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ABSTRACT/RÉSUMÉ

This paper describes the OECD’s new small global forecasting model for the three main OECD economic regions: the United States, the euro area, and Japan. The key variables – which include output, inflation, the trade balance, and import prices – are driven by monetary and fiscal policy, exchange rates, and world demand. The projections from the model are used as a starting point to help animate the early stages of the OECD’s forecasting round. The model is essentially a demand-side model with a particular focus on the impact of global linkages and the transmission of influences between regions.

JEL code: F47, F42, E17, C53
Keywords: Macroeconomic model, forecasting, OECD, International

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Ce document décrit le nouveau petit modèle global de prévision pour les trois principales régions de l'OCDE : les États-Unis, la zone euro et le Japon. Les variables-clés, qui incluent la production, l'inflation, la balance commerciale et les prix d'importation, sont déterminées par la politique fiscale et monétaire, les taux de change et la demande mondiale. Les prévisions du modèle sont utilisées comme un point de départ pour stimuler la dicusssion lors des premières étapes de l'exercice de prévision de l'OCDE. Ce modèle est essentiellement un modèle de demande qui se concentre particulièrement sur l'impact des liens globaux et sur la transmission des influences entre régions.

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A SMALL GLOBAL FORECASTING MODEL

David RAE and David TURNER[1]

1. Introduction

1. This paper describes the OECD's new small global forecasting model. The main focus of the model is the production of globally-consistent short-term forecasts of the major aggregates for the three main OECD economic regions: the United States, the euro area, and Japan. The rest of the world is modelled as a fourth composite region, albeit in a crude way. The key variables – which include output, inflation, the trade balance, and import prices – are driven by monetary and fiscal policy, exchange rates, and world demand. The projections from the model are used as a starting point to help animate the early stages of the OECD's forecasting round.

2. A particular focus of the model is the impact of global linkages and the transmission of influences between regions. Consequently, the three regional models are linked directly *via* trade, interest rates, and exchange rates. There are two additional linkages. First, output and inflation in the rest of the world depend on developments in the three main regions, and feed back on them through the trade equations. Second, commodity prices are endogenous and depend on world output and inflation. Both linkages provide important additional channels through which shocks are propagated across regions.

3. The model is essentially a demand-side model. Output is based on an IS-style relationship, although this has been split into domestic demand and net export components rather than being modelled as a single reduced form equation. Potential output is assumed to be exogenous, and the model can therefore be written in terms of an output gap. In other words, the model explains why growth may differ from the potential growth rate but does not attempt to explain changes in potential growth. This approach seems to be a reasonable simplification given the model's primary roles of short term forecasting and analysis of global linkages. However, it does mean that it has a limited ability to analyse the impact of supply side factors that may be expected to change potential output.

4. Subject to the above constraints, the primary design criterion is that it be small in order to provide simple direct insights into specific forecast judgements on the basis of clear model properties. In addition, being small implies that few inputs or exogenous assumptions are required and makes it easier to decompose the influences behind the forecasts of each variable. In particular, the main equations have been solved out in terms of their explanatory variables so that the particular contributions to inflation or growth can be identified at any point in time.

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1 . The authors are members of the OECD's Macroeconomic Analysis and Systems Management Division. The paper reflects helpful comments from numerous colleagues, including Laurence Boone, Thomas Dalsgaard, Jorgen Elmeskov, Michael Feiner, Pete Richardson, and Ignazio Visco. Special thanks to Laurence Le Fouler and Isabelle Wanner for their excellent research assistance; and also to Rosemary Chahed and Jan-Cathryn Davies for document preparation.

5. A further design criterion has been to ensure that extra relationships can be added without major re-estimation or re-coding. For example, a standard forecasting application would have exogenous exchange rates and short-term and long-term interest rates, and (mostly) backward-looking inflation expectations. However, monetary policy reaction functions can be added (as demonstrated later in the paper), along with alternative assumptions regarding the formation of expectations. This allows a little more economic richness to be temporarily added to the model when it is used for policy analyses, especially for those situations in which financial markets and expectations play important roles in the transmission of shocks within and between regions.

6. Another feature is that it incorporates several concepts that provide a consistent point of contact between the model and the larger projection exercise. Demand and the composition of output are modelled relative to a specific (and exogenous) view about potential output,[2] inflation is modelled in a framework in which the output gap is important and real exchange rates and relative demand pressures play important roles. While very different in size and structure, the small model can be thought of as a simplified version of INTERLINK's demand side. One difference, however, is that this model is based on quarterly data whereas INTERLINK and the forecasting round use semi-annual data. In this respect, the model is able to take better account of short-term developments in key variables.

7. As with any model, there is a trade-off between the goodness-of-fit of individual equations and the model having properties that conform to priors about macroeconomics. The equations reported in this paper reflect a compromise between these choices. The estimation philosophy is that differences in equation specifications across regions appear only where there is a clear economic rationale. For example, the empirical importance of stock market wealth to the United States economy has led to the inclusion of such a variable in the United States domestic demand equation.[3] Otherwise, coefficient values are relatively freely estimated. However, a few coefficients have been restricted, particularly where they were poorly determined, in order to deliver properties closer to our priors or to be more consistent with results for other regions. Various homogeneity and global closure restrictions are also imposed to ensure that the model settles down to a sensible steady-state path. Goodness-of-fit is an important criterion for a forecasting model but particular weight has been given to accuracy in recent years, partly because the short-run dynamics of highly-reduced form equations may not remain stable over long spans of history.

2. Overview of the model

8. Each of the three OECD regions (the United States, the euro area, and Japan) consists of four main blocks:[4]

- *Output* is determined through an IS-style relationship, although domestic demand and net exports are modelled separately, partly for econometric reasons, and partly to emphasise the model's role of capturing international linkages. Potential output growth and fiscal policy are exogenous.

- *Inflation*. The main inflation variable is core CPI inflation, which is modelled using a Phillips curve. Inflation therefore depends on the output gap and various components of imported

2. Potential output is estimated in a consistent way across countries, based on a production function approach. See Giorno *et al.* (1995) for details.

3. Such effects are less easy to identify in other regions.

4. Recent examples of this style of model include Duguay (1994), Bharucha and Kent (1998), Ball (1998), Hargreaves (1999), and Beechey *et al.* (2000).

inflation. Headline CPI inflation depends on core inflation plus a wedge that is determined by commodity and oil price inflation.

- *Import Prices*. Manufacturing and service import prices are modelled, and depend on foreign and domestic consumer prices, the exchange rate, and commodity prices.

- *Financial Variables*. For forecasting purposes, short-term and long-term interest rates and nominal exchange rates are exogenous. For simulations, short-term interest rates can be determined by forward-looking monetary policy rules in which short-term interest rates depend on the output gap and the expected future core inflation rate (relative to an exogenous target rate). Bond rates will then depend on expected future short-term rates. Exchange rates can be endogenised using a (risk-adjusted) uncovered interest parity condition.

A separate block covers the rest of the world:

- *Commodity Prices* are modelled explicitly in order to capture an important mechanism through which global demand shocks can have inflationary consequences and be propagated between regions. Oil prices are exogenous.

- *Output and Inflation*. The output gap and inflation in the rest of the world are linked to output and inflation in the three main regions, and therefore provide other feedback channels for the main regions.

Key features and estimation results for each block are discussed in more detail below.

2.1 Inflation

9. The main inflation variable is core CPI inflation, defined as the CPI excluding food and energy. This was chosen because it is possibly the best single measure of the 'general inflationary pressures' that that monetary policy is concerned with. The exclusion of energy prices is also useful when monetary policy reaction functions are added the model, to ensure for example that policy does not react to (i.e., 'lets through') the direct effects of an oil shock while reacting to second-round effects, such as the shock feeding through to inflation expectations. Core inflation is determined by a Phillips curve, where the explanatory variables are a pressure of demand term, in the form of the output gap, and supply shocks in the form of various components of import prices:

$$\pi = \pi^e + \alpha_0 ygap + \text{lags}\left(\omega\left(\pi^m - \pi\right)\right) + \text{lags}\left(\omega \Delta \pi^m\right) + \text{lags}\left(\nu \Delta \pi^{com}\right) + \text{lags}\left(\gamma \Delta \pi^{oil}\right),$$

where π is core CPI inflation, π^e is expected inflation, and *ygap* is the output gap.[5] The remaining terms capture import prices, where the inflation rate of import prices of manufactures and services (π^m) is separated out from commodity price inflation (π^{com}) and oil price inflation (π^{oil}). All import prices are measured in local currency terms, and the lags are designed to capture slow passthrough. Non-commodity, non-oil import prices are weighted by the degree of openness of the economy, ω, which is measured by the share of these imports in total value added. This measure of openness has risen over time in all the regions to reach its current level of 11 per cent for the United States, 12 per cent in the euro area, and 6 per cent for Japan. Commodity price inflation is weighted by the share of manufacturing in GDP, ν, while oil price

5. The *lags* function is shorthand for a general distributed lag, which may include current-dated values. Detailed data definitions and sources are given in an Annex.

inflation is weighted by an index of oil intensity in production, γ, which has halved since the early 1970s in all regions. All these weights are exogenous in model simulations.

10. For estimation purposes and in the standard version of the model, the coefficients on the lagged inflation terms are assumed to sum to unity, proxying the combined effects of nominal inertia and (backward-looking) inflation expectations. In that case the Phillips curve can be written in terms of the change in the inflation rate, $\Delta\pi$. Alternative specifications could include a weighted average of forward-looking and backward-looking expectations.

11. Each of the three regions also has a simple equation linking core CPI to headline CPI:

$$\pi^{head} = \pi + \text{lags}\left(\pi^{com}\right) + \text{lags}\left(\pi^{oil}\right)$$

Here the headline CPI inflation rate, π^{head}, is built up from the core rate by adding the direct (or accounting) impact of oil and commodity prices. With this formulation it is possible to distinguish the direct (or accounting) effects of oil and commodity price shocks from the indirect or second-round effects, in which they may get built into the general inflation process.

