BANK OF GREECE

AGGREGATE SUPPLY AND DEMAND, THE REAL EXCHANGE RATE AND OIL PRICE DENOMINATION

Yiannis Stournaras

Working Paper

No. 26   July 2005

AGGREGATE SUPPLY AND DEMAND, THE REAL EXCHANGE RATE AND OIL PRICE DENOMINATION

Yiannis Stournaras
Bank of Greece and University of Athens

ABSTRACT

In an aggregate supply, aggregate demand model of an open economy with imperfect competition in labour and product markets, the effectiveness of monetary and fiscal policies depends on the degree of wage indexation, the exchange rate regime and the currency denomination of the international prices of raw materials, such as oil. In a two country world with a floating exchange rate, real consumer wage rigidity and the prices of imported raw materials fixed in the currency of Country 2, monetary policy is effective only in Country 2, but fiscal policy is relatively more effective in Country 1. These results may explain certain characteristics and have certain implications for economic policy in the US and the Eurozone.

***Keywords*:** Open economy macroeconomics, real exchange rate, oil price denomination
***JEL classification*:** F41,Q43

***Acknowledgements*:** I wish to thank participants in research seminars in the Economic Research Department, Bank of Greece and in the Department of Economics, University of Athens for their useful comments. Particularly I wish to thank Vassilis Droucopoulos and George Krimpas for insightful suggestions and a useful discussion on the subject.

Address for Correspondence:
Yiannis Stournaras,
Economic Research Department,
Bank of Greece, 21 E. Venizelos Ave.,
102 50 Athens, Greece,
Tel.: + 30 210-320 3604
E-mail: stournaras@grmail.com

1. Introduction

The effectiveness of fiscal and monetary policies in open economies continues to be a central issue in macroeconomics. The analytical framework is provided mainly by the Mundell-Fleming-Dornbusch model (see, among others, Mundell, 1968; Dornbusch, 1980; McCallum, 1996; Heijdra and Van der Ploeg, 2002). In recent years, many authors use the new open economy macroeconomics model to tackle the same questions (Obstfeld and Rogoff, 1996, chapter 10; Obstfeld, 2001; Lane, 2001).

The formation of EMU and the prospective participation of the enlargement countries has revived interest in the economics of optimum currency areas, the choice of exchange rate regime and the coordination of economic policies (see, among others, de Grauwe, 2001; Buti, 2003). One of the main conclusions of the theory of optimum currency areas is that the choice of exchange rate regime and the effectiveness of monetary policy depends critically on the nature of wage formation (Ishiyama, 1975; Edwards, 1989; Masson and Taylor, 1992; Buiter, 1999). Those who argue in favour of flexible exchange rates, including Friedman (1953), want to retain exchange rate flexibility as an instrument of adjustment in a world of sticky nominal prices and wages. However, the presence of real rigidities implies that nominal variables, such as the nominal exchange rate, play no role in the adjustment of output and the real exchange rate.

In the present paper we develop a model to deal with certain of the above issues. In Moschos and Stournaras (1998) an aggregate supply relationship was derived in a model of an open economy with imperfect competition in its labour and product markets. This relationship was used for an empirical investigation of real wage rigidity in Greece in order to examine whether the loss of the exchange rate instrument (following Greece's participation in EMU) would imply a real cost or not. In the present paper, this aggregate supply relationship is developed further and is combined with an aggregate demand one, derived from traditional IS – LM equations under perfect capital mobility. Within this framework we investigate the effectiveness of (*ad hoc*) monetary and fiscal policies under fixed and flexible exchange rates and under complete consumer wage indexation (real consumer wage rigidity) and incomplete wage indexation (nominal wage rigidity). We also investigate the effects of an adverse supply-side shock (such as an increase in the international oil price) as well as the effects of benign changes in market structure (the wage pressure parameter and/or the mark-up coefficient), technology or the labour force. An interesting implication of the analysis is that fixing the international raw material prices in the home currency introduces an element of nominal inertia even under real consumer wage rigidity. In effect, the supply relationship under nominal wage rigidity is qualitatively similar to the supply relationship under real wage rigidity but with the international raw material prices fixed in the home currency.

We extend the analysis to a two-country world, under a floating exchange rate, real consumer wage rigidity in both Country 1 and Country 2, and the price of imported raw materials fixed in the currency of Country 2. In effect, Country 1 is characterized by real rigidity, while Country 2 by nominal rigidity.

Within such a framework, an expansionary monetary policy in Country 1 has no effect on output. An expansionary monetary policy in Country 2 has a positive effect on both countries' output through a reduction in the "world" interest rate. An expansionary fiscal policy in Country 1 is more effective than an expansionary fiscal policy in Country 2: the appreciation of Country 2's exchange rate as a result of an increase in its government expenditure, combined with nominal rigidity due to the fixing of raw material prices in its currency, mitigates the initial effect of increased government expenditure on output since it shifts its aggregate supply curve to the left.

If it is true that the Eurozone is characterized by real rigidities and the US by nominal rigidities (the international pricing of raw materials in US dollars is one reason, the nature of wage adjustment might be another – see Branson and Rotemberg, 1980; Nickell, 1997), our analysis suggests that the Fed is in a position to affect "world" output but the ECB is not and that Eurozone government expenditure is more effective as an instrument to affect output compared to US government expenditure. The present two-country model and its results extend in many ways those of Branson and Rotemberg (op. cit.), as well as Heijdra and Van der Ploeg (op. cit. chapter 11), who examine the impact of monetary and fiscal policy under different assumptions about wage formation in the two countries.

We do not attempt to justify the choice of this well-known aggregate supply, Mundell – Fleming, IS - LM model as a framework of analysis (see, among others, Carlin and Soskice (1990), who also use an imperfect competition framework, similar in spirit to the present one). We do not attempt either to stress its differences and similarities with the new open economy macroeconomics (Obstfeld, op. cit. and Walsh, 2003, chapter 6 might be useful references for comparisons).

At the methodological level, we do not examine monetary and fiscal policies within an explicitly utilitarian, intertemporal framework: our emphasis is on how supply-side characteristics affect the relative efficiency of instruments. In particular we examine the impact of small ("unit") increases of government expenditure and money on output, the nominal and the real exchange rate as well as on prices.

We have retained the LM equation, despite its demise from the recent economic policy literature and its substitution with an interest rate reaction function ("Taylor rule"). Apart from the arguments invoked by Friedman (2003) in supporting the presence of an LM equation, we think that its absence is inconceivable in models aimed at explaining the factors determining exchange rates.

Krugman (2000) provides support for an aggregate supply/IS - LM approach to "real world" macroeconomics and open-economy macroeconomics. Vanhoose (2004) provides a detailed, critical assessment of the new open economy macroeconomics and asks a number of questions related to the relative ability of "old" and "new" open economy macroeconomics to explain the real world. Vines (2003), in his review article on Keynes, provides a useful discussion on whether the constituent parts of open-economy macroeconomic models should be chosen for reasons of "realism", rather than for reasons of "coherence".

Finally, Gali (1992) has found that an aggregate supply/IS - LM framework explains postwar US data quite well.

2. One country: A small open economy

2.1 Aggregate supply

The domestic economy specializes in the production of its own final good, y, which is an imperfect substitute for a final good, y^*, produced abroad. Both goods are consumed in the home country. Inputs to the production of y are labour and an imported composite commodity, which, for simplicity, we will call oil. The price of the domestic, final good is set as a constant mark-up over its marginal cost as a result of profit maximizing behaviour of a domestic representative producer and a constant own price elasticity of demand for y. The foreign price of the foreign final good, the foreign price of oil as well as foreign output will be exogenous.

The nominal wage rate is set according to a wage equation. This can be conceived as the outcome of a wage bargain between the profit maximizing representative union and firm, while employment is set by the firm given the nominal wage and the other variables (see, *inter alia*, Nickell and Andrews, 1983; Blanchflower and Oswald, 1994; Blanchard and Katz, 1999). Other interpretations of the wage equation are also possible.

