CHAPTER 12. AN OVERVIEW OF THE OXFORD WORLD MACROECONOMIC MODEL

Introduction

This chapter and the next one are based on the paper
http://www.oef.com/model_overviews/wukmacover.pdf

Many of the most important and interesting macroeconomic issues are inherently international. A change in US monetary policy, for instance, has repercussions for the whole world; oil and commodity price shocks have been the major source of terms of trade movements in Europe in the last quarter century or so; governments are increasingly collaborating over monetary, fiscal and environmental policies. All of this means that single country econometric models, which treat world trade, world prices and exchange rates as exogenous, are not best suited to analysing some of the most important issues of interest to financial and business economists.

The Oxford World Macroeconomic Model reflects that priority, as coverage of the major trading countries is both deep, and wide.

The Oxford Model incorporates well-behaved, theory-consistent models for all of the individual countries covered, not just the big seven. It allows for significant cross-country differences in model structures, but ensures that those differences truly reflect economic, as opposed to economic model-builders', idiosyncrasies. Where possible, and it is possible in the majority of cases, the functional form for equations is left the same across countries. Parameters differ of course, and this means that different countries exhibit different behaviour in response to shocks (although economy structure also accounts for variations). Now, however, tracing the root cause of these differences, and attributing them to underlying behaviour or structure, is much simpler. For instance, real wage rigidity is higher in some countries than others, and specific coefficients in wage and price equations reflect this. Unemployment will tend to rise further and faster in these countries in response to an adverse demand shock, even though the functional form of wage and price equations is identical across countries.

The Oxford World Model comprises twenty-four country models of industrialised countries and more than 20 ‘emerging market’ country models. These models are identical in structure but the bigger models incorporate greater desegregation and more financial sector detail. The model also comprises six trading blocs including all the other countries in the world. The country models are fully interlinked via trade, prices, exchange rates and interest rates, with the blocs completing all the world coverage.

1. The error correction specification of the typical equation

The equations which make up the Oxford World Model are set out in the various EQN files (e.g. see UKEQNS.HLP for details of the UK model). These typically fall into two groups:

(i) Behavioural relationships - e.g. relating wages to prices, productivity and unemployment
(ii) Technical relationships - e.g. the national income identities.

It is the behavioural relationships which represent the analytical content of the Oxford Model. In general, these equations have a standard ‘error correction’ format where:

$$\Delta Y_t = \alpha_0 \Delta Y_{t-1} + \alpha_1 \Delta X_t + \alpha_2 \Delta X_{t-1} - \beta\left(Y_{t-1} - \gamma X_{t-1}\right) + R_t \qquad (1)$$

with: Y=dependent variable
X=explanatory variable(s)
R= residual
Ä= first-difference operator

The term in parentheses in equation (1) represents the long-run relationship between X and Y. That is, when the model has reached (static) equilibrium - so that $\Delta Y_t = \Delta Y_{t-1} = \Delta X_t = \Delta X_{t-1} = 0$ - then $Y_t = \gamma X_t$. Note, if Y and X are expressed in logarithmic terms, this equation implies that a 1% increase in X will lead eventually to a rise of γ % in Y

(i.e. 'γ' represents the long term elasticity of Y with respect to X). Economic theory is used to determine the appropriate explanatory variables to include in X and also determine any restrictions on the value of γ (e.g. in the context of an equation relating to wages and prices, static homogeneity would imply that γ=1).
Cointegration techniques are used to estimate this long term relationship.

Of course, economies are frequently out of equilibrium. The terms in ΔY and ΔX in equation (1) therefore seek to model the adjustment of Y back to its long term relationship with X (i.e. the 'dynamics' of the equation). So, if there is a 1% sustained rise in X then:

-Y will rise immediately by α_1%
-In the next quarter, Y will rise by $[(1+\alpha_0-\beta)\alpha_1+\alpha_2+\beta\gamma]$ %, and so on until..
-.....Eventually, Y will rise by γ%, which represents the end of the adjustment process

The speed with which Y adjusts to its long run relationship with X depends, in particular, on the size of coefficient β. Note for equation (1) to be stable, β must lie between 0 and 1. However, the closer β is to 1, the faster the equation will reach equilibrium following a shock. For short term forecasts, it is important to understand the dynamics of the model equations as the long-term properties.