12. The estimation results are shown in Tables 1 and 2, and the single equation dynamic properties are presented in Figure 1. Detailed data definitions are given in an Annex. The output gap is strongly significant for each region, although the gap appears in a non-linear form in the Japanese equation. Japan's equation has a goal-line effect, in which it is difficult to drive inflation lower when it is already very low.[6] Specifically, when inflation is below 1 per cent per annum, a negative output gap will only reduce inflation by 1 quarter of the amount that it would otherwise. This feature is important when trying to explain Japanese inflation over the past few years. A similar effect was tested for in the United States and euro equations but was not found to be empirically important, possibly because those two regions have not had Japan's experience of a prolonged period of low inflation. Although measured with some uncertainty, the sacrifice ratios are broadly consistent with those found in other Phillips curve work, including Richardson *et al.* (2000) and Turner and Seghezza (1999).

6. The analogy comes from American football, where the closer to the goal-line you are, the harder it is to gain extra yardage. The cut-off of 1 per cent per annum is fairly arbitrary but was chosen after experimenting with several values.

Table 1. **Core CPI Inflation**

Dependent Variable: $\Delta\pi = \Delta(100\ \Delta\log\ \textit{core-CPI})$

	United States	**Euro Area**	**Japan**
Lagged dependent variables			
Lag 1	-0.551 ***	-0.473 ***	-0.636 ***
Lag 2	-0.366 ***	-0.168 **	-0.251 ***
Lag 4	-0.145 **		
Gaps			
Output Gap	0.045 ***	0.055 ***	
Output Gap_{-1}			0.075 *(1)* **
Δ Domestic demand $_{-1}$			0.107 **
Import prices [2]			
$\omega_{-1}\ (\pi^m - \pi)_{-1}$	0.501 *	0.518 ***	0.302 [5]
$\Delta\ \pi^m$	0.242		0.515 ***
$\Delta\ \pi^m_{-2}$			0.515 ***
Commodity Prices [3]			
Average, lags 1-8	0.411 ***		0.255 **
Average, lags 1-4		0.117 ***	
Oil Prices [4]			
Full sample			0.149 ***
- pre-1980	0.141 ***	0.040 **	
- post-1980	0.066	0.029	
Sacrifice Ratio	2.9	1.9	1.6 *(6.3)* [6]
Dummies		93q1	97q2
Estimation period	63:2 - 00:4	74:2 - 00:1	71:2 - 00:1
Standard error	0.23%	0.16%	0.46%

Data definitions are in an Annex.

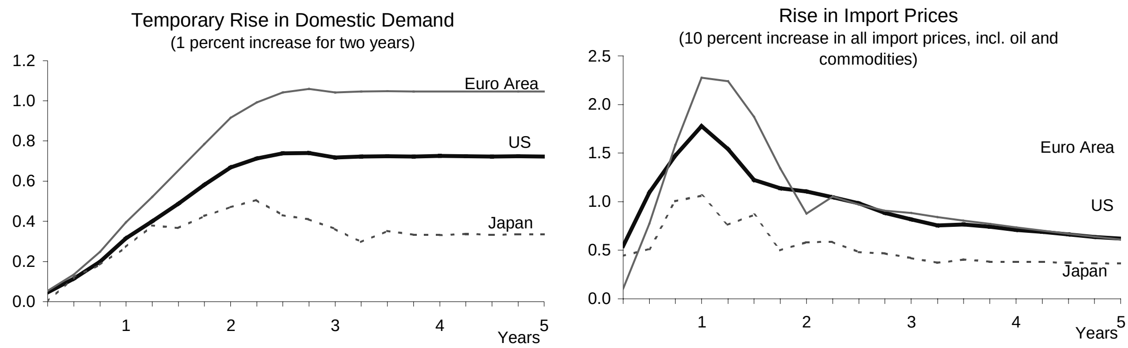
One, two, and three stars denote significance at 10, 5, and 1 percent levels.

1. If gap is negative and inflation is less than 1% p.a. then coefficient is one-quarter of the reported value
2. Manufactures and services.
3. Calculated as $\upsilon\ \Delta\pi^{com}_{-1}$, where ω is the weight of manufacturing in OECD value added.
4. Calculated as $\gamma\ \Delta\pi^{oil}_{-1}$, where ω is a measure of intensity of oil use in production. The lag structure is as follows: US: Average of lags 1-3; Euro Area: lag 1; Japan: lags 0 and 1.
5. Three quarter lag.
6. The sacrifice ratio in brackets is for the "flat" portion of the Phillips curve (i.e., low and falling inflation).

Recent Residuals (positive value means under-prediction)

	United States	Euro Area	Japan
97 Q1	0.12	0.00	-0.14
Q2	0.10	-0.06	0.00
Q3	-0.12	0.01	0.00
Q4	0.10	0.07	-0.22
98 Q1	0.08	0.12	-0.37
Q2	0.19	0.23	-0.11
Q3	0.04	0.12	-0.17
Q4	-0.04	0.13	0.77
99 Q1	-0.18	-0.18	0.30
Q2	0.05	0.14	-0.01
Q3	-0.13	0.02	-0.16
Q4	-0.11	0.00	0.29
00 Q1	-0.19	-0.09	0.35

Figure 1. **Impacts on Headline Inflation (Single equation properties)**
Deviations from Baseline (Annual inflation rate, percentage points)



13. Manufacturing and services import prices are statistically significant for each region, and their impact on inflation is quite large. The (π^m-π) term ensures that manufacturing and service import prices are eventually fully passed on to consumer prices,[7] but the adjustment is significantly slower in Japan than in the other two regions. That is partly because the import price coefficient is estimated to be lower, and partly because Japan's economy is more closed in the sense that imports represent a substantially smaller share of GDP. Commodity price inflation is also significant in a macroeconomic and econometric sense, with the long lag structure implying that only sustained changes in commodity prices feed through to the core inflation rate, while short-term blips tend to be discounted. There is some evidence that the impact of oil prices appears to have changed over time, at least for the United States and euro area. Even after accounting for the declining importance of oil in production, the estimated feed-through of oil prices to core inflation is less than half as strong in the post-1980 period as it was before 1980 (see Hooker 1999). Finally, because only terms in $\Delta\pi$ are included, commodity and oil price inflation has the property that it 'drops in and drops out' of consumer price inflation.

7. The model-wide implications of this term depend on the assumed exchange rate regime. Under fixed exchange rates, this term forces all countries to have the same steady state inflation rate (in order that real exchange rates are untrended). However, under floating rates each country can have its own inflation rate with the nominal exchange rate moving according to the inflation differentials between countries.

Table 2. **Headline CPI Inflation**

Dependent Variable: $\pi^h = 100\ \Delta\log CPI$

	United States		Euro Area		Japan	
Core Inflation	0.964	***	0.976	***	0.964	***
Commodity Price Inflation						
Lag 0	0.010	**				
Lag 1					0.019	***
Lag 2	0.010	***				
Lag 3			0.013	***		
Oil Price Inflation						
Lag 0	0.016	***	0.006	**	0.006	***
Lag 1			0.005	**		
Lag 2					0.011	***
Estimation period	63:2 - 00:1		80:1 - 00:1		70:4 - 00:1	
Standard error	0.27%		0.20%		0.30%	

Data definitions are in an Annex.

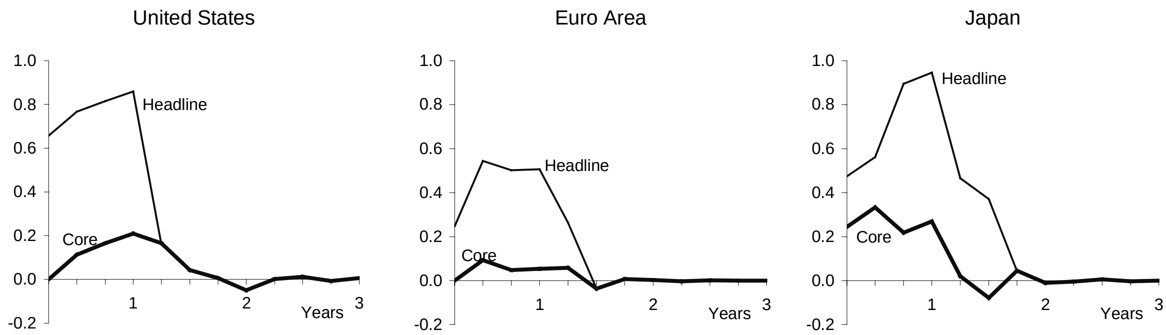
One, two, and three stars denote significance at 10, 5, and 1 percent levels.

Coefficients restricted to sum to one.

14. Figure 2 illustrates the different responses of headline and core inflation following a rise in oil prices. Note that the Figure shows the single equation properties, not a full model simulation. A rise in oil prices by 50 per cent has a large and relatively quick impact on headline inflation, which rises by between ½ and 1 per cent, although the impact drops out within 12-18 months (the lags are slightly longer in Japan). The core inflation rate rises by considerably less, by around 0.1 to 0.25 per cent.

Figure 2. **Impacts on Inflation of a 50% rise in oil prices (Single equation properties)**

Deviations from Baseline (Annual inflation rate, percentage points)



2.2 GDP and the output gap

15. The output gap, *ygap*, is based on an IS-curve relationship, as a function of real interest rates (r), fiscal variables (g), the real exchange rate (rer), and other variables:

$$\Delta ygap = f(r, g, rer, ...). \quad [1]$$

Given that GDP (y) and *ygap* are related by the identity $ygap = 100.(y/y^*\text{-}1)$ where y^* is potential output, equation [1] can be re-written as:

$\Delta \log y = \Delta \log y^* + g(r, g, rer, ...)$.