The supply side of the economy is described by equations (1) - (4):

$$c = -(1+\sigma)t + \sigma y + \lambda q + (1-\lambda)w + l \tag{1}$$

$$p = \phi - (1+\sigma)t + \sigma y + \lambda q + (1-\lambda)w + l \tag{2}$$

$$w = \zeta + \varepsilon[dp + (1-d)f] + n(h - \bar{h}) + v(y - h) \tag{3}$$

$$h = (1+\sigma)y + \lambda(q - w) - (1+\sigma)t + k \tag{4}$$

Equation (1) is the (natural) logarithm of a marginal cost function, c, based on a Cobb-Douglas production function. It is homogeneous of degree one in factor prices, w (the log of the wage rate) and q (the log of the oil price); y is the log of domestic output, σ is a nonnegative parameter ($\sigma = 0$ if there are constant returns to scale), λ is the partial elasticity of marginal cost with respect to the oil price, $(1-\lambda)$ is the partial elasticity with respect to the wage rate ($0 < \lambda < 1$), t is the efficiency (technology) factor in the production function and l is a constant parameter, which, from now on will be normalised to zero. The underlying cost function, C, is defined as the minimum cost of producing a target output, Y, given the prices W and Q of the two factors of production and the Cobb-Douglas production function. The marginal cost function, c, in equation (1) is the (log of the) partial derivative of the cost function, C, with respect to output. (For the properties of cost functions, see Dixit, 1990 and MasColell, Whinston and Green, 1995.)

Equation (2) sets the (log of the) price of domestic output, p, as a constant mark-up, ϕ (in logs), over marginal cost, c.

Equation (3) is the wage equation. ζ is a measure of wage pressure encompassing all exogenous factors which affect union power, other than unemployment and labour productivity, such as the size and duration of unemployment benefits, the regulatory framework etc. [$dp + (1-d)f$] is the log of the Consumer Price Index (CPI), d is the share of domestic output in consumption, $(1-d)$ is the share of foreign output in consumption and f is the log of the price of foreign output in domestic currency; ε is the wage indexation parameter. If $\varepsilon = 1$ ($0 \le \varepsilon < 1$) there is complete (incomplete) wage indexation to the CPI; $\bar{h}$ is the log of the (exogenous) labour supply; $h - \bar{h}$ is the log of the labour demand to labour supply ratio which captures the pressure of unemployment on the wage rate as measured by the partial elasticity $0 \le \eta \le 1$; $y-h$ is the log of labour productivity which captures the pressure of average labour productivity on the wage rate as measured by the partial elasticity $0 \le \nu \le 1$. Blanchard and Katz (op. cit.) examine the properties of a wage curve such as (3) above and its relationship with a Phillips curve equation.

Equation (4) gives (the log of) labour demand, h. This is the partial derivative of the underlying cost function with respect to the wage rate and is a function of output, y, the (log of the) ratio of the oil price to the wage rate, the efficiency factor t and a constant parameter, k, which from now on will be normalized to zero. It will be assumed that w in equation (3) exceeds the wage rate which clears the labour market, so that unemployment prevails ($h < \bar{h}$).

Combining equations (2), (3) and (4), we derive the (inverse of the) supply function:

$$p = \mu_0 + \mu_1 y + \mu_2 q + \mu_3 f \qquad (5)$$

where μ_0, μ_1, μ_2, and μ_3 are specified in Appendix A. It can be shown $\mu_1 \ge 0$, $0 \le \mu_2 < 1$, $0 < \mu_3 \le 1$ (see also Moschos and Stournaras, 1998).

Denoting with q^* and f^* the (logs of the) international prices of imported oil and the foreign final good, and e the log of the nominal exchange rate (units of domestic currency per unit of foreign currency), we can subtract f from both sides of (5) and write it as:

$$rer = \mu_0 + \mu_1 y + (\mu_2 + \mu_3 - 1)e + \mu_2 q^* + (\mu_3 - 1) f^* \qquad (6)$$

where $rer = p - f, q = q^* + e, f = f^* + e$.

In equation (6), rer is the (log of the) real exchange rate, $p - f$, that is, the inverse of (the log of) competitiveness, $f - p$. It is straightforward to prove the following two propositions (see Moschos and Stournaras, 1998).

Proposition 1: $\mu_2 + \mu_3 = 1$ ($0 < \mu_2 + \mu_3 < 1$) if and only if $\varepsilon = 1$ ($0 \le \varepsilon < 1$).

This says that changes in the nominal exchange rate cause equiproportional (less than equiproportional) changes in the price of domestic output iff there is complete (incomplete) wage indexation on the CPI. (In other words, the nominal exchange rate, e, does not affect the real exchange rate if there is complete wage indexation).

Proposition 2: Ceteris paribus, a reduction in the mark-up coefficient, ϕ, an increase in the efficiency factor, t, an increase in labour supply, $\overline{h}$, a reduction in the wage pressure variable, ζ, a reduction in the international oil price, q^*, and an increase in the international price of foreign output, f^*, reduce the real exchange rate (or, increase the competitiveness of domestic output).

2.2 Aggregate demand

The demand side is given by reduced form IS – LM type of equations in log-linear form:

$$y = ag - \beta R^* - \gamma rer + \theta y^* \quad (7)$$

$$m - p = \eta y - \delta R^* \quad (8)$$

$$rer = p - f^* - e \quad (9)$$

In equation (7), the (log of) output demanded, y, depends positively on (the log of) real government expenditure, g (which, for simplicity, consists entirely of domestic output), negatively on the world interest rate, R^* (there is perfect capital mobility, while a higher interest rate leads to lower consumption and therefore, lower demand for domestic output; it should be noticed that there is no investment demand in the model), negatively on the (log of the) real exchange rate, rer, (because an appreciation of the real exchange rate makes domestic output more expensive than foreign output) and positively on (the log of) foreign output, y^* (because higher foreign output implies higher foreign consumption and therefore higher demand for domestic output). The constant parameter which appears due to log-linearisation has been normalised to zero. The real and nominal interest rates coincide, since we are concerned only with the stationary state under perfect foresight and not with the formation of expectations and the dynamics of the system (McCallum, 1996, chapter 6). This simplifying assumption allows us to concentrate on the issues at hand. The model can be extended and become dynamic, but this is outside the scope of the paper.

Output demanded and supplied are both denoted by y since we will assume that the product market clears, that is the representative domestic producer chooses p to clear the market.

In equation (8), the (log of the) real quantity of domestic money, $m-p$, depends positively on (the log of the) domestic output, y, and negatively on the interest rate, R^*. For simplicity, the relevant deflator here is taken to be p and not the (log of the) CPI. All parameters in (7) and (8) are positive:

$\alpha, \beta, \gamma, \delta, \eta, \theta \geq 0$

No attempt has been made to derive equations (7) and (8) from an explicit utilitarian model. Rankin (1986, 1987) provides a consistent micro-foundation to IS-LM, while Heijdra and Van der Ploeg (op. cit.) use the Armington (1969) two-stage approach to allocate consumption into the domestic final good and the foreign final good, deriving an equation similar to (7).

The domestic economy can be described by the above system of four equations: the aggregate supply equation (6), which, incidentally, implies that an appreciation of the real exchange rate increases output supply because it reduces the real product wage, the (IS) equation (7), the (LM**)** equation (8) and the definition of the real exchange rate (9).

The four unknowns (endogenous variables) are (in logs): output, y, the real exchange rate, rer, the price of domestic output, p, and either the nominal exchange, e, (if there is a floating exchange rate regime) or the quantity of money, m, (if there is a fixed exchange rate regime).

The exogenous variables are: g (a policy variable), R^*, y^*, q^*, f^* (determined internationally) μ_0 (which incorporates all exogenous supply side parameters – see Appendix A) and either m (if there is a floating exchange rate regime) or e (if there is a fixed exchange rate regime).

