Whither Monetary Union?

Revisiting the EMU One Year On[†]

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Abstract

This essay seeks to draw together the diverse range of arguments pertaining to the economics of monetary integration and attempts to provide a formal framework for the study of monetary unions. Where possible, models are used to flesh out the more common verbal arguments that are often found in the literature, and where relevant, empirical work on European Monetary Union is reviewed and critiqued. The latter part of the paper draws on recent data for the euro-zone and attempts to assess the success of monetary integration in Europe with respect to the economic arguments already put forward. In particular, main macroeconomic indicators such as prices, unemployment and investment are examined and interpreted in the light of economic reasoning.

Keywords: monetary integration, European Monetary Union

JEL Classification: F33, F36

I. Introduction

The euro's slump to its recent lows has provided valuable ammunition for the critics of monetary union; whilst its proponents argue that the fledgling currency's exchange rate has little to do with its success in the long run. Both provide masterful arguments in support for their case; yet, all too often, personal opinion or political bias taints the arguments.

This essay attempts to provide a modern, coherent structure for analysing the economics of monetary union, and its associated costs and benefits. Its aim is to address the issue of monetary unification in general and the European Monetary Union (EMU) in particular. In the section following, a review is made of the literature concerning monetary integration, with an emphasis on formal models and empirical research. Section III will then analyse, *inter alia*, monthly data for inflation, interest rates, employment and investment, and attempt to provide some early insight on the state of the monetary union in Europe, before a final section concludes the paper.

II. Monetary Integration

The study of monetary union necessarily requires a careful understanding of the various costs and benefits involved in introducing a common currency. A wealth of literature exists in the field, and this section will confine itself to a discussion of the more prominent findings, in particular research that has relevance to the EMU. Although the literature tends to address the benefits and costs and separate issues, it is common that a purported benefit often entails costs as well. This section will therefore address each issue in tandem, and only highlight cases when a consensus does exist.

Optimum currency areas[1]

The most common approach to analysing monetary union finds its roots in the theory of optimum currency areas (OCAs), initiated by Mundell in 1961. It attempts to determine the bounds of a region within which a single currency would be optimal, and in so doing, identifies several structural features that would, in principle, delineate an optimal currency area. These include factors such as the asymmetry of shocks to the economy[2], the degree of openness of the constituent economies (McKinnon 1963) and the degree of industrial diversification (Kenen 1969).

Formal models of optimum currency areas have been proposed; this section presents a simplified version[3] of the model used in Bayoumi (1994), which is a general equilibrium model with regionally differentiated goods. The model assumes that nominal wages are rigid and are sticky downwards, and

[1] The optimum currency area literature is wide-ranging and extensive. Recent reviews are provided by Masson & Taylor (1993) and Tavlas (1993a, b).

[2] The issue of asymmetric shocks has given rise to a whole strand of literature in itself, and is addressed more fully in the following subsection.

[3] Specifically, Bayoumi extends the analysis to include multiple regions as well as consider the effects of labour mobility.

that each region specialises in the production of one good. In a world with m regions, the production function for region i is

$$Y_i = L_i^{\alpha} e^{\varepsilon_{it}} \tag{1}$$

where Y_i =labour L_i ($0 \leq L_i \leq 1$) is the only input used in the production of output Y_i for region i, with α being a parameter which is less than 1 and ε_{it} is an independent, identically distributed disturbance of mean zero and variance σ^2. This can be normalised with respect to region 1 such that the productivity shock ε_{1t} is equal to zero, and the price of output P_i is set as the numeraire.