Consequently, an advantage of treating potential output as exogenous and writing the model in terms of the gap is that it avoids having to model or explain changes in potential output. In other words, the long term or trend changes in growth can be taken as given so that the model can focus on short term or cyclical variations in growth. That considerably simplifies the estimation and is likely to lead to equations that are econometrically more sound.[8]

16. In keeping with the need to keep the model small, a single IS curve for each region was initially estimated. However, it quickly became clear that several important coefficients were poorly determined or had the wrong sign. Thus the output gap (*ygap*) was split into two components: domestic demand and net exports. Obviously output can be cut any number of ways but this disaggregation seemed most useful and relevant given the purpose of the model. Hence *ygap* is written:

$$ygap = 100.\left((dd + nx)/y^* - 1\right) \equiv ddgap + nxgap$$

where *dd* and *nx* are domestic demand and net exports respectively. These are discussed separately in the following two sections.

Domestic demand

17. The equation for the domestic demand gap, *ddgap*, takes the following form,

$$\Delta ddgap = -\delta(r - c) + \text{lags}(\Delta ddgap) + \text{lags}(\Delta irs) + \text{lags}(\Delta\Delta xmgap) + \text{lags}(\Delta\Delta gspend) + \text{lags}(\Delta\Delta grev)$$

where *r* is a measure of real long-term interest rates,[9] *c* is a constant, *irs* is the short-term interest rate, *gspend* is cyclically-adjusted government spending (as a proportion of potential output), and *grev* is cyclically adjusted government revenues (*grev* minus *gspend* equals the cyclically adjusted budget balance).

18. The first term captures the level of long-term real interest rates: high real interest rates will keep the growth rate of domestic demand permanently below the potential growth rate. Given that the other terms in the equation will eventually go to zero, the only way to ensure that domestic demand growth returns toits potential rate is for the real interest rate to return to its equilibrium level, *c*. Consequently, there is a policy-neutral real interest rate implicit in the model. This formulation also implies that there is no error-correction mechanism in this equation that ensures the gap 'automatically' returns to zero. However, a non-zero gap has consequences for inflation and therefore for trade competitiveness, so the model as a whole has the property that gaps will eventually close. Of course, equilibrium can be restored more quickly by explicit monetary or fiscal policy action.

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8. As evidenced by the burgeoning literature on the empirical determinants of trend growth, it is difficult to econometrically estimate robust equations that explain potential output. In more technical terms, the approach followed here assumes that potential is weakly exogenous with respect to the other explanatory variables (*r, g, etc*) - at least over business cycle frequencies - which seems a reasonable first approximation.

9 . For the purposes of estimation, the inflation expectations component of real interest rates is proxied by a very smooth Hodrick Prescott filter through actual inflation. In model simulation, these expectations can be substituted out with model-consistent forward expectations of inflation.

19. The other terms in the equation are relatively simple. Lagged dependent variables capture slow adjustment. Lags of net exports (relative to potential) capture the feed-through from foreign trade to domestic demand. For example, a depreciation of the exchange rate that leads to a rise in exports will lead to greater income of producers and workers in the tradeables sector, which should feed through to domestic demand with a lag. Changes in short-term interest rates capture monetary policy influences and allow a richer dynamic response to changes in policy than the simple equilibrium real interest rate term. Finally, fiscal policy is captured through the separate influences of government spending and revenue. Spending and revenue are treated separately because the dynamic response to spending and tax shocks is likely to be considerably different.[10] The dynamic functional form of the fiscal and net export variables (specifically, that they have been double-differenced) ensures they will have only temporary effects on output. For example, a permanent rise of government spending of 1 per cent of GDP will eventually be fully crowded out by a 1 per cent fall in private domestic spending. Such crowding-out effects are somewhat mechanistic given the size and reduced form nature of the model, proxying transmission mechanisms that are treated more explicitly in larger models.

20. Several country-specific variables have been added to the domestic demand equations in order to capture recent experience. For the United States, a measure of share-market wealth relative to disposable income has been an important recent determinant of domestic demand. The Japanese equation includes the real price of land because the 1990s cannot be explained by monetary and fiscal variables alone. The long stagnation is partly driven by balance sheet problems in the financial sector, which in turn is partly the result of the collapse of asset prices since the late 1980s.

21. The estimation results are shown in Table 3 and the single-equation simulation properties are shown in Figure 3.[11] Key results are:

- There is a strong feed-through from net exports to domestic demand in all regions, with a lag of 1-2 quarters.

- Changes in short-term interest rates are strongly significant and operate with a lag of around 2 quarters in the United States and euro area, and 1 quarter in Japan. The coefficients on long-term real interest rates are relatively small[12] so this term will have only a small impact on short-term forecasts, but has an important stabilising role in the model when used for simulations. Figure 3 shows that the total interest rate effect is weaker in the euro area than in the other two regions.

- The government spending multiplier is initially around 1 or higher implying that private spending is crowded in to begin with, but crowding out occurs relatively quickly; after two years, around two-thirds of the initial shock has been offset by a reduction in private spending.

- A 10 per cent rise in United States stock prices has a strong but temporary impact on domestic demand, with demand peaking around 1–1.5 per cent higher after 18 months. This is in line with a '3-5¢ rule' for consumption (whereby a $1 increase in wealth will lead to an eventual increase in

10. Making this distinction led to substantial improvements in the equations compared with earlier versions.

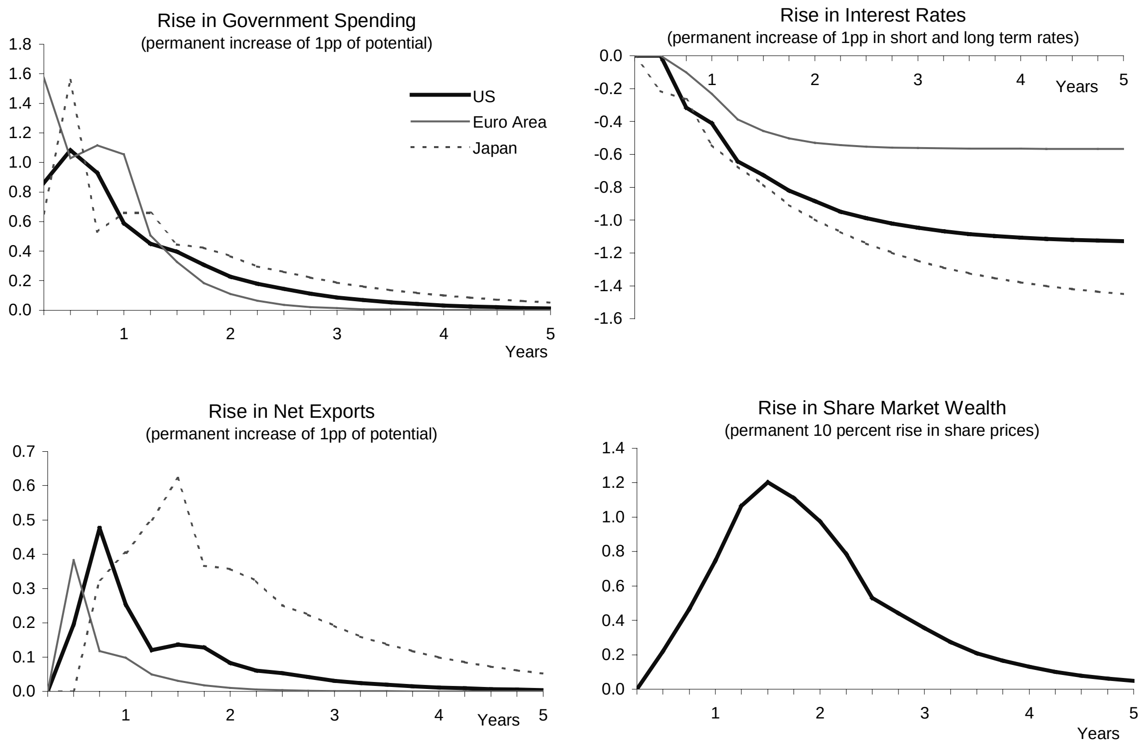
11. In this and other equations, dynamics have initially been freely estimated but then often simplified by imposing the same coefficient on different lags. For example, the coefficients on lags 1-3 of $\Delta ddgap$ in the Japanese equation have been imposed to be equal because they were approximately equal when freely estimated.

12. The Euro coefficient was imposed at –0.06 (a restriction accepted at the 10 per cent level) because the freely estimated coefficient was too small.

consumption of between 3 and 5 cents), plus an extra effect for business investment.[13] The impact on domestic demand relative to potential output is temporary because the required portfolio adjustments will not be permanent.

- Finally, two specification checks were performed. First, export growth (relative to potential) was added to each equation. This ‘trade multiplier’ effect was added because it is possible that domestic demand will respond to an increase in the volume of trade even if *net* exports remain unchanged. However, this additional multiplier was insignificant in each region suggesting that the net export formulation is a useful simplification. Second, richer dynamic adjustment from potential output to actual output was tested by adding lags of potential growth. However, they were insignificant in each region.

Figure 3. **Impacts on Domestic Demand (Single Equation Properties)**
Deviations from Baseline (percent)



13. Sharemarket wealth is close to 200 per cent of disposable income, and consumption is around two-thirds of GDP. Hence, a 10 per cent rise in share prices corresponds in dollar terms to 20 per cent of GDP and 30 per cent of consumption. If 4¢ of each dollar is spent, consumption will rise by 4/100×30 = 1.2 per cent. Hence GDP will increase by approximately 0.8 per cent. The remaining effect comes from the extra investment generated by higher household demand (Meredith (1997) finds that the investment boost may be worth at least as much as the direct rise in consumption).