In this imperfect competition model, output supply is equal to output demand. This is achieved through a flexible domestic price p which clears the product market. There is unemployment ($h < \overline{h}$) since it has been assumed that the wage rate determined by wage bargaining in equation (3) exceeds the wage rate that clears the labour market ($h = \overline{h}$). Unemployment is "Classical" rather than "Keynesian" since the output market clears**.** The solution of the model describes a stationary equilibrium with perfect foresight.

2.3 Results

(i) Complete wage indexation (real consumer wage rigidity)

Under $\varepsilon = 1$, that is, under complete wage indexation (in which case $\mu_2 + \mu_3 = 1$ in equation (6) due to Proposition 1) there is a dichotomy, in the sense that output, y, and the real exchange rate, rer, are determined by the real side of the model, i.e. equations (6) and (7), and are independent from the domestic monetary factors, *m* and *e*, and from the exchange rate regime. Indeed, solving (6) and (7) for y and rer we obtain:

$$y^0 = \frac{1}{1+\gamma\mu_1}[\alpha g - \beta R^* - \gamma\mu_0 - \gamma\mu_2 q^* + \gamma\mu_2 f^* + \theta y^*] \quad (10)$$

$$rer^0 = \frac{1}{1+\gamma\mu_1}\left[\mu_0 + \mu_2 q^* - \mu_2 f^* + \mu_1\alpha g - \mu_1\beta R^* + \mu_1\theta y^*\right] \quad (11)$$

Following the determination of y and rer from equations (6) and (7) we can now determine the monetary variables using equations (8) and (9).

(A) Under a *floating exchange rate*, equation (8) determines the price of domestic output, given money supply $\overline{m}$, output $y = y^0$ and the world interest rate R^*:

$$p^0 = \overline{m} - \eta y^0 + \delta R^* \quad (12)$$

while the exchange rate e is given by equation (9), given $rer = rer^0$ from equation (11), $p = p^0$ from equation (12) and the internationally determined f^*:

$$e^0 = p^0 - f^* - rer^0 \quad (13)$$

or, using equation (12):

$$e^0 = \overline{m} - ny^0 + \delta R^* - f^* - rer^0 \quad (14)$$

(B) Under a *fixed exchange rate* ($e = \overline{e}$), the price of domestic output is determined by equation (9), given rer^0, $\overline{e}$ and f^*:

$$p^0 = \overline{e} + f^* + rer^0 \quad (15)$$

while the (now endogenous) quantity of money is given by equation (8), given y^0, R^* and p^0:

$$m^0 = p^0 + \eta y^0 - \delta R^* \quad (16)$$

Equations (12) and (15) imply the well-known result that, for given output and the real exchange rate (as they are determined by the real side of the economy) and given the world interest rate, R^*, the domestic price, p, is determined by domestic money supply, $\overline{m}$, in the case of a floating exchange rate, and by the foreign price f^* in the case of a fixed exchange rate.

A diagrammatic representation of the solution (10) and (11) is useful. Equations (6) and (7) are depicted in Figure 1, as aggregate supply (AS) and aggregate demand (AD) respectively. The solution is at point A, with $y = y^0$, $rer = rer^0$.

Due to labour and product market non-competitive behaviour, output in A is less than it would be under perfect competition, obtained when $\phi = 0$ in equation (2), and $h = \overline{h}$ (instead of equation (3)).

The position of AD depends on g, y^*, and R^*, while the position of AS depends on μ_0, f^* and q^*. It is straightforward to show that equilibrium output increases with an increase in government expenditure g, foreign output y^*, and the international price of the foreign final good, f^*. Also, equilibrium output increases with a reduction in the international oil price, q^*, and the world interest rate, R^*. Finally, it increases with a reduction in μ_0: that is, with a reduction of the mark-up coefficient, ϕ, a reduction in the wage pressure parameter, ζ, an increase in the efficiency factor, t, and an increase in the exogenous labour supply, $\overline{h}$. Shifts in aggregate demand parameters move equilibrium output and the real exchange rate in the same direction, while shifts in aggregate supply parameters move equilibrium output and the real exchange rate in opposite directions. The government expenditure multiplier is positive while benign supply side changes (such as a reduction in the wage pressure parameter and a reduction in the mark-up coefficient) have a positive effect on output.

Domestic monetary factors play no role in the determination of domestic output and the real exchange rate. In the classical Mundell – Fleming model with perfect capital mobility, monetary policy is effective under floating exchange rates because of domestic nominal price and wage stickiness, which implies that a depreciation of the nominal exchange rate (as a result of monetary expansion) increases competitiveness and, thus, aggregate demand and output. In the present model the price of domestic output is not sticky but flexible (although the product market is not fully competitive, that is, $\phi > 0$). Also, there is complete wage indexation to the consumer price index. For simplicity, we have called this 'real consumer wage rigidity' although this does not mean a fixed real consumer wage: even under complete wage indexation ($\varepsilon = 1$), the real consumer wage (that is, the nominal wage rate deflated by the CPI) is not fixed, since it depends on labour market conditions ($h - \bar{h}$) and labour productivity $(y - h)$ – see equation (3). Only under the additional (to $\varepsilon = 1$) assumption $n = v = 0,$ the real consumer wage is fixed and equal to ζ (see Appendix A for an analysis of this, as well as the "wage militancy" case, defined as $\varepsilon = 1,\ n = 0,\ v = 1$). Furthermore, the real producer wage (that is, the wage rate deflated by the price of domestic output, p) is not fixed, which allows for a supply curve which is a positive function of the real exchange rate. This, combined with non-competitive behaviour in labour and product markets, makes fiscal policy effective under both exchange rate regimes. In the classical Mundell – Fleming model, fiscal policy is not effective under a floating exchange rate because output is fully determined by the LM equation, due to domestic nominal price stickiness: if m, p and R^* are given exogenously, y is fully determined by equation (8). Buiter (op. cit.) criticizes the traditional literature on optimal currency areas for failing to distinguish between nominal and real wage rigidity.

The model is capable of handling other exchange rate regimes as well. For instance, if monetary authorities choose the nominal exchange rate in such a way as to satisfy a target real exchange rate ($rer = \overline{rer}$), it can be shown that in general, equilibrium in the model will be achieved through quantity rationing, since output supply will differ from output demand for all real exchange rate targets other than rer^0 in Figure 1. Under the assumption of a real exchange rate target, the relevant demand and supply curves in Figure 1 will be the segments to the left of point A in the diagram.

(ii) Incomplete consumer wage indexation (nominal wage rigidity)

Many models in the literature usually assume an extreme form of nominal wage rigidity equivalent to $\varepsilon = 0$ in our equation (3). Here, we will identify nominal wage rigidity with incomplete consumer wage indexation, which may be due to incomes policy, the tax system or the nature of wage contracts.

Under incomplete consumer wage indexation (that is, $0 \le \varepsilon < 1$ in equation (3)), we have $0 < \mu_2 + \mu_3 < 1$ in equation (6); see Proposition 1. Defining $\mu_2 + \mu_3 - 1 = \xi$

($-1 < \xi < 0$) we can write the supply equation (6) as

$$rer = \mu_0 + \mu_1 y + \xi e + \mu_2 q^* + (\xi - \mu_2) f^* \qquad (17)$$

Now, the real exchange rate depends, *inter alia*, on the nominal exchange rate, and the model does not exhibit a dichotomy between the real and the monetary sides as before.

Diagrammatically, the position of the aggregate supply curve in Figure 1 now depends on μ_0, q^*, f^* <u>and</u> e and shifts to the right with a nominal depreciation (an increase in e), resulting in higher equilibrium output and a lower equilibrium real exchange rate.

The economy can now be described by the system of equations (17), (7), (8), and (9).