2. An outline of the country model

The structure of each of the country models is based on the income-expenditure accounting framework. However, the models also have a coherent treatment of supply. In the long run, each of the economies behaves like the textbook description of a one sector economy under Cobb-Douglas technology in equilibrium that is as the Solow's growth model.

Countries have a natural growth rate, which is ultimately beyond the power of governments to alter, and is the result of population and productivity growth. Output cycles around a deterministic trend, so at any point in time we can define the level of potential output, corresponding to which is a natural rate of unemployment.

Firms are assumed to set prices given output and the capital stock, but the labour market is imperfectly competitive. Firms bargain with workers over wages, but they get to choose the level of employment. Countries with high real wages get high unemployment in the long run, and countries with rigid real wages get persistently high unemployment relative to the natural rate.

Inflation is a monetary phenomenon in the long run. The model has a vertical Phillips curve, so expansionary demand policies put upward pressure on inflation. Unchecked, these pressures would cause the price level to accelerate away without bound, and in order to prevent this we have endogenised monetary policy. For the main industrialised countries, the latter is summarised in an inflation target, and interest rates are assumed to move up whenever inflation is above the target rate, and/or output is above potential (a so-called ‘Taylor rule’). A by-product of this new system is that simulations under fixed interest rates make sense for only a couple of years or so. If you do not “do” monetary policy, and Phillips curves are vertical, then you end up with hyperinflation (or hyperdeflation, depending on the shock) after a few years. We know, since Wicksell that setting the nominal interest rate to a given value leads to an unstable economy.

Consumption is a function of real incomes, real financial wealth, real interest rates and inflation. Investment equations are influenced by “q-theories”, in which the investment rate is determined by its opportunity cost, after taking taxes and allowances into account.

Countries are assumed to be “small”, in the sense that exports are determined by demand and a country cannot ultimately determine its own terms of trade. Consequently, exports are a function of world demand and the real exchange rate, and the world trade matrix ensures adding-up consistency across countries. Imports are determined by real domestic demand and competitiveness.

A financial block forecasts total rates of return on cash, stocks and bonds. For the treatment of asset holdings the private sector is broken down to personal and corporate components, but no further. General government net debt is identified, and both net overseas assets and net IPD flows are derived by residual.

The following is a highly condensed version of a typical Oxford country model, which typically consists of more than 200 variables. The equations presented are all "long-run" relationships; i.e they abstract from dynamics. Lower case mnemonics denote logs of variables.

2.1. Demand

goods market

c = a1*pedy + (1-a1)*(penw-pc) - a2*rrh (consumption)

pedy; real personal disposable income
penw; personal sector net financial wealth
pc; personal consumption deflator

This is the standard econometric treatment pioneered by Hendry et al (1985). The dynamic equations take the form:

$$\Delta c = a_1 \Delta y + a_2 \Delta u - a_3 \left[c(-1) - a_4 y(-1) - (1 - a_4) W(-1) + a_5 R(-1) \right]$$

where lower case letters denote logs and c, y and u are consumption, real income and unemployment respectively, while W and R refer to the financial wealth-income ratio and real interest rates. These error-correction formulations appear to mimic consumption smoothing in a number of countries very well.

st = gdp + e1*time (inventory level)

mgnf = tfe + c1*wcr + c2*time (non-fuel imports)
xgnf = wt -d1*wcr + d2*time (non-fuel exports)

tfe; total final expenditure
wcr; relative unit labour costs

Trade flows are disaggregated into fuel, non-fuel goods, and services. The non-fuel goods components reflect the bulk of exports and imports for most countries. Exports and imports are demand determined:

$$\Delta x = \Delta wt - a_1 cu - a_2 \Delta wcr - a_3 \left[x(-1) - wt(-1) - a_4 trx \right]$$

$$\Delta m = b_1 \Delta tfe + b_2 \Delta wcr - b_{,,} \left[m(-1) - tfe(-1) - b_{,} wcr(-1) - b_5 cu(-1) \right]$$

x refers to exports of non-fuel goods; m to the equivalent imports; wt is world trade; tfe, total final expenditure; wcr, relative unit labour costs; and cu, capacity utilisation as measured by model estimates of the output gap. The time trends capture secular shifts in a country’s world trade share caused by non-price factors, and the impact of the long-term increase in the specialisation of production on import penetration. Trade competitiveness elasticities are typically between 0.3 and 0.6; and most country models satisfying the Marshall-Lerner conditions, so that a sustained improvement in competitiveness will lead to an improvement in the trade balance in the long run.