Table 3. **Domestic Demand**

Dependent Variable: Δ(*DD/potential-1).100*

	United States	**Euro Area**	**Japan**
Lagged dependents			
Δ Dom demand gap$_{-1}$		0.308 ***	0.249 ***
Δ Dom demand gap$_{-2}$		0.162 *	0.249 ***
Δ Dom demand gap$_{-3}$			0.249 ***
Δ_4 Dom demand gap$_{-1}$	0.130 ***		
Net Exports			
$\Delta\Delta$ Net export gap$_{-1}$	0.197		
$\Delta\Delta$ Net export gap$_{-2}$	0.451 **	0.383 ***	0.326 **
$\Delta\Delta$ Net export gap$_{-3}$	0.166		0.326 **
$\Delta\Delta$ Net export gap$_{-4}$			0.326 **
$\Delta\Delta$ Net export gap$_{-5}$			0.326 **
Interest Rates			
Real IRL [1]	-0.066 *	-0.06 [a]	-0.064
Δ IRS $_{-1}$			-0.214 ***
Δ IRS $_{-2}$	-0.316 ***	-0.100 ***	
Δ IRS $_{-3}$	-0.053	-0.100 ***	-0.214 ***
Δ IRS $_{-4}$	-0.179 ***	-0.100 ***	
Fiscal policy			
$\Delta\Delta$ Spending	0.862 ***	1.573 ***	0.663 ***
$\Delta\Delta$ Spending$_{-1}$	0.971 ***	0.544	1.632 ***
$\Delta\Delta$ Spending$_{-2}$	0.678 **	0.544	
$\Delta\Delta$ Spending$_{-3}$	0.214	0.544	
$\Delta\Delta$ Tax		0.545	
$\Delta\Delta$ Tax$_{-1}$		-0.398	-1.091 **
$\Delta\Delta$ Tax$_{-2}$		0.402	
$\Delta\Delta$ Tax$_{-3}$		0.150	-0.449 **
$\Delta\Delta$ Tax$_{-4}$	-0.210	-0.228	-0.622 ***
Other Variables			
(2) $\Delta\Delta$ Sharemarket wealth $_{-1}$	0.022 ***		
(3) $\Delta\Delta$ Land prices $_{-1}$			0.488 ***
$\Delta\Delta$ Land prices $_{-3}$			0.380 ***
Dummies	70q4, 78q2, 80q2	93q1	97q2
Estimation period	66:1 - 00:1	75:4 - 00:1	75:4 - 00:1
Standard error	0.55	0.38	0.63

Data definitions are in an Annex.

One, two, and three stars denote significance at 10, 5, and 1 percent levels.

(1) Real interest rates minus equilibrium level. The equilibrium is estimated (it equals the constant term in the regression divided by the real IRL coefficient). Inflation expectations area mixture of forward and backward looking, as proxied by a smooth Hodrick-Prescott filter of actual inflation.

(2) Sharemarket wealth as a proportion of disposable income, including indirect holdings. An (econometrically estimated) 8-quarter lag structure is built into this variable.

(3) Urban land price index/CPI

Recent Residuals (positive value means under-prediction)

		United States		Euro Area		Japan	
97	Q1	0.2	*(0.1)*	0.0	*-(0.2)*	0.3	*(0.4)*
	Q2	0.0	*(0.0)*	0.3	*(0.5)*	0.0	*(0.0)*
	Q3	-0.2	*-(0.3)*	-0.1	*(0.0)*	-0.3	*-(0.5)*
	Q4	-0.5	*-(0.4)*	0.4	*(0.3)*	-0.3	*-(0.2)*
98	Q1	0.1	*(0.0)*	0.2	*(0.2)*	-0.1	*-(0.5)*
	Q2	-0.8	*-(1.0)*	0.0	*(0.1)*	-0.5	*-(0.3)*
	Q3	-0.8	*-(0.7)*	-0.1	*(0.0)*	-1.0	*-(1.3)*
	Q4	-0.9	*-(0.6)*	0.2	*-(0.3)*	-0.7	*-(1.0)*
99	Q1	1.5	*(1.1)*	-0.2	*-(0.3)*	1.2	*(1.3)*
	Q2	1.3	*(1.0)*	-0.2	*-(0.2)*	1.3	*(1.4)*
	Q3	-1.2	*-(1.2)*	-0.4	*(0.0)*	-0.9	*-(0.6)*
	Q4	-0.1	*(0.1)*	-0.1	*-(0.2)*	-0.1	*-(0.6)*
00	Q1	1.1	*(0.9)*	-0.1	*-(0.2)*	0.9	*(2.0)*

Value in brackets is the residual for the total output gap

Net exports

22. Net exports as a proportion of potential output are explained by the real effective exchange rate, the local domestic demand gap, and the trade-weighted foreign domestic demand gap. Although differences in openness or import propensities may lead to the coefficients being different on local and foreign domestic demand gaps, in practice the restriction that the coefficients are equal but opposite in sign was accepted for each region. In that case, the equation can be rewritten in terms of the *relative* gap:

$$\Delta xmgap = \text{lags}(\Delta xmgap) + \text{lags}(\Delta rer) + \text{lags}(\Delta relgap)$$

where *rer* is the log real effective exchange rate (based on relative CPIs) and *relgap* is the relative domestic demand gap (foreign minus domestic).

23. The estimation results are in Table 4 and Figure 4. The real exchange rate has a strong and significant impact on net exports in each region. The lag structure is quite long in each case, up to two years, implying that a sustained real exchange rate change is more important than an equal-sized short-term blip. The long -term elasticities are fairly similar across regions: a ten per cent depreciation of the real exchange rate will raise net exports as a share of GDP by 0.6 per cent in the United States, 0.7 per cent in the euro area, and 0.8 per cent in Japan. The size and timing of these responses is consistent with a short-run J-curve effect and with other evidence, including from INTERLINK.

Figure 4. **Impacts on Net Exports (Single equation properties)**
Deviations from Baseline (percentage points of potential GDP)

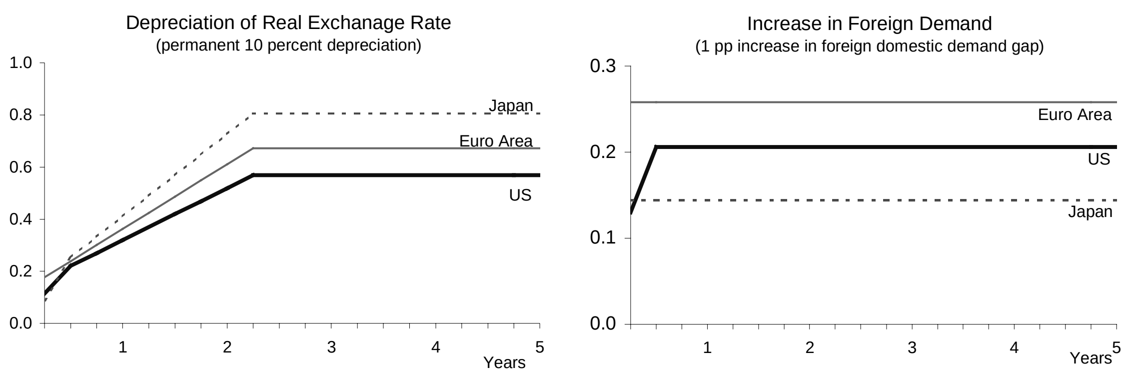


Table 4. **Net Exports**

Dependent Variable: Δ(*net exports/potential).100*

	United States	Euro Area	Japan
Δ log Real Exchange Rate			
Lag 0	-1.157 **	-1.856 ***	-1.237 ***
Lag 1	-1.157 **		-1.237 ***
Average, lags 2-8	-3.652 ***		-5.445 ***
Average, lags 1-8		-5.202 ***	
Relative Domestic Demand Gap *(Foreign-domestic)*			
Δ Relative gap	0.130 ***	0.258 ***	0.135 ***
Δ Relative gap $_{-1}$	0.076 ***		
Dummies	78q1		
Estimation period	74:4 - 00:1	74:3 - 00:1	74:3 - 00:1
Standard error	0.19	0.18	0.30

Data definitions are in an Annex.

One, two, and three stars denote significance at 10, 5, and 1 percent levels.

Recent Residuals (positive value means under-prediction)

	United States	Euro Area	Japan
97 Q1	-0.2	-0.2	0.1
Q2	0.0	0.2	0.0
Q3	-0.1	0.1	-0.2
Q4	0.1	-0.1	0.1
98 Q1	-0.1	0.0	-0.4
Q2	-0.2	0.1	0.1
Q3	0.1	0.0	-0.3
Q4	0.3	-0.5	-0.3
99 Q1	-0.4	-0.1	0.1
Q2	-0.3	0.0	0.1
Q3	0.0	0.4	0.2
Q4	0.2	0.0	-0.5
00 Q1	-0.2	0.0	1.1

2.3 Import prices

24. Manufacturing and service import prices are assumed to be a weighted average of price-taking and price-making behaviour. For price takers, the import price is simply equal to foreign prices divided by the nominal exchange rate. For price makers, the import price is determined by the local price of competing goods, which is proxied by the domestic CPI. With this formulation, long run import prices can be written as a function of the real exchange rate, commodity prices, and domestic consumer prices. An error-correction equation is used to determine short run import prices. A time trend is also included to capture the long term decline in import prices relative to consumer prices.

25. Unfortunately there is no suitable time-series for euro area import prices that excludes intra-euro-area trade. This is particularly a problem when trying to estimate a real exchange rate elasticity because the trade-weighted real exchange rate excludes intra-euro currencies. Consequently, the coefficients of the euro equation have been imposed at values similar to the United States-Japan average but making adjustments in order to improve recent forecasting performance.[14]

14. Despite being imposed, the residuals from the long-run part of the equation are stationary implying that the long run represents a valid cointegrating relationship.