(A) Under a *floating exchange rate*, the endogenous variables are y, rer, e, and p, while money, m is exogenous: $m = \overline{m}$. Solving the system with respect to output we obtain:

$$y^0 = \frac{1}{1 + \mu_1 \gamma + \xi - \eta \xi \gamma}[a(1+\xi)g - (\beta + \beta\xi + \gamma\xi\delta)R^* - \gamma\mu_0 - \gamma\mu_2 q^* + \gamma\mu_2 f^* - \gamma\xi\overline{m} + \theta(1+\xi)y^*] \quad (18)$$

An increase in money supply, $\overline{m}$, has a positive effect on output, y, since $\xi < 0$ in (18). The transmission mechanism is the following: An increase in $\overline{m}$ causes a depreciation of the nominal exchange rate (see equations (12) and (13) or equation (14)), which, in turn, reduces the real exchange rate (see (17)) and increases output (see (7)).

An interesting result is that the government expenditure multiplier (dy/dg) is higher under real consumer wage rigidity than under incomplete wage indexation. Indeed, from (10) and (18) we can take the difference, Δ, between the two fiscal multipliers:

$$\Delta = \frac{a}{1+\gamma\mu_1} - \frac{\alpha(1+\xi)}{1+\xi+\gamma\mu_1 - \eta\xi\gamma} = \frac{-\alpha\eta\xi\gamma - \alpha\mu_1\xi\gamma}{(1+\gamma\mu_1)(1+\xi+\gamma\mu_1-\eta\xi\gamma)} > 0 \qquad (19)$$

The explanation of this result is the following: An increase in government expenditure, g, causes an appreciation of the nominal exchange rate since it increases output and thus, money demand; see equation (14). Under complete wage indexation, we have seen that a nominal appreciation of the exchange rate does not affect the real exchange rate. However, under incomplete wage indexation, it does; see equation (17); In terms of Figure 1, it shifts the AS curve up, since its position now depends on e as well, resulting in lower output and a higher real exchange rate.

An oil price shock (a large increase in q^*) shifts the AS curve up, and reduces output and competitiveness (it causes a real exchange rate appreciation). Our analysis suggests that under real consumer wage rigidity, these effects cannot be avoided by choosing a floating exchange rate. Only supply side measures (which reduce μ_o) and an increase in government expenditure, g, can be used as instruments against such effects.

Under incomplete consumer wage indexation, a floating exchange rate along with an expansionary monetary policy can also be used to mitigate the effects of an oil price shock on output. This follows directly from equation (18), since $\xi < 0$.

(B) Under a *fixed exchange rate*, the endogenous variables are y, rer, p and m, while e is exogenous: $e = \bar{e}$. Solving the system with respect to output, we obtain:

$$y^0 = \frac{1}{1+\gamma\mu_1}[ag - \beta R^* - \gamma\mu_0 - \gamma\xi\bar{e} - \gamma\mu_2 q^* - \gamma(\xi - \mu_2)f^* + \theta y^*] \qquad (20)$$

From (20) it follows that monetary policy has no effect on output (as in the classical Mundell – Fleming model) although a discrete devaluation does have a positive impact. It also follows that the fiscal multiplier ($a/_{1+\gamma\mu_1}$) is equal to that under real consumer wage rigidity (see equation (10)) and is higher than the fiscal multiplier under a floating exchange rate ($(\alpha(1+\xi)/(1+\xi+\gamma\mu_1-\eta\xi\gamma)$ in equation (18)). The explanation is the same as before; see the discussion following (19).

(iii) International oil price denomination in the home currency

Let us now assume that real consumer wage rigidity prevails ($\mu_2 + \mu_3 = 1$ as a result of $\varepsilon = 1$) but that oil is priced internationally in the home currency. Such is the case, for example, if the home country is the US with the international oil price denominated in US dollars. Now the price of oil continues to be exogenous, fixed by oil producers outside the home country, but it is denominated in the home currency: $q = \bar{q}$. The foreign, final good y^* continues to be priced in the foreign currency, so that $f = f^* + e$. Under this assumption and since $\mu_2 + \mu_3 = 1$, the supply equation (6) becomes:

$$rer = \mu_0 + \mu_1 y + \mu_2\bar{q} - \mu_2 f^* - \mu_2 e \qquad (21)$$

Equation (21) is qualitatively similar to (17), despite the fact that real consumer wage rigidity prevails. The real exchange rate depends, *inter alia*, on the nominal exchange rate as before. The economy can be described by equations (21), (7), (8) and (9).

(A) Under a *floating exchange rate*, the money supply is exogenous ($m = \overline{m}$) and the endogenous variables are y, rer , p and e. Solving the system with respect to output we obtain:

$$y^{o}=\frac{1}{1-\mu_2+\gamma\mu_1+\eta\gamma\mu_2}[\alpha g\mu_3 - R^{*}(\beta\mu_3+\delta\gamma\mu_2) - \gamma\mu_o - \gamma\mu_2\overline{q} + \gamma\mu_2 f^{*} + \gamma\mu_2\overline{m} + \theta\mu_3 y^{*}] \quad (22)$$

which is qualitatively similar to equation (18). An expansionary monetary policy has a positive effect on output through a depreciation of the nominal exchange rate. In this case, the negative effects of a higher oil price on output can be mitigated by supply side measures (which reduce μ_0), higher government expenditure, g, and by an expansionary monetary policy.

(B) Under a *fixed exchange rate* ($e = \overline{e}$), money is endogenous, and the solution of the system of equations (21), (7), (8) and (9) with respect to output gives:

$$y^{0} = \frac{1}{1+\gamma\mu_1}[ag - \beta R^{*} - \gamma\mu_0 - \gamma\mu_2\overline{q} + \gamma\mu_2 f^{*} + \theta y^{*} + \gamma\mu_2\overline{e}] \quad (23)$$

Comparing the fiscal multipliers under fixed and floating exchange rates (from equations (23) and (22)) we can easily show that fiscal policy is stronger under a fixed rather than a floating exchange rate. The explanation is the same as before.

Before we proceed to an analysis with two countries, we should stress the basic result of this section. That is, fixing the international price of imported raw materials in the home currency introduces an element of nominal rigidity that makes monetary policy effective even if real consumer wage rigidity prevails. This is not surprising: With nominal wage rigidity, a nominal depreciation of the home currency shifts the aggregate supply curve to the right, reducing the real exchange rate and increasing output. In simpler models where the "law of one price" holds, a nominal depreciation simply reduces the real product wage and increases output. Similarly, if raw material prices are fixed in the home currency, a depreciation of the home currency shifts the aggregate supply curve to the right by reducing the real cost of imported raw materials (see equation (21), the term $\mu_2(\overline{q}-e)$) and increases output. An interesting question, which, however, is outside the scope of the present paper, has to do with the factors which determine the choice of invoice currency for raw materials, as well as the pricing policies of their producers. A price equation for raw materials, such as oil, can, in principle, be introduced in the present model, in tandem with the wage equation (3), with parameters encompassing market structure, exhaustibility considerations, indexation etc. However it should be kept in mind that the behaviour of the oil price is different from the behaviour of other raw material prices, mainly due to different market structures. An empirical issue is the behaviour of real, raw material and commodity prices over a number of years and their contribution to the behaviour of output and prices in the US and the other OECD countries. Recent developments in the oil market have revived an interest in explaining such factors.

3. Two countries: Two large open economies

In the previous section the economy under consideration was small, facing a given world interest rate, R^*, a given price of the foreign, final good, f^*, a given foreign output, y^* etc. Now, we will assume that there are two large countries, Country 1 and Country 2 specializing in the production of two final goods y_1 and y_2 respectively, which are imperfect substitutes and consumed in both countries. The two goods, y_1 and y_2 are produced by two specializing representative producers, one in Country 1 and the other in Country 2. There will be no strategic interaction between the representative producers of y_1 and y_2. They both set the price of their products in their own markets, treating the other's output and price as exogenous. Production inputs are labour and oil. Labour is not mobile between the two countries and oil is imported in both countries from an outside oil producing zone. The oil price continues to be exogenous in both countries, but now it is assumed that it is fixed by oil exporters in the currency of Country 2. This is the only asymmetry characterizing the two economies. (It might be helpful in this respect to think of Country 2 as the US and Country 1 as the Eurozone). The two countries are characterized by real, consumer wage rigidity, they are exactly similar in the structure of their product, labour and money markets, and operate under a floating exchange rate.