The equations for trade in services are analogous to those for non-fuel goods, while imports of fuel meet the gap between, on the one hand, domestic and export demand and, on the other, domestic production. All trade prices are a weighted average of domestic and world prices.

money market

mon = b1*gdp + (1-b1)*(prnw-pc) - b2*RSH (real money balances)
RLG = b3*RSH + (1-b3)*RLG,US + b4*GGDBT/GDP! (long bond rate)
rxd = rxd(expected) + log(1+RSH,US/400) - log(1+RSH/400) + RISK (exchange rate)

2.2. Supply

capital accumulation

K = (1-DELTA)*K(-1) + IPNR (capital stock)
IPNR = K(-1) + f1*QR + short run GDP effects (non-residential investment)

gdp; gross domestic product

qr; Tobin's "q"

Three aspects of gross fixed investment are identified in the Oxford Model: private business, private housing and government (which is exogenous).

The equations for business investment are based on so-called q-theories of investment. In these, capital is time-consuming to install and these adjustment costs drive a wedge between the post-tax marginal product of capital and its marginal cost. Profit maximising firms invest when the marginal return is greater than the replacement cost (q > 1), and reduce investment, or even scrap, when the reverse holds. In the long run, the capital stock reaches its desired level, all investment is replacement, q = 1 and the familiar marginal productivity relationship holds. The equations take the following form:

$$\Delta i = a_1 q - a_2 [i(-1) - k(-1)] + a_3 \Delta y$$

where i is private sector business fixed investment, k is the equivalent capital stock and y is GDP; q is defined as the post tax marginal product of capital relative to the real interest rate. With Cobb-Douglas, constant return to scale technology, the capital-output ratio is constant in the long run, and equal to the post-tax, post-depreciation real interest rate divided by the capital share. There are also short-term accelerator effects from changes in output, which can be justified in a q-framework if some companies are credit-constrained.

Personal sector housing investment is determined analogously to consumption, by real income, wealth and interest rates, since it is considered part of a portfolio of spending decisions taken by households.

RRH = f6*RSH + (1-f6)*RLG - 100*inflation (expected) (real interest rate)

labour market and the nairu

LS = PART*POPW (labour supply)

popw; population aged 16-64

part = f2*(er-pgdp) (participation rate)

nairu = f3*WEDGE (natural rate of unemployment)

wedge is the (log) difference between the real product wage and real take-home pay, and consists of direct, indirect and payroll taxes, as well as producer prices relative to consumer prices.

ESTAR = (1-NAIRU/100)*LS (natural employment level)

yhat = α *estar + (1-α)*k(-1) + g1*trend (potential output)

cumod = gdp - yhat (output gap)

epr = gdp -er +pgdp (employment)

er = pgdp + gdp - epr - f4*(up - nairu) (average earnings)

prices

pgdp = er -gdp + epr + f5*cumod (gdp deflator)