Table 5. **Import Prices**

Dependent Variable: p = log (PM/CPI), PM is manufactures and services import prices

Implicit Long Run

US	$\log PM = const + 0.547 \log CPI + 0.453 \log p^f/e - 0.008\, trend^1$
Euro	$\log PM = const + 0.4 \log CPI + 0.6 \log p^f/e - 0.0057\, trend$
Japan	$\log PM = const + 0.260 \log CPI + 0.740 \log p^f/e - 0.00083\, trend^2$

Short Run

	United States	**Euro Area**[3]	**Japan**
Equilibrium Correction			
p_{-1}	-0.163 ***	-0.2	-0.254 ***
rer_{-1} (=log p.e/p^f)	-0.074 ***	-0.12	-0.187 ***
Lagged dependents			
Lag 1	0.139 **	0.1	
Lag 4			
Δ Real exchange rate			
Lag 0	-0.267 ***	-0.2	-0.483 ***
Lag 4			-0.158 ***
Commodity Prices			
Δ log (*pcom/cpi*)		0.07	0.131 ***
Δ log $(pcom/cpi)_{-2}$	0.052 ***		
Trend/100	-0.130 ***	-0.114 ***	-0.207 ***
Dummies	87q1		
Estimation period	77:1 - 00:1	(imposed)	80:1 - 00:1
Standard error	0.67%	0.82%[4]	1.50%

Data definitions are in an Annex.

One, two, and three stars denote significance at 10, 5, and 1 percent levels.

1. Trend applies after 1980 only.
2. Trend applies before 1994 only.
3. Coefficients imposed. See text for a discussion.
4. Standard error and residuals (below) for Euro based on implicit residuals from imposed equation, 1980-2000

Recent Residuals (positive value means under-prediction)

	United States	Euro Area	Japan
97 Q1	0.0%	*-1.2%*	-1.9%
Q2	-0.3%	*0.0%*	-0.2%
Q3	-0.2%	*-0.6%*	1.8%
Q4	0.2%	*-0.2%*	0.5%
98 Q1	0.2%	*0.3%*	3.6%
Q2	0.2%	*-0.6%*	-0.1%
Q3	0.6%	*0.5%*	0.1%
Q4	-0.2%	*-0.1%*	-1.5%
99 Q1	0.4%	*-0.8%*	-1.0%
Q2	0.2%	*-1.2%*	-0.7%
Q3	0.3%	*-0.9%*	0.1%
Q4	-0.2%	*0.4%*	-0.2%
00 Q1	0.9%	*-1.5%*	-2.1%

26. Results are shown in Table 5. The relative weight on domestic prices versus foreign prices implies that Japan is significantly more of a price-taker than is the United States.[15] Speed of adjustment to long-run equilibrium is reasonably fast, and around half of the exchange rate impact comes through in the first quarter. Commodity prices have a significant impact on non-commodity import prices, implying

15. The long-run equation can be rewritten so that relative import prices (PM/CPI) are a function of the real exchange rate. In that case, the real exchange rate elasticity is -0.45 for the United States and -0.74 for Japan.

effects that work through the production chain, but the effect is only temporary. Oil prices were not significant.

2.4 Commodity prices

27. As mentioned earlier, commodity prices can be an important channel through which global demand shocks are magnified and propagated across regions. Commodity prices tend to be much more volatile than prices for final output, but have an asymmetry in their behaviour. Price rises tend to be large and quick, while price declines tend to be milder but to last longer. In addition, there is a strong commodity price cycle, and this cycle is highly correlated with the world demand cycle.

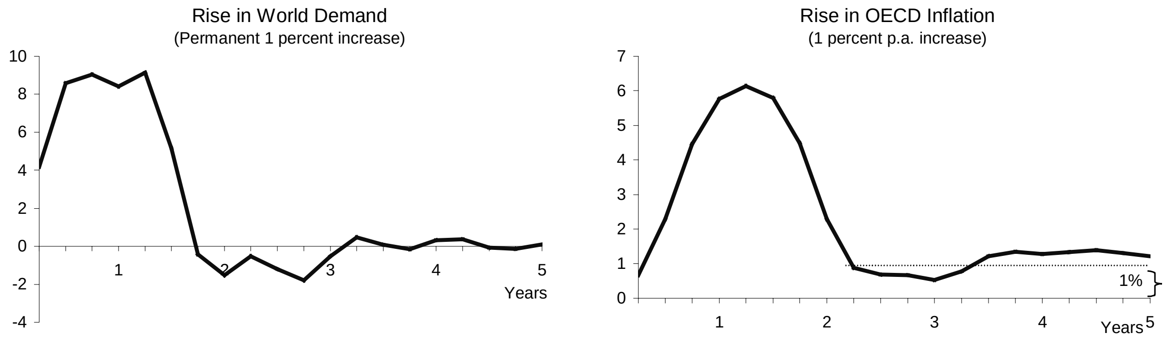
28. Commodity prices are determined by a complex interaction of supply and demand factors, but for the purposes of this model the key features can be simplified and modelled as follows. It is assumed that the inflation rate of non-oil commodity prices measured in US Dollars (π^{com}) depends on world inflation and the world output gap. In the absence of shocks and with the world economy growing at potential, commodity price inflation will settle down to the world inflation rate (after adjusting for a constant 'drift' term that captures the trend decline in real commodity prices). Modelling π^{com} as a function of the world output gap implies that if the world economy is growing at its potential rate then there will be no excess demand and no pressure on manufacturing capacity, and consequently no pressure on real commodity prices (whether they be commodities that are used as inputs to the production process, or commodities for final consumption). Several forms of asymmetry were tested in estimation to capture the apparent asymmetry in the commodity price cycle, including distinguishing between rises and falls in inflation, between positive and negative output gaps, and between positive and negative *changes* in the gap. There was little strong evidence to help choose between the alternatives but the following equation was chosen as the simplest econometrically sound equation that captures the key features:

$$\begin{aligned} \pi^{com} - \pi^{oecd} &= \underset{(3.0)}{-0.0082} + \underset{(7.1)}{0.467}(\pi^{com} - \pi^{oecd})_{-1} + \underset{(4.2)}{4.18}\langle \Delta wldgap/100 \rangle^{+} \\ &\quad + \underset{(7.2)}{0.577}\Delta\pi^{com}_{-1} - \underset{(5.8)}{0.409}\Delta\pi^{com}_{-2} + \underset{(4.8)}{0.358}\Delta\pi^{c}_{-3} + \underset{(1.9)}{1.635}\Delta\pi^{oecd} + \underset{(3.9)}{3.207}\Delta\pi^{oecd}_{-1} + \underset{(4.8)}{3.925}\Delta\pi^{oecd}_{-2} \end{aligned} \quad [2]$$

Estimation period: 1970:2 – 1999:4. t-values in brackets.
R^2 = 0.79. Std. Error = 2.4%
DW = 1.9 AR(4) p-value = 0.59 Jarque-Bera Normality p-value = 0.99

29. The single equation properties are shown in Figure 5. Changes in world output are estimated to have a large and statistically significant impact on commodity price inflation but only if world output growth *exceeds* potential (as denoted by the $\langle \Delta wldgap/100 \rangle^{+}$ term). The OECD output gap was tested as an alternative measure of global excess demand but performed less well, the difference being most important during the recent Asian crisis. The OECD inflation rate excluding high inflation countries (π^{oecd}) is used to proxy world inflation, and the large coefficients imply a substantial degree of overshooting of commodity prices relative to consumer prices. Finally, the constant term implies that real commodity prices will fall by approximately 3½ per cent per annum, *ceteris paribus*.

Figure 5. **Impacts on Commodity Price Inflation (Single equation properties)**
Deviations from Baseline (Annual inflation rate, percentage points)



2.5 *Other variables*

Monetary policy rules

30. The large recent literature on modelling monetary policy in small models of this type has two branches: optimal rules; and the relative performance of simple "rules of thumb" or interest rate reaction functions. Examples include Drew and Hunt (1998), Ball (1998), Svensson (1998), Fair (2000), Rudebusch (1999), and Smets (1998). Looking at optimal policy is certainly feasible in the context of this model, but beyond the scope of this paper. Instead, some preliminary experiments have been performed using simple interest rate reaction functions. A general précis of that branch of the literature suggest that policy rules work better if: (a) interest rates respond to expected future inflation, rather than current inflation; (b) the current output gap is included; and (c) the weights are higher than the simple Taylor rule. Experiments have been made with the following rule:

$$r = r^* + \alpha\, ygap + \beta\left(\Pi^{e}_{t+6} - \Pi^{*}\right)$$

where $r = i - \Pi$ is the real short term interest rate, r^* is the equilibrium real interest rate, Π is the annual rate of core inflation, and Π^e and Π^* are the expected and target annual inflation rates respectively. In this way, interest rates are increased if the output gap is currently above zero or if the expected core inflation rate in eighteen months time is above its target level. A rule that looks ahead eighteen months was chosen partly because the 18-months to 2-year period is typically regarded as the period over which monetary policy has its greatest influence. In addition, it ensures that policy does not react to short-term blips in inflation (i.e., those in the next 1 or 2 quarters) unless they lead to longer lasting inflationary pressures. The weights chosen for the version of the model discussed here are $\alpha = 0.75$ and $\beta = 1.0$, although they are experimental and may be revised after further research. For comparison, the 'standard' Taylor rule depends on the output gap and current inflation, with weights of 0.5 on each variable.[16] This rule is not intended to mimic actual central bank behaviour, but to approximate an optimal policy rule in the context of this model.

16. Attempts to estimate the coefficients of the policy rule for the United States include Judd and Rudebusch (1998) and Clarida, Gali, and Gertler (1998). Both papers include an interest rate smoothing term in order to fit historical policy. Ball (1997) and Levin (1996) show that higher weights than implicit in the Taylor rule are more successful at stabilising output and inflation in a small model of this sort (Ball) and in the Fed's FRB model (Levin).

Long-term interest rates

31. Long-term interest rates feed into domestic demand and can be modelled using an approximation to the expectations theory of the term structure. The bond rate, i^B, is assumed to be a weighted average of all future short rates, i^S, where the weights decline geometrically in the future:

$$i_t^B = (1-\lambda)\sum_{i=0}^{\infty}\lambda^i \, \mathrm{E}\left(i_{t+i}^S \mid t\right) + \varphi \qquad [3]$$

where λ determines the speed with which the weights decline and φ is an exogenous term or liquidity premium to capture the fact that the yield curve slopes up on average. With this formulation, bond rates are purely forward looking but put more weight on the near future than would be the case under the pure expectations theory. In contrast, the pure theory gives *equal* weight to next quarter's 90-day bill rate as it does to the 90-day rate in each of the next 39 quarters but zero weight to anything after 40 quarters. Aside from [3] being more a plausible guide to investment decisions in the domestic demand equation, it greatly simplifies the model solution. It can be rewritten by taking a Koyck lead:

$$i_t^B = (1-\lambda)\,\mathrm{E}\left(i_{t+1}^B\right) + \lambda\left(i_t^S + \varphi\right)$$

so that today's bond rate is a weighted average of next period's expected bond rate and the current short-term rate. The parameter λ is set to 0.9 to give a mean lead of 2½ years between short- and long-rates, which is approximately consistent with the observed relative volatility of bonds and bills.[17] The term premium, φ, has been set to 1 per cent.

Nominal exchange rates

32. Exchange rates against the United States Dollar (USD), e_t, can be endogenised using uncovered interest rate parity (UIP).

$$\log e_t \approx \mathrm{E}\left(\log e_{t+1}\right) + \left(i - i^f - \eta\right)/400$$

where i and i^f are the domestic and trade-weighted foreign short term interest rates respectively, and η is an exogenous risk premium. Since UIP assumes perfect capital markets, equilibrium requires that real interest rates in all regions be equal in the long run, adjusted for a risk premium. Under UIP the exchange rate is a jumping variable. A possible alternative that would reduce the degree of jumping is to model the exchange rate as a weighted average of the current rate and the UIP rate.

Rest of the world output gap

33. The output gap in the rest-of-the-world (i.e., the world minus the three major regions) is determined by a simple form of trade multiplier equation, but with an error-correction term to ensure that the rest-of-the-world gap returns to zero. The lag structure has been determined empirically:

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17. Bond rates appear to move 'too much' to be consistent with the pure expectations theory, but the formulation used in the model will mimic the observed 'excess' volatility because it puts more weight on the near future.

$$\Delta rowgap = \underset{(2.9)}{-0.055} rowgap_{-1} + \underset{(3.2)}{0.300} \Delta rowgap_{-1} + \underset{(2.4)}{0.198} \Delta rowgap_{-2}$$

$$+ \underset{(2.5)}{0.114} \Delta (usygap + usygap_{-1}) + \underset{(2.5)}{0.132} \Delta eurygap + \underset{(1.3)}{0.047} \Delta japygap_{-2} \qquad [4]$$

Estimation period: 1974:3 – 1999:3. t-values in brackets.
R^2 = 0.49. Std. Error = 0.27 DW = 2.0

The coefficient estimates imply that output in the United States has the largest impact on demand in the rest-of-the-world, followed by the euro area and then Japan. The World Output Gap is then an accounting identity:

$$worldgap = 0.26 usgap + 0.21 eurgap + 0.19 japgap + 0.34 rowgap$$

3. Simulation properties

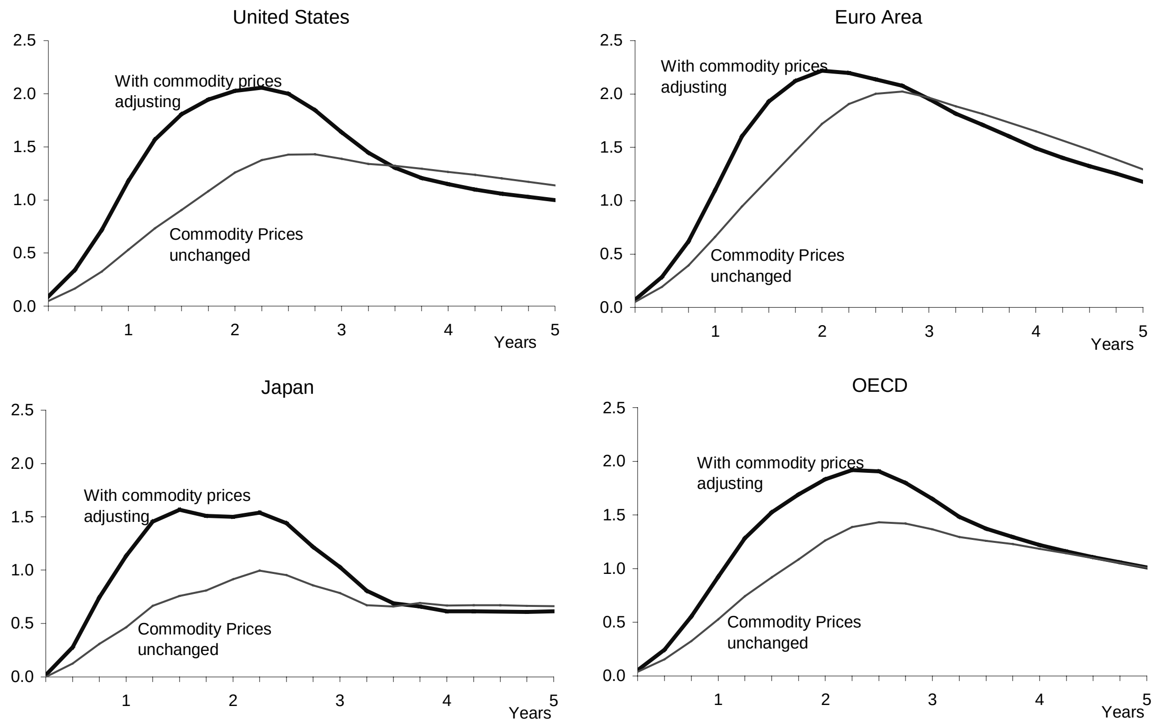
This section describes some simulations in order to demonstrate the major properties of the model. The simulations have been chosen specifically to emphasise the nature and size of the international linkages in the model. A range of 'standard multiplier' shock results are reported in the Annex.

3.1 The inflationary consequences of a global boom

34. The first simulation illustrates the role of commodity prices in propagating a global demand shock. World domestic demand is assumed to be two per cent above baseline for two years. It is assumed that monetary policy does not react so that the demand and commodity price channels can be separated from the monetary policy channel as influences on global inflation.[18] The impacts are summarised in Figure 6. The thin line shows the impacts with commodity prices held at their baseline level, while the thick line assumes that commodity prices move according to equation [2].

18. More precisely, output in each region jumps by two per cent in the first quarter, stays at that level until quarter 8, then returns to baseline. Nominal interest rates and exchange rates are unchanged.

Figure 6. **World Demand Shock - Impacts on Headline Inflation**
Annual rate, deviations from Baseline in percent



35. Even with commodity prices held fixed at their baseline level, the demand shock has relatively large impacts on inflation. For example, United States headline inflation is 1.4 per cent higher after two years, and euro area inflation rises even higher but at a slightly slower pace. However, with endogenous commodity prices the increased demand pressure leads to a 20 per cent rise in commodity prices which pushes United States and euro inflation more than 2 per cent above baseline. Overall, the commodity price channel adds around half as much again to the inflationary consequences of a demand shock (slightly less than half in the euro area). The key to this result is that the demand shock is genuinely global. A single-region shock will clearly have much smaller impacts on world demand, and therefore lead to perhaps marginal pressure on commodity prices. One policy implication concerns the recommendation in Stiglitz (1997) that monetary policy be used to "test the waters" because any inflation that results from excess demand will be slow in emerging. That may be reasonable for any individual country if the rest of the world remains sluggish. However, if a majority of OECD countries simultaneously move into a situation of excess demand, then the size of the pickup of inflation may be substantially increased. In addition, inflation picks up considerably more quickly if commodity prices are affected, implying that central banks will have much less time to react. Thus the view that "small mistakes have only small consequences" may need to be supplemented with "provided everybody doesn't make the same mistake at the same time".

3.2 United States domestic demand and monetary policy

36. This section describes an illustrative simulation to consider the role of international spillovers, the impact of monetary policy feedback rules, and the impact of floating exchange rates. The experiment is an immediate jump in United States domestic demand of 2 per cent. Half of this shock is then unwound the

following year, leaving the remaining half to be unwound endogenously either by the economic feedbacks built into the model or by explicit monetary policy action.[19]

37. Figure 7 shows three variations on this simulation. The first (the thick line) assumes no monetary policy response (unchanged nominal interest rates) and therefore fixed nominal exchange rates. The second (the thin solid line) assumes that monetary policy adjust interest rates according to a rule of the type discussed in Section 2.5, but *still with fixed nominal exchange rates*. The third simulation (the dashed line) assumes that exchange rates are floating, being determined by uncovered interest rate parity. Note that the scales for the United States are different to those for the euro area and Japan.

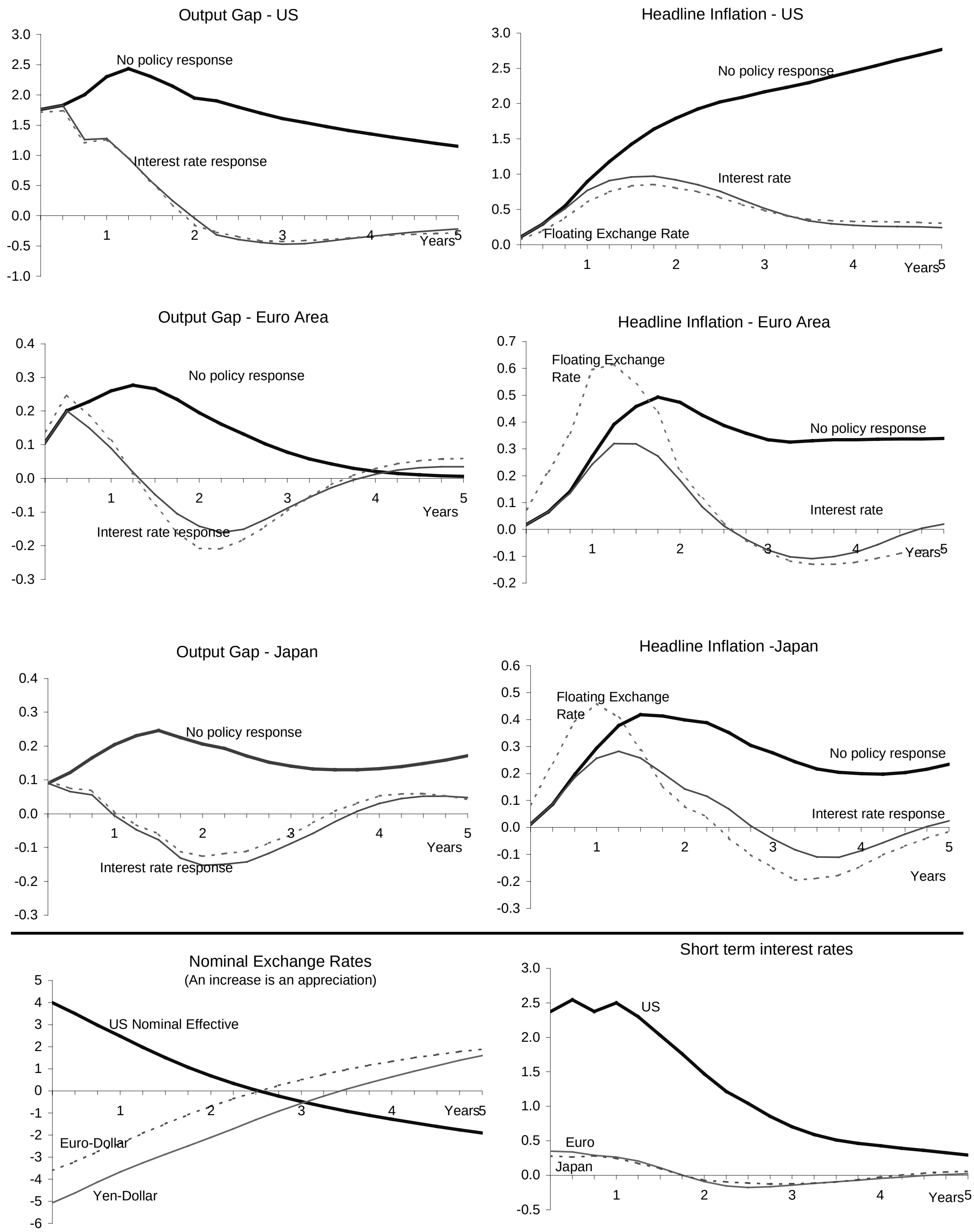
38. Focussing first on the no-policy-response case (the thick line), the initial shock to United States domestic demand is amplified by the momentum or inertia effects in the domestic demand equation, so that the partial unwinding of the shock leaves the output gap still around 2 per cent above baseline after two years. United States inflation picks up strongly – 2 per cent above baseline after two years – and continues to climb so long as the output gap is positive. The main automatic equilibrating mechanism in the model works through trade. Higher inflation at a fixed nominal exchange rate implies an appreciating real exchange rate. The consequent reduction in net exports will reduce the output gap directly and will also feed through to lower domestic demand. However, partly because the share of trade in total output is not large for the United States, this mechanism is comparatively weak. With no equilibrium correction mechanisms in the model, it will take many years for this trade channel to bring the economy back to equilibrium. Note also that the spillovers to the euro area and Japan are not negligible. Output rises by around 0.3 per cent in both regions, and the inflation rate rises by 0.4 – 0.5 per cent per annum. The inflation impact will be partly due to stronger output and partly to imported inflation, including an effect from commodity prices.

19. In this simulation, the demand shock is brought about by a residual adjustment to the domestic demand equation but keeping the equation endogenous.

Figure 7. **US Demand Shock**

Deviations from baseline in percent

Note that scales for the US are different to those for the Euro Area and Japan



39. An active interest rate response stabilises the system much more quickly (the thin line). The bottom-right panel of Figure 6 shows that short-term United States interest rates rise by 2½ per centage points in response to the higher output gap and the expected future inflation. Bond rates jump by less – a little over 1 per cent because the forward-looking nature of the bond market expects short rates to come back in the future. This response is sufficient to close the United States output gap within two years, and to return United States inflation towards target after three. Here almost all the monetary policy work is done by the United States; given that exchange rates are fixed, interest rates in the euro area and Japan rise by only 25 basis points or thereabouts.

40. The dashed lines show the impact of a floating exchange rate in transmitting the shock across regions. The United States nominal effective exchange rate jumps by 4 per cent in response to higher interest rates. This is not a large amount, but bear in mind that nominal interest rates do not stay high for long. The euro and Yen depreciate by 4–5 per cent against the dollar. The interesting result is that these depreciations have a significant effect on inflation in the euro area and Japan. Not only do they contribute at least as much as the direct trade-output channel, they also cause inflation to rise considerably faster. The implication here is that, at least as far as monetary policy is concerned, significantly misleading policy signals may be given if the exchange rate channel is ignored (see also Hall and Whitley 1999). This also illustrates one of the strengths of keeping a model small. The role of exchange rates in transmitting shocks between regions is often missed in large global models such as INTERLINK because it is technically difficult to solve them with forward-looking jumping variables.

4. Summary and future developments

41. This paper has described preliminary work on a short-term forecasting model of the major economic regions, with a particular focus on international linkages. With that in mind, there are several areas for potential further work. First, the impact of policy could be considered in greater depth by investigating alternative monetary policy reaction functions and alternative exchange rate rules. Second, the role of expectations as a transmission mechanism of policy both within and between regions could be developed. Third, closer scrutiny of differences in dynamics across regions may be warranted. For example, small differences in lag structures can imply large differences in the speed and magnitude with which an oil shock affects inflation in the three regions. Finally, the number of regions may need to be reconsidered. For example, the United States and Japan together account for less than 20 per cent of euro area trade, with the remainder accounted for by the 'rest of the world' block. This is a particular weakness given the diversity of countries that make up this 'residual' block and the likelihood that they are at different stages of the business cycle. A possible parsimonious solution would be to divide this block into more homogenous regions, each of which would explain the output gap as a single reduced form of the output gap in other regions.

ANNEX – STANDARD SIMULATION RESULTS

Tables A1–A3 present standard simulation results to illustrate the comparative properties of the three regional models plus the strength of interactions between regions. They are not intended to represent genuine policy simulations but are provided as simple diagnostics to document the properties of the model. The full model is run in each case (i.e., all three regional models plus the world block) with each table detailing the results of three separate simulations. For example, the first panel of Table A1 shows the impacts of a rise in US interest rates, assuming euro and Japanese rates are unchanged.

Table A1 shows a rise in short-term interest rates by 1 per cent for two years. Long-term interest rates are determined by the forward-looking equation in the model (see Section 2.5) and therefore rise by less than 1 per cent because financial markets anticipate that the tightening in monetary policy is temporary (in fact, long-term rates initially jump by around ½ per cent, then decline over the following two years). Nominal exchange rates are held fixed. Each region takes at least half a year to respond significantly to a tightening of monetary policy, with the peak response being around eighteen months after the tightening. Output in the euro area is the least sensitive of the three regions to the rise in interest rates. The full inflationary impact takes between two and three years to occur, although the slightly slow response is partly because the quicker-acting exchange rate channel has been neutralised in the simulations. The cross-country spillover effects are smaller than in INTERLINK.

Table A2 shows the impacts of a permanent increase in government spending of 1 per cent of potential GDP. Nominal exchange rates are again held fixed, as are nominal interest rates. Government spending initially crowds in private spending but crowding out occurs relatively quickly. Half of the impulse has gone within 4 quarters, and the spending increase has been fully crowded out within two years.

Table A3 shows the impacts of an exchange rate depreciation in each of the three regions, holding nominal interest rates fixed. Japanese activity is most sensitive to exchange rate movements, which is consistent with other evidence that Japan's exports are more price sensitive than most countries (Murata, Turner, Rae, and Le Fouler 2000). However, the euro area inflation rate is the most sensitive to a depreciation, partly because it is a 'more open' economy than the other two.

Table A1. **Impact of a rise in interest rates**
A 1 percent increase of short term rates for two years
Deviations from baseline in percent

	Quarters after shock						
	1	**2**	**3**	**4**	**8**	**12**	**16**
				Rise in interest rates in the United States			
United States							
Output Gap	0.0	0.0	-0.3	-0.4	-0.9	-0.8	-0.4
Inflation[1]	0.0	0.0	0.0	-0.1	-0.4	-0.7	-0.8
Net Exports[2]	0.0	0.0	0.0	0.1	0.2	0.2	0.2
Euro Area							
Output Gap	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
Inflation[1]	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1
Net Exports[2]	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
Japan							
Output Gap	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
Inflation[1]	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
Net Exports[2]	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
				Rise in interest rates in the Euro Area			
United States							
Output Gap	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euro Area							
Output Gap	0.0	0.0	-0.1	-0.2	-0.6	-0.5	-0.2
Inflation[1]	0.0	0.0	0.0	0.0	-0.3	-0.6	-0.7
Net Exports[2]	0.0	0.0	0.0	0.1	0.2	0.2	0.2
Japan							
Output Gap	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Rise in interest rates in Japan			
United States							
Output Gap	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
Inflation[1]	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euro Area							
Output Gap	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan							
Output Gap	0.0	-0.2	-0.3	-0.6	-1.1	-0.9	-0.7
Inflation[1]	0.0	0.0	0.0	-0.1	-0.4	-0.6	-0.6
Net Exports[2]	0.0	0.0	0.0	0.1	0.2	0.2	0.2

1. Annual rate of headline inflation.
2. As a percent of potential output.

Table A2. **Impact of a rise in government spending**

Permanent increase of 1 percent of potential output

Deviations from baseline in percent

	Quarters after shock						
	1	**2**	**3**	**4**	**8**	**12**	**16**
	Rise in spending in the United States						
United States							
Output Gap	0.8	0.9	0.7	0.4	0.2	0.0	-0.1
Inflation[1]	0.0	0.1	0.2	0.3	0.4	0.3	0.3
Net Exports[2]	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1
Euro Area							
Output Gap	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.1	0.1	0.1	0.0	0.0
Net Exports[2]	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Japan							
Output Gap	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.1	0.1	0.1	0.0	0.0
Net Exports[2]	0.0	0.1	0.1	0.0	0.0	0.0	0.0
	Rise in spending in the Euro Area						
United States							
Output Gap	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.1	0.1	0.1	0.1	0.0
Net Exports[2]	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Euro Area							
Output Gap	1.2	0.7	0.9	0.8	0.1	-0.1	-0.1
Inflation[1]	0.1	0.2	0.3	0.5	0.6	0.5	0.4
Net Exports[2]	-0.4	-0.2	-0.3	-0.2	-0.1	-0.1	-0.1
Japan							
Output Gap	0.1	0.0	0.1	0.1	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.1	0.1	0.1	0.0	0.0
Net Exports[2]	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	Rise in spending in Japan						
United States							
Output Gap	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.1	0.1	0.1	0.0	0.0
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euro Area							
Output Gap	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.0	0.1	0.1	0.0	0.0
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan							
Output Gap	0.6	1.3	0.4	0.5	0.3	0.1	0.0
Inflation[1]	0.0	0.1	0.3	0.3	0.3	0.2	0.2
Net Exports[2]	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1

1. Annual rate of headline inflation.
2. As a percent of potential output.

Table A3. **Impact of an exchange rate depreciation**

A permanent ten percent nominal depreciation

Deviations from baseline in percent

	Quarters after shock						
	1	**2**	**3**	**4**	**8**	**12**	**16**
				Depreciation of the United States Dollar			
United States							
Output Gap	0.1	0.2	0.3	0.4	0.5	0.5	0.4
Inflation[1]	0.1	0.2	0.4	0.5	0.8	1.0	1.1
Net Exports[2]	0.1	0.2	0.3	0.3	0.5	0.5	0.4
Euro Area							
Output Gap	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inflation[1]	-0.1	-0.3	-0.4	-0.6	0.0	0.0	-0.1
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan							
Output Gap	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1
Inflation[1]	-0.2	-0.4	-0.6	-0.7	-0.2	-0.1	-0.1
Net Exports[2]	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
				Depreciation of the Euro			
United States							
Output Gap	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
Inflation[1]	0.0	0.0	0.0	0.0	0.1	0.0	-0.1
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euro Area							
Output Gap	0.2	0.3	0.3	0.4	0.6	0.5	0.4
Inflation[1]	0.1	0.4	0.7	1.2	1.2	1.4	1.5
Net Exports[2]	0.2	0.2	0.3	0.3	0.5	0.5	0.4
Japan							
Output Gap	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Inflation[1]	0.0	0.0	0.0	0.0	0.1	0.0	-0.1
Net Exports[2]	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1
				Depreciation of the Yen			
United States							
Output Gap	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Inflation[1]	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Net Exports[2]	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Euro Area							
Output Gap	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inflation[1]	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Net Exports[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan							
Output Gap	0.1	0.2	0.3	0.5	0.8	0.9	0.7
Inflation[1]	0.3	0.5	0.9	1.0	0.6	0.6	0.7
Net Exports[2]	0.1	0.2	0.3	0.4	0.6	0.7	0.6

1. Annual rate of headline inflation.
2. As a percent of potential output.

APPENDIX - DATA DEFINITIONS

All data is quarterly, seasonally adjusted, and is based on the OECD's Analytic Database (ADB). The euro area volume aggregates are calculated by aggregating the growth rates of individual countries, weighted by the previous period's share of nominal GDP at current exchange rates. Euro area financial aggregates are weighted averages of the levels of country variables, using the same GDP weights as above. A detailed description of ADB data can be found on the OECD's web site at www.oecd.org/eco/data/eoinv.pdf. A description of variables by category is given below (ADB mnemonics are in capitals).

Inflation, prices, exchange rates

Core inflation	$\pi = 100.\Delta \log(core\ CPI)$
Core CPI	CPI excluding food and energy. Source: MEI
Headline CPI	CPI all items, seasonally adjusted. Source: MEI Euro area CPI is the harmonised CPI index from 1995, non-harmonised before that.
Import prices	π^{imp} = rate of change of implicit deflator for imports of manufactures and services, where the deflator has been detrended from 1980 using a time trend.
Weight on import prices	ω = (MM+MSR)/(GDP+MM+MSR) where MM and MSR are imports of manufactures and services respectively.
Commodity prices	WPHD: primary commodities excl. energy, world price, HWWA-index US$
Weight on commodity prices	Weight of manufacturing output in GDP.
Oil prices	WPOIL: OECD crude oil import price, cif, US$ per barrel
Weight on oil prices	ν = oil intensity in output = production plus imports of oil relative to GDP. Source: OECD Energy Yearbook.
OECD Inflation	GDP weighted average of OECD consumer price inflation, excluding high inflation countries.
Real exchange rate	*rer* = log real exchange rate (CPIDR) based on relative CPIs. Weights based on manufacturing exports adjusting for third-country competitors. Euro area weights exclude intra-euro trade.

Output and Spending

Domestic demand gap	*ddgap* = 100.(TDDV/GDPVTR-1) where TDDV is domestic demand and GDPVTR is potential output (both in volume terms).
Net export gap	*xmgap* = 100.(XGSV-MGSV)/GDPVTR, where XGSV and MGSV are exports and imports of goods and services, volume, respectively.
Output gap	*ygap* = 100.(GDPV/GDPVTR-1).
Government spending	*gspend* = 100.(CGV+IGV)/GDPVTR
Government revenue	*grev* = NLGQA + *gspend*, where NLGQA is the cyclically adjusted general government balance.
World gap and rest of world gap	*wldgap* = GDP weighted world output gap. Based on Secretariat's estimates of output gaps for OECD members. The gap for the rest of the world is based on taking a Hodrick Prescott filter through an aggregate of rest-of-the-world GDP.
Relative gap	*relgap* = *ddgap* – foreign *ddgap*, where the foreign *ddgap* is a trade weighted average of foreign domestic demand gaps.

Interest Rates

Short-term interest rate	IRS
Long-term interest rate	IRL
Real long-term interest rate	r = IRL – π^e where π^e is inflation expectations, proxied by very smooth Hodrick Prescott filter

(domestic demand eqn)	through actual inflation (λ=20,000).
Real short-term interest rate (policy rule)	IRS – annual core inflation rate.

<u>Other</u>

US Sharemarket wealth	US household sharemarket wealth relative to disposable income. Wealth source: US Federal Reserve Board Flow of Funds Table L100.
Japanese land prices	Japanese urban land price index. Source: Japan real estate institute.

BIBLIOGRAPHY

BALL, Laurence (1998), 'Policy Rules for Open Economies', Reserve Bank of Australia Research Discussion Paper 9806.

BEECHEY, Meredith, Nargis BARUCHA, Adam CAGLIARINI, David GRUEN, Christopher THOMPSON (2000), 'A Small Model of the Australian macroeconomy', Reserve Bank of Australia Research Discussion Paper 2000-05.

BHARUCHA, Nargis and Christopher KENT (1998), 'Inflation Targeting in a Small Open Economy', Reserve Bank of Australia Research Discussion Paper 9807.

COENEN, Gunter and Volker WIELAND (2000), 'A Small Estimated Euro Area Model with Rational Expectations and Nominal Rigidities,' ECB Working Paper No. 30.

DE BROUWER, Gordon and Luci ELLIS (1998), 'Forward-Looking behaviour and credibility: Some evidence and implications for policy', Reserve Bank of Australia Research Discussion Paper 9803.

DUGUAY, Pierre (1994), 'Empirical Evidence on the Strength of the Monetary Transmission Mechanism in Canada: An aggregate approach', *Journal of Monetary Economics* 33.

FAIR, Ray C. (2000), 'Estimated, Calibrated, and Optimal Interest Rate Rules', http://fairmodel.econ.yale.edu/rayfair/pdf/1999D.PDF.

GIORNO, Claude, Pete RICHARDSON, Deborah ROSEVEARE, and Paul VAN DEN NOORD (1995), 'Estimating Potential Output, Output Gaps and Structural Budget Balances', *OECD Economic Studies* No. 24, 1995/I.

HALL, Stephen G. and John D. WHITLEY (1999), 'Linkages between Countries in International Models', unpublished.

HARGREAVES, David (1999), 'SDS-FPS: A Small Demand-side Version of the Forecasting and Policy System core model', Reserve Bank of New Zealand Discussion Paper G99/10.

HOOKER, Mark (1999), 'Are Oil Shocks Inflationary? Asymmetric and Nonlinear Specifications versus Changes in Regime', Federal Reserve Board Finance and Economics Discussion Paper 1999-65.

MEREDITH, Guy (1997), 'Effect of Equity Prices on Aggregate Demand', unpublished IMF Office Memorandum.

MURATA, Keiko, David TURNER, David RAE and Laurence LE FOULER (2000), 'Modelling Manufacturing Export Volumes Equations - A system estimation approach', OECD Working Paper 235.

RICHARDSON, Pete, Laurence BOONE, Claude GIORNO, Mara MEACCI, David RAE and David TURNER, 'The Concept, Policy Use and Measurement of Structural Unemployment: Estimating a Time Varying NAIRU across 21 OECD Countries', OECD Working Paper 250.

RUDEBUSCH, Glenn (1999), 'Is the Fed Too Timid? Monetary Policy in an Uncertain World', mimeo, Federal Reserve Bank of San Francisco.

SMETS, Frank (1998), 'Output Gap Uncertainty – Does it Matter for the Taylor Rule?', BIS Working Paper No. 60.

STIGLITZ, Joseph (1997), 'Reflections on the Natural Rate Hypothesis', *Journal of Economic Perspectives*, 11(1), 3-10.

TURNER, David and Elena Seghezza, 'Testing for a Common OECD Phillips Curve', OECD Working Paper 219.

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