The model treats the economy of the "third" country, that is the oil producing "zone" as exogenous. This prevents the examination of the interaction between oil revenue, the world interest rate and the exchange rate.

Due to perfect symmetry, the product, labour and money markets are characterized by exactly the same parameters. The same parameters also characterize the output demand equations (IS equations) in both countries. The assumption of similar parameters in the two countries is not necessary for the analysis. It is imposed in order to simplify calculations and is justified since our purpose is to show the effects of oil price denomination in the currency of one of the two countries.

The two economies are now characterized by the following seven equations:

$$rer = \mu_0 + \mu_1 y_1 + \mu_2 \overline{q}^* - \mu_2 f^* \tag{24}$$

$$-rer = \mu_0 + \mu_1 y_2 + \mu_2 \overline{q}^* - \mu_2 (p - e) \tag{25}$$

$$y_1 = a g_1 - \beta R^* - \gamma rer + \theta y_2 \tag{26}$$

$$y_2 = a g_2 - \beta R^* + \gamma rer + \theta y_1 \tag{27}$$

$$m_1 - p = \eta y_1 - \delta R^* \tag{28}$$

$$m_2 - f^* = \eta y_2 - \delta R^* \tag{29}$$

$$rer = p - f^* - e \tag{30}$$

The seven endogenous variables are rer, y_1, y_2, e, p, f^*, R^*. The exogenous variables are μ_0, g_1, g_2, m_1, m_2, $\overline{q}^*$, with a star denoting prices in Country 2 currency. The exchange rate e is defined as units of Country 1 currency per unit of Country 2 currency. All variables are in logs except the interest rate, R^*.

Equation (24) is exactly the same as equation (6), that is the real exchange rate equation of Country 1, with $\mu_2 + \mu_3 = 1$, i.e. with real, consumer wage rigidity. Recall that equation (6) is derived directly from the inverse supply function (5). Also, $q = q^* + e, f = f^* + e$.

Equation (25) is the same as (24) for Country 2. It is derived from a similar, inverse supply function as (5):

$$f^* = \mu_0 + \mu_1 y_2 + \mu_2 \overline{q}^* + \mu_3 p^* \tag{31}$$

where $p^* = p - e$; p^* is the price of the final good which is produced in Country 1, expressed in Country 2 currency. It might be useful to think of y_1 as production of a "made in the Eurozone" car and y_2 as production of a "made in the US" car; p is the euro price of y_1 and p^* is the dollar price of y_1; similarly, f^* is the dollar price of y_2 and f is the euro price of y_2. The law of one price holds for the same cars, but the prices of the two cars generally differ because they are imperfect substitutes: $f = f^* + e, p = p^* + e$, but $f \neq p$.

Assuming now real, consumer wage rigidity for Country 2 as well ($\mu_2 + \mu_3 = 1$) and subtracting p^* from both sides of equation (31), we derive equation (25), that is the real exchange rate equation for Country 2. Obviously, the (log of the) real exchange rate of Country 1 is exactly the opposite of (the log of) the real exchange rate of Country 2: when Country 1's competitiveness improves, Country 2's competitiveness worsens by the same amount.

The meaning of equations (26) – (30) is obvious from the previous section and we do not need to elaborate on them further. The parameters of the IS - LM equations are the same in both countries due to the assumed symmetry. In equations (26) and (27) it has been assumed for simplicity that government expenditure in Country 1 consists only of Country 1 output; likewise for Country 2. Imposing the (reasonable) stability constraints $\theta < 1$, $\mu_1 < 1 + [(1+\theta)(2-\mu_2)/2\gamma]$, and solving the above system of equations we obtain:

$$e = (m_1 - m_2) - (g_1 - g_2)M \tag{32}$$

$$rer = \frac{\alpha\mu_1(g_1 - g_2)}{(1+\theta)(2-\mu_2) + 2\gamma} \tag{33}$$

$$R^* = \frac{\frac{\mu_2}{\mu_1}\bar{q}^* + \frac{\mu_0}{\mu_1} - \frac{\mu_2}{\mu_1}m_2 + \frac{g_1}{2}(A - \frac{\mu_2}{\mu_1}M) + \frac{g_2}{2}(A + \frac{\mu_2}{\mu_1}M)}{N} \tag{34}$$

$$y_1 = \alpha\frac{g_1}{2}[\frac{\Theta}{1+\theta} + \frac{1}{1-\theta}] + \frac{\alpha g_2}{2}[\frac{1}{1-\theta} - \frac{\Theta}{1+\theta}] - \frac{\beta}{1-\theta}R^* \tag{35}$$

$$y_2 = \alpha\frac{g_2}{2}[\frac{1}{1-\theta} + \frac{\Theta}{1-\theta}] + \frac{\alpha g_1}{2}[\frac{1}{1-\theta} - \frac{\Theta}{1+\theta}] - \frac{\beta}{1-\theta}R^* \tag{36}$$

$$p = m_1 + R^*(\delta + \frac{\eta\beta}{1-\theta}) - \frac{\alpha\eta(g_1 + g_2)}{2(1-\theta)} - \frac{\alpha\eta(g_1 - g_2)\Theta}{2(1+\theta)} \tag{37}$$

$$f^* = m_2 + R^*(\delta + \frac{\eta\beta}{1-\theta}) - \frac{\alpha\eta(g_1+g_2)}{2(1-\theta)} + \frac{\alpha\eta(g_1-g_2)\Theta}{2(1+\theta)} , \tag{38}$$

where:

$$N = \frac{\beta}{1-\theta} + \frac{\mu_2}{\mu_1}(\delta + \frac{\eta\beta}{1-\theta}) > 0 \tag{39}$$

$$M = \frac{\mu_1 + \eta(2-\mu_2)}{(1+\theta)(2-\mu_2)+2\gamma} > 0 \tag{40}$$

$$0 < \Theta = \frac{(1+\theta)(2-\mu_2)+2\gamma(1-\mu_1)}{(1+\theta)(2-\mu_2)+2\gamma} < 1 \tag{41}$$

$$\mathrm{A} = \frac{\alpha}{1-\theta} + \frac{\mu_2}{\mu_1}(\frac{\alpha\eta}{1-\theta}) > 0 \tag{42}$$

Also, from equations (35) and (36) we obtain:

$$y_1 - y_2 = \frac{a(g_1-g_2)\Theta}{1+\theta} \tag{43}$$

$$y_1 + y_2 = \frac{a(g_1+g_2)}{1-\theta} - \frac{2\beta R^*}{1-\theta}, \tag{44}$$

where equation (43) is the log of the ratio of Country 1 output to Country 2 output. Equation (44) does not have a direct economic meaning. (It is not the log of world output – see Appendix B). However it will be used later to calculate the impact on world output of an equi-proportional increase in government expenditure in both countries ($\mathrm{d}g_1 = \mathrm{d}g_2 = \mathrm{d}g$).

From equations (32) – (44) we can derive a number of results:

From (32), an increase in the money supply in Country 1 relative to Country 2 leads to a nominal depreciation (appreciation) of Country 1's (2's) currency. An increase in government expenditure in Country 1 relative to Country 2 leads to a nominal appreciation (depreciation) of Country 1's (2's) currency. If $\mathrm{d}m_1 = \mathrm{d}m_2$ and $\mathrm{d}g_1 = \mathrm{d}g_2$ there is no change in the exchange rate.

From (33) and (43) an increase in government expenditure in Country 1 relative to Country 2 leads to higher output of y_1 relative to y_2 and a higher real exchange rate for Country 1. If $\mathrm{d}g_1 = \mathrm{d}g_2$, there is no change in relative output and the real exchange rate. The result that relative output and the real exchange rate depend only on relative government expenditure is due to the assumption of similar structures in the two economies.