In a competitive market, the real wage ($W_i/P_i \cdot E_i$) equates to the marginal product of labour

$$w_i - p_i + e_i = \log(\alpha_i) - (1 - \alpha) l_i + \varepsilon_{it} \tag{2}$$

where lowercase letters indicate logarithms, and where W_i and E_i are the nominal wages and exchange rate, respectively. In the following discussion, sticky wages arise when, in the absence of productivity shocks ($\varepsilon_{it} = 0$) with the exchange rate is normalised to 1, wages are given by ω, which is consistent with full employment ($L_i = 1$); yet when labour demand is below full employment level W_i remains at ω. Bayoumi applies the 'iceberg' model of trade – where goods which originate from region j shrink by a factor ($1 - T_j$) upon arrival in region i – in order to capture the costs of a flexible exchange rate between two regions (ie. the ratio E_i/E_j is allowed to vary). For simplicity, the cost T is assumed to be the same for all transactions.

Consumption is region j is based on a Cobb-Douglas utility function over all n goods,

$$U_j = \sum_{i=1}^{n} \beta_{ji} \log(C_{ji}) - \delta \tag{3}$$

where C_{ji} is the consumption of good i in region j and δ is a constant term equal to the sum of $\beta_{ji} \log(C_{ji})$, applied to simplify later calculation. Demand for good i from region j is given by

$$Y_{ji} = \beta_{ji} Y_j P_j / P_i \tag{4}$$

When two regions are not in a currency union, the volume of goods consumed in region j is less than that consumed in region i due to transaction costs. This implies, from (4),

$$C_{ji} = \beta_{ji} (1 - T_j) / P_i \tag{5}$$

where T_j is equal to zero for regions within the union and T for regions outside of it.

In a free float, nominal wages are set at ω, and full employment implies that $y_i = \varepsilon_i$. This yields

$$c_{ji} = \log \beta_{ji} + \log(1 - T) + \varepsilon_i \tag{6}$$

where we have made use of the fact that $Y_i = \sum_i \beta_{ji}/P_i = 1/P_i$. Substituting into (3) yields

$$U_j = \sum_{i=1}^{n} \beta_{ji}\, \varepsilon_{it} + \sum_{i \neq j} \beta_{ji} \log (1 - T) \qquad (7)$$

Consider now a hypothetical two-country currency union between regions *j* and *k*. Assuming an average of the exchange rates of the two regions, ie. $e_{jk} = (\varepsilon_j + \varepsilon_k)/2$, and a shock in region *j* such that an excess demand for labour arises (and a corresponding fall in demand for labour in region *k*), output in both regions will be

$$\begin{aligned} y_j &= \varepsilon_{jt} \\ y_k &= \varepsilon_{kt} - \alpha(\varepsilon_{jt} - \varepsilon_{kt}) / [2(1 - \alpha)] \end{aligned} \qquad (8)$$

with the corresponding wages

$$\begin{aligned} w_j &= \log (\omega) + (\varepsilon_{jt} - \varepsilon_{kt})/2 \\ w_k &= \omega \end{aligned} \qquad (9)$$

Bayoumi calculates the welfare effects from the difference between the utilities for the new equilibrium and those defined in equation (7). These are, for the two regions *j* and *k* within the union and *l* without,

$$\begin{aligned} \Delta U_j &= \beta_{jk} \log (1 - T) - \beta_{jk}\alpha\, (\varepsilon_j - \varepsilon_k) / [2(1 - \alpha)] \\ \Delta U_k &= \beta_{kj} \log (1 - T) - \beta_{kk}\alpha\, (\varepsilon_j - \varepsilon_k) / [2(1 - \alpha)] \\ \Delta U_l &= -\beta_{lk}\alpha\, (\varepsilon_j - \varepsilon_k) / [2(1 - \alpha)] \end{aligned} \qquad (10)$$

In first two equations, the first term derives from the gain in the elimination of transaction costs with the other region, whilst the second term is the loss in welfare associated with the lower output in region *k* due to the lower flexibility of real wages due to the currency union. The final equation shows that the impact of currency unions on other regions is unambiguously negative. Within a currency union, each region has a 50 percent chance of facing excess demand for labour with another 50 percent chance of the opposite happening. The expