_HI	Final consumption, constant prices (households)
DEBT_HI_ST	Short term loans to households by UK MFIs
DKIVP_PR	Gross Fixed Capital Formation, deflator private sector
DKV_HI	Gross fixed capital formation, constant prices (households)
DKV_NFCPC	Gross fixed capital formation, all non financial companies
EARNINGS_PRIV	Private sector earnings
GDPP	GDP at market prices, deflator
GOSN_NFCPC	Gross operating surplus, non-financial companies
GVAN_M	GVA at basic prices nominal £m Sum(market)
HMEANADV	Mean mortgage advance
KMLV_NFCPC	Total non financial asset stock, constant prices, non finance companies
LFSE_PRIV	Employment private sector
LR	10 yr bond yield
MV	Imports G&S, constant prices
NFASN_HI	Net financial balance (households)
NUMLOANS	Number of Loans
POPW	Populaiton 16-64
REPAY_RATE	Rate of annual repayment of long term secured loans (households)
RULC	Unit labour costs
TAX_CAP_ALLOW_WRITEDOWN	Corporation tax allowances writedown rate %
TAX_CTRATE	Corporation tax rate
WTI	World trade index
XV	Exports G&S, constant prices
XV_OIL	Crude Primary Oil Exports
YDN_HI	Gross Disposable income, (excl net capital transfers) (households)

A full list of exogenous variables used in the model is given below:

BR	Short term interest rate (bank rate)
CN_GG	Final consumption, General government, nominal prices
COMPHN_GG_RATES	Wage increase, public sector
GAS_PDTN	North Sea, gas production
NATINCPOPW	Natural increase, working age population
NIC_MAIN	Nat Insurance rate, main rate
OIL_PDTN	North Sea,Oil production
OILPR$PB	Brent Crude Oil price ($)
POPN65	Population aged over 65
QE	Quantitative Easing (£bn)
QE_EURO	Quantitative Easing Eurozone (binary variable)
TAX_CAP_ALLOW_W	Capital tax writedown allowance
TAX_CTRATE	Corporation tax rate
TAX_INC_BASIC_RAT	basic rate of income tax
USA_BR	Interest rate, bank rate, short term rate, USA
USA_CPI	CPI, USA
USA_GDP	GDP, USA ,$ Billions
USA_LR	USA,10 YEAR treasury yield
VATRATES	VAT rates
WTI	World trade index
XV_OIL	UK, Crude Primary Oil Exports