From (34), adverse supply-side changes (such as an increase in the oil price $\overline{q}^*$), or in the labour and product market parameters which increase μ_0 (see Proposition 2 in section 1), lead to a higher interest rate, R^*, and lower output (see (35) and (36)). A monetary expansion in Country 2 is a "locomotive" policy: it reduces R^* ($\partial R^* / \partial m_2 = - \mu_2 / N\mu_1$) and increases both y_1 and y_2 ($\partial y_1 / \partial m_2 = \partial y_2 / \partial m_2 = (\beta/(1-\theta))(\mu_2 / \mathrm{N}\mu_1)$. Not surprisingly, a monetary expansion in Country 1, which is characterized by real rigidity, has no effect on the interest rate or in output ($\partial R^* / \partial m_1 = \partial y_1 / \partial m_1 = \partial y_2 / \partial m_1 = 0$).

From (34), (35), and (36), the effect of higher government expenditure on output is mitigated by a higher interest rate, due to higher money demand. From (44), assuming $\mathrm{d}g_1 = \mathrm{d}g_2 = \mathrm{d}g$ and taking into account (34), it is straightforward to show:

$$\frac{1}{2}\frac{d(y_1+y_2)}{dg} = \frac{1}{1-\theta}[\alpha - \beta\frac{\mathrm{A}}{\mathrm{N}}] = \frac{1}{1-\theta}[\frac{\alpha\mu_2(1-\theta)\delta}{\beta(\mu_1+\eta\mu_2)+\mu_2(1-\theta)\delta}] > 0 \qquad (45)$$

It can be shown (see Appendix B) that the left-hand-side of equation (45) is the impact on world output of an equiproportional increase in government expenditure in both countries ($\mathrm{d}g_1 = \mathrm{d}g_2 = \mathrm{d}g$) under the assumption that, initially, the share of each country in world output is equal to one half. Hence we can interpret equation (45) as saying that the "direct" effect of an increase in "world government expenditure" on "world output" ($\alpha/1-\theta)$) is larger than the (negative) interest rate effect ($\beta\mathrm{A}/(1-\theta)\mathrm{N}$), so that the global fiscal multiplier is positive.

From equations (35) and (36) we obtain:

$$\frac{\partial y_1}{\partial g_1} = \frac{a\Theta}{2(1+\theta)} + \frac{a}{2(1-\theta)} - \frac{\beta}{2(1-\theta)}(\frac{A}{N} - \frac{\mu_2}{\mu_1}\frac{\mathrm{M}}{\mathrm{N}}) \qquad (46)$$

$$\frac{\partial y_2}{\partial g_2} = \frac{a\Theta}{2(1+\theta)} + \frac{a}{2(1-\theta)} - \frac{\beta}{2(1-\theta)}(\frac{A}{N} + \frac{\mu_2}{\mu_1}\frac{\mathrm{M}}{\mathrm{N}}) \qquad (47)$$

$$\frac{\partial y_1}{\partial g_2} = \frac{a}{2(1-\theta)} - \frac{a\Theta}{2(1+\theta)} - \frac{\beta}{2(1-\theta)}(\frac{A}{N} + \frac{\mu_2}{\mu_1}\frac{\mathrm{M}}{\mathrm{N}}) \qquad (48)$$

$$\frac{\partial y_2}{\partial g_1} = \frac{a}{2(1-\theta)} - \frac{a\Theta}{2(1+\theta)} - \frac{\beta}{2(1-\theta)}(\frac{A}{N} - \frac{\mu_2}{\mu_1}\frac{\mathrm{M}}{\mathrm{N}}) \qquad (49)$$

From equation (46) it follows that $\partial y_1 / \partial g_1 > 0$ since the term $[\alpha - \beta(\mathrm{A/N})]$ is positive (see equation (45)) and the other terms are also positive (see equations (39) - (42)). The signs of $\partial y_2 / \partial g_1$, $\partial y_2 / \partial g_2$ and $\partial y_1 / \partial g_2$ are however, ambiguous; they cannot be determined without further constraints on the parameters.

Using equations (46) – (49) we can also obtain:

$$\frac{\partial y_1}{\partial g_1} + \frac{\partial y_2}{\partial g_1} = \frac{1}{1-\theta}[\alpha - \frac{\beta \mathrm{A}}{\mathrm{N}} + \frac{\beta\mu_2}{\mu_1}\frac{\mathrm{M}}{\mathrm{N}}] \qquad (50)$$

$$\frac{\partial y_1}{\partial g_2} + \frac{\partial y_2}{\partial g_2} = \frac{1}{1-\theta}[\alpha - \frac{\beta \mathrm{A}}{\mathrm{N}} - \frac{\beta\mu_2}{\mu_1}\frac{\mathrm{M}}{\mathrm{N}}] \qquad (51)$$

$$\frac{\partial y_1}{\partial g_1} + \frac{\partial y_1}{\partial g_2} = \frac{\partial y_2}{\partial g_1} + \frac{\partial y_2}{\partial g_2} = \frac{1}{1-\theta}[\alpha - \frac{\beta \mathrm{A}}{\mathrm{N}}] \qquad (52)$$

$$\frac{\partial y_1}{\partial g_1} > \frac{\partial y_2}{\partial g_2}, \frac{\partial y_2}{\partial g_1} > \frac{\partial y_1}{\partial g_2} \qquad (53)$$

The right hand side of equation (50) is positive due to the result in equation (45) and since $\beta\mu_2\mathrm{M} / \mu_1 N > 0$. The same applies to the sums in equation (52), while the sign of the sum in equation (51) is ambiguous. The inequalities in (53) follow directly from equations (46) – (49).

These results imply (a) an expansionary fiscal policy in Country 1 has a positive effect on Country 1's output, an ambiguous effect on Country 2's output, while the sum of the two relevant multipliers (equation (50)) is positive; (b) an expansionary fiscal policy in Country 2 has ambiguous effects on both countries' output; (c) a simultaneous increase in government expenditure in both countries has a positive (and the same) impact on both countries' output (d) government expenditure in Country 1 is a more effective instrument than government expenditure in Country 2 for affecting output.

This sort of result is not unknown in the literature. Heijdra and Van der Ploeg (2002), chapter 11, derive similar conclusions in a two-country framework with differences in the degree of wage rigidity. In the present model it is the fixing of the oil price in Country 2 currency which is responsible for this asymmetry, rather than differences in wage formation. The intuitive explanation is that Country 2's currency appreciation as a result of an increase in its government expenditure mitigates the initial effect on output because of the nominal rigidity introduced by fixing the oil price in its currency: in effect, the nominal appreciation shifts its supply curve up. On the contrary, the real rigidity prevailing in Country 1 implies that the currency appreciation due to higher government expenditure does not have an adverse effect on its aggregate supply. The preceding analysis of the small, open economy contributes to a better understanding of this result.

From equations (34), (37) and (38) it is straightforward to show:

$$\frac{\partial p}{\partial m_1} = 1 + \frac{\partial R^*}{\partial m_1}(\delta + \frac{\eta\beta}{1-\theta}) = 1 \qquad (54)$$

$$0 < \frac{\partial f^*}{\partial m_2} = 1 + \frac{\partial R^*}{\partial m_2}(\delta + \frac{\eta\beta}{1-\theta}) = 1 - \frac{\mu_2}{\mu_1 \mathrm{N}}(\delta + \frac{\eta\beta}{1-\theta}) < 1 \qquad (55)$$

That is, an increase in money supply in Country 1 implies a proportional increase in the price of its output, while an increase in money supply in Country 2 implies a less than proportional increase in the price of its output. This result is consistent with the previous one according to which an expansion of Country 1 money supply cannot affect output while an expansion of Country 2 money supply reduces the world interest rate and increases both y_1 and y_2.