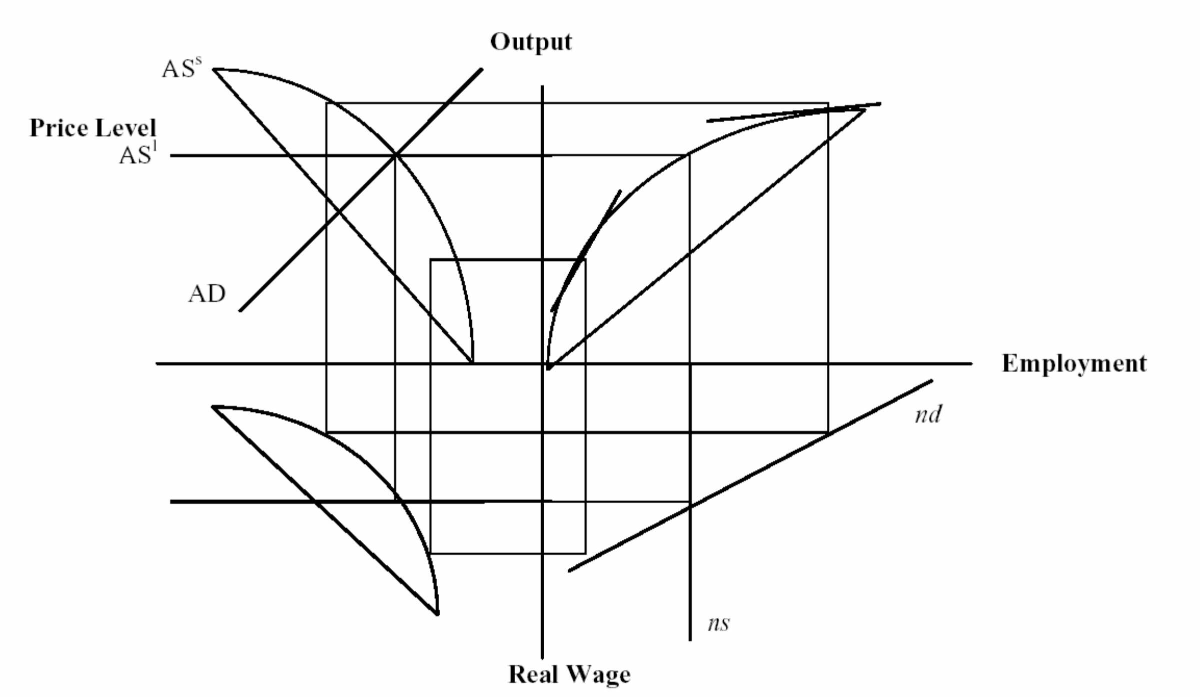
pmgnf = h1*pgdp + h2*(wpmf+rxd) + (1-h1-h2)*(wpc+rxd) (import prices)

cpix = j1*pgdp + (1-j1)*pm (consumer prices)

Given its importance to overall model properties, this is probably best summarised as a block, rather than equation by equation. The following diagram is a useful, if simplistic, description of the key features of the model's supply side:

The north-east quadrant shows the production function with diminishing returns, relating output to employment. Tangents to the production function are the marginal product of labour, which in equilibrium equals the real wage. These tangents trace out a demand for labour in the south east quadrant - our employment equation (*nd*). Given a fixed labour supply (*ns*), the intersection generates the equilibrium real wage consistent with no involuntary unemployment and normal (or potential) output. The latter is traced out along the vertical aggregate supply curve (ASl) in the northwest quadrant.

In the short run, however, relatively rigid real wages generate involuntary unemployment ($nd \neq ns$), while nominal inertia means that the short run relationship between real wages and the price level is shown by the hyperbola in the south-west quadrant. Short run changes in labour demand then trace out a positively sloped short run aggregated supply curve (ASs), ensuring that changes in aggregate demand (AD), as derived from an IS-LM system, translate into short run changes in prices and output, although the long run effects are felt on prices alone.



In short, the employment equation defines a level of real unit labour costs (real wages/productivity) which is constant in the long run. Consistent with this level of real unit labour costs are natural levels of output and unemployment. When the economy is away from these natural levels, inflation and interest rates move to bring the economy back towards equilibrium. The larger are nominal and real rigidities, the larger and longer-lived are real disequilibria.

Algebraically, the employment equation solves in the long run for the constant level of real unit labour costs, given by labour’s share in the production function, while the wage and price equations solve in the long run for the level of unemployment consistent with this labour share. In the short run, both wage and price equations incorporate nominal and real wage rigidity, which ensure the existence of “involuntary” unemployment and monetary effects on the real economy.

With vertical Phillips and aggregate supply curves, monetary policy determines the inflation rate, while structural, or supply side policy determines the unemployment rate. The NAIRU (non-accelerating inflation rate of unemployment) is related to the so-called ‘tax wedge’ (the gap between the total real cost of labour to employers, including social security contributions, and the real value of post-tax wages received by employees), and to real energy prices.

2.3. Government Policy

Monetary

ΔRSH = l1*(inflation - inflation(-1)) + l2*(inflation - target) + l3*cumod (‘Taylor’ rule)

Fiscal

Government spending and major tax rates all currently exogenous

2.4. Rest of the World

WT = trade-weighted average of trading partners' imports (world trade)
WPMF = trade-weighted average of import prices (world prices)
WPC = weighted average of world non-fuel commodity prices