4. Conclusions

We have shown that in a small open economy with imperfect competition in its labour and product markets, fiscal policy is effective under both floating and fixed exchange rates. The fiscal multiplier is larger under complete consumer wage indexation (real consumer wage rigidity) than under incomplete wage indexation (nominal wage rigidity) and under a fixed exchange rate than under a floating one. This is so because under nominal wage rigidity, the appreciation of the nominal exchange rate due to higher government expenditure leads to an appreciation of the real exchange rate which mitigates the effects of government expenditure on output. Monetary policy is effective in a floating exchange rate regime only under nominal wage rigidity. Under real wage rigidity it has no effect on output. Supply side changes, such as a reduction in the (exogenous) wage pressure variable and in firm market power, a reduction in the international price of raw materials such as oil, an increase in the labour force, and an increase in the efficiency factor in production always boost competitiveness and output.

An interesting result is that fixing the international price of raw materials in the home currency introduces nominal inertia even under real wage rigidity and makes monetary policy effective under a floating exchange rate: an increase in money supply entails a currency depreciation, which reduces the real cost of imported raw materials and boosts output.

In a two, similar country world under a floating exchange rate, real consumer wage rigidity in both countries, and the price of raw materials fixed in the currency of Country 2, an expansionary monetary policy in Country 2 is a "locomotive" policy, that is it increases output in both countries through a reduction in the world interest rate. An increase in money supply in Country 1 has no effect on output.

An increase in government expenditure in Country 1 has a positive effect on output in Country 1, an ambiguous effect on output in Country 2, while an increase in government expenditure in Country 2 produces ambiguous effects on both countries' output. This is so because the appreciation of Country 1 currency as a result of higher government expenditure has no effect on its output due to real wage rigidity (that is, the supply curve does not shift). In addition, the corresponding depreciation of Country 2's currency boosts its output due to nominal inertia (that is, its supply curve shifts to the right). On the contrary, a rise in government expenditure in Country 2 causes an appreciation of its currency, which due to nominal rigidity, mitigates the initial positive effect on its output. In addition, the depreciation of Country 1 currency has no effect on its output due to real rigidity. However, a simultaneous increase in government expenditure in both countries has a positive impact on both countries' output, while the real exchange rate remains unaffected.

One might be tempted to infer that if the Eurozone is characterized by real rigidities and the US by nominal rigidities (the fixing of international prices of raw materials in US dollars is one reason, the labour market might be another), the Fed is in a position to affect domestic and world output but the ECB is not, while Eurozone government expenditure is more effective as an instrument to affect output than US government expenditure.

References

Armington, P. S. (1969), "A theory of demand for products distinguished by place of production", *IMF Staff Papers*, 16, 159-178.

Blanchard, O. and L. Katz (1999), "Wage dynamics: reconciling theory and evidence", *American Economic Review*, 89 (2), 69-74.

Blanchflower, D. and A. Oswald (1994), *The wage curve*, MIT Press.

Branson, W. and J. Rotemberg (1980), "International adjustment with wage rigidity", *European Economic Review*, 13, 309-332.

Buiter, W. (2000), "Optimal currency areas", *Scottish Journal of Political Economy*, 47 (2), 213-250.

Buti, M. (2003, editor), *Monetary and fiscal policies in EMU*, Cambridge University Press.

Carlin, W. and D. Soskice (1990), *Macroeconomics and the wage bargain*, Oxford University Press.

De Grauwe, P. (2001), *Economics of monetary union*, Oxford University Press.

Dixit, A. (1990), *Optimization in economic theory*, Oxford University Press.

Dornbusch, R. (1980), *Open economy macroeconomics*, Basic Books, New York.

Edwards, S. (1989), *Real exchange rates, devaluation and adjustment*, MIT Press.

Friedman, M. (1953), "The case for flexible exchange rates" in *Essays in Positive Economics,* University of Chicago Press.

Friedman, B. (2003), "The LM curve: a not-so-fond farewell", Working Paper 10123, National Bureau of Economic Research.

Gali, J. (1992), "How well does the IS - LM model fit postwar US data?", *The Quarterly Journal of Economics*, 107 (2), 709-738.

Heijdra, B. and F. Van der Ploeg (2002), *Foundations of modern macroeconomics*, Oxford University Press.

Ishiyama, Y. (1975), "The theory of optimum currency areas: A survey", *IMF Staff Papers*, 22, 344-383.

Krugman, P. (2000), "How complicated does the model have to be?", *Oxford Review of Economic Policy*, 16 (4), 33-42.

Lane, P. (2001), "The new open economy macroeconomics: a survey", Journal of International Economics, 54, 235-266.

MasColell, A., M. Whinston, and J. Green (1995), *Microeconomic theory*, Oxford University Press.

Masson, P. and M. P. Taylor (1992), "Common currency areas and currency unions", Discussion Paper No. 617, CEPR.

McCallum, B. (1996), *International monetary economics*, Oxford University Press.

Moschos, D. and Y. Stournaras (1998), "Domestic and foreign price links in an aggregate supply framework: the case of Greece", *Journal of Development Economics*, 56, 141-157.

Mundell, R. A. (1968), *International Economics*, Macmillan, New York.

Nickell, S. and M. Andrews (1983), "Unions, real wages and employment in Britain 1951-79", *Oxford Economic Papers*, 35, 507-530.

Nickell, S. (1997), "Unemployment and labour market rigidities: Europe versus North America", *The Journal of Economic Perspectives*, 11 (3), 55-74.

Obstfeld, M. and K. Rogoff (1996), *Foundations of International Macroeconomics*, MIT Press.

Obstfeld, M. (2001), "International Macroeconomics: Beyond the Mundell-Fleming model", Working Paper 8369, National Bureau of Economic Research.

Rankin, N. (1986), "Debt policy under fixed and flexible prices", *Oxford Economic Papers*, 38, 481-500.

Rankin, N. (1987), "Disequilibrium and the welfare maximising levels of government spending, taxation and debt", *The Economic Journal*, 97, 65-85.

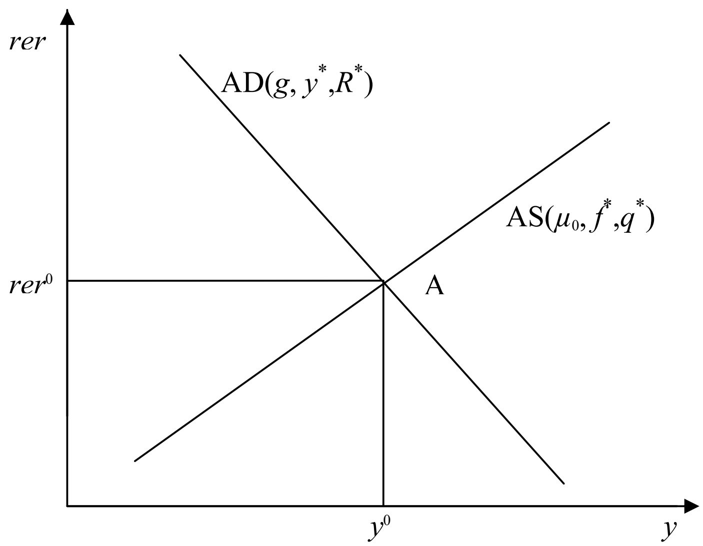
Vanhoose, D. (2004), "The new open economy macroeconomics: A critical appraisal", *Open Economies Review*, 15, 193-215.

Vines, D. (2003), "John Maynard Keynes 1937-1946: The creation of international macroeconomics", *The Economic Journal*, 113, F338-F361.

Walsh, C. (2003), *Monetary theory and policy*, MIT Press.

FIGURE 1

AGGREGATE SUPPLY - AGGREGATE DEMAND



APPENDIX A

We specify the coefficients μ_0, μ_1, μ_2, μ_3 of the (inverse) supply function in equation (5) in the main text.

Substituting equations (3) and (4) in equation (2), we derive equation (5) (all in the main text) where:

$$\mu_1 = \frac{\sigma[1+(n-\nu)\lambda]+(1-\lambda)[(n-\nu)(1+\sigma)+\nu]}{1+(n-\nu)\lambda-(1-\lambda)\varepsilon d} \tag{A1}$$

$$\mu_2 = \frac{\lambda[1+(n-\nu)\lambda]+(1-\lambda)(n-\nu)\lambda}{1+(n-\nu)\lambda-(1-\lambda)\varepsilon d} \tag{A2}$$

$$\mu_3 = \frac{\varepsilon(1-\lambda)(1-d)}{1+(n-\nu)\lambda-(1-\lambda)\varepsilon d} \tag{A3}$$

$$\mu_0 = \frac{\phi[1+(n-\nu)\lambda]+(1-\lambda)\zeta-(1-\lambda)n\bar{h}-(1+\sigma)t[1+(n-\nu)\lambda+(1-\lambda)(n-\nu)]}{1+(n-\nu)\lambda-(1-\lambda)\varepsilon d} \tag{A4}$$

Using the above equations and the assumptions used in the text, it is straightforward to show:

$$0 \le \mu_2 < 1,\ 0 < \mu_3 \le 1,\ \ 0 \le \mu_1. \tag{A5}$$

Two special cases deserve further attention.

(A) The "wage militancy" case, defined as: complete wage indexation $(\varepsilon = 1)$, no response of the wage rate to labour market conditions ($n = 0$) and unit elasticity of the wage rate with respect to labour productivity ($\nu = 1$). In this case, the coefficients of the inverse supply function become:

$$\mu_1 = 0,\ \ \mu_2 = 0,\ \ \mu_3 = 1,\ \ \mu_0 = (\phi+\zeta)/(1-d), \tag{A6}$$

and equations (5) and (6) in the text become:

$$p = (\phi+\zeta)/(1-d) + f \tag{A7}$$

$$rer = (\phi+\zeta)/(1-d) \tag{A8}$$

which imply that the inverse supply curve is "flat", or that the real exchange is independent of output, foreign prices, labour supply $\bar{h}$, and the efficiency factor t; it is exclusively determined by the mark-up coefficient, ϕ, and the wage pressure parameter ζ. In terms of

Figure 1 in the main text, the AS curve is horizontal (parallel to the y axis) cutting the *rer* axis at $(\phi+\zeta)/(1-d)$.

(B) The "fixed real consumer wage" case, defined as $\varepsilon=1$, $n=v=0$. In this case, the coefficients of the inverse supply function are described by (A9) and (A10):

$$0<\mu_2<1,\ 0<\mu_3<1,\ 0<\mu_1 \tag{A9}$$

$$\mu_0=\frac{\phi+(1-\lambda)\zeta-(1+\sigma)t}{1-(1-\lambda)d} \tag{A10}$$

APPENDIX B

We show that the left hand side of equation (45), that is $\frac{1}{2}\frac{d(y_1+y_2)}{dg}$, is the impact on world output of an equiproportional increase in government expenditure in both countries $\mathrm{d}g_1 = \mathrm{d}g_2 = \mathrm{d}g$ under the assumption that, initially, the share of each country in world output is equal to 1/2.

We define world output (in real terms) as:

$$Y = (P/F)Y_1 + Y_2 \qquad \text{(B1)}$$

where capital letters denote initial variables (not their logs). The term in parentheses is the real exchange rate, *RER*, of Country 1, Y_1 is Country 1's production, Y_2 is Country 2's production, P is the price of Y_1 and *F* the price of Y_2, both expressed in Country 1 currency. In equation (B1), real world output has been expressed in terms of Country 2 production. Denoting $\ln Y = y$ and taking the differential in (B1), we obtain:

$$dy = \frac{dY}{Y} = \frac{d[(RER)Y_1 + Y_2]}{(RER)Y_1 + Y_2} \qquad \text{(B2)}$$

Assuming $(RER)Y_1/[(RER)Y_1 + Y_2] = Y_2/[(RER)Y_1 + Y_2] = \frac{1}{2}$ (which is consistent with our assumption that the two countries are similar), working out the differential in (B2), dividing all sides in (B2) by $\mathrm{d}g\,(= \mathrm{d}g_1 = \mathrm{d}g_2)$ and using small letters to denote the logs of the variables as in the main text, we obtain:

$$\frac{dy}{dg} = \frac{1}{2}\frac{d(y_1+y_2)+d(rer)}{dg} = \frac{1}{2}\frac{d(y_1+y_2)}{dg}, \qquad \text{(B3)}$$

since $\frac{d(rer)}{dg} = 0$ following equation (33) in the main text.

BANK OF GREECE WORKING PAPERS

1. Brissimis, S. N., G. Hondroyiannis, P.A.V.B. Swamy and G. S. Tavlas, “Empirical Modelling of Money Demand in Periods of Structural Change: The Case of Greece”, February 2003.

2. Lazaretou, S., “Greek Monetary Economics in Retrospect: The Adventures of the Drachma”, April 2003.

3. Papazoglou, C. and E. J. Pentecost, “The Dynamic Adjustment of a Transition Economy in the Early Stages of Transformation”, May 2003.

4. Hall, S. G. and N. G. Zonzilos, “An Indicator Measuring Underlying Economic Activity in Greece”, August 2003.

5. Brissimis, S. N. and N. S. Magginas, “Changes in Financial Structure and Asset Price Substitutability: A Test of the Bank Lending Channel”, September 2003.

6. Gibson, H. D. and E. Tsakalotos, “Capital Flows and Speculative Attacks in Prospective EU Member States”, October 2003.

7. Milionis, A. E., “Modelling Economic Time Series in the Presence of Variance Non-Stationarity: A Practical Approach”, November 2003.

8. Christodoulopoulos, T. N. and I. Grigoratou, “The Effect of Dynamic Hedging of Options Positions on Intermediate-Maturity Interest Rates”, December 2003.

9. Kamberoglou, N. C., E. Liapis, G. T. Simigiannis and P. Tzamourani, “Cost Efficiency in Greek Banking”, January 2004.

10. Brissimis, S. N. and N. S. Magginas, “Forward-Looking Information in VAR Models and the Price Puzzle”, February 2004.

11. Papaspyrou, T., “EMU Strategies: Lessons From Past Experience in View of EU Enlargement”, March 2004.

12. Dellas, H. and G. S. Tavlas, "Wage Rigidity and Monetary Union", April 2004.

13. Hondroyiannis, G. and S. Lazaretou, "Inflation Persistence During Periods of Structural Change: An Assessment Using Greek Data", June 2004.

14. Zonzilos, N., "Econometric Modelling at the Bank of Greece", June 2004.

15. Brissimis, S. N., D. A. Sideris and F. K. Voumvaki, "Testing Long-Run Purchasing Power Parity under Exchange Rate Targeting", July 2004.

16. Lazaretou, S., "The Drachma, Foreign Creditors and the International Monetary System: Tales of a Currency During the 19^{th} and the Early 20^{th} Century", August 2004.

17. Hondroyiannis G., S. Lolos and E. Papapetrou, " Financial Markets and Economic Growth in Greece, 1986-1999", September 2004.

18. Dellas, H. and G. S. Tavlas, "The Global Implications of Regional Exchange Rate Regimes", October 2004.

19. Sideris, D., "Testing for Long-run PPP in a System Context: Evidence for the US, Germany and Japan", November 2004.

20. Sideris, D. and N. Zonzilos, "The Greek Model of the European System of Central Banks Multi-Country Model", February 2005.

21. Kapopoulos, P. and S. Lazaretou, "Does Corporate Ownership Structure Matter for Economic Growth? A Cross - Country Analysis", March 2005.

22. Brissimis, S. N. and T. S. Kosma, "Market Power Innovative Activity and Exchange Rate Pass-Through", April 2005.

23. Christodoulopoulos, T. N. and I. Grigoratou, "Measuring Liquidity in the Greek Government Securities Market", May 2005.

24. Stoubos, G. and I. Tsikripis, "Regional Integration Challenges in South East Europe: Banking Sector Trends", June 2005.

25. Athanasoglou, P. P., S. N. Brissimis and M. D. Delis, “Bank-Specific, Industry-Specific and Macroeconomic Determinants of Bank Profitability”, June 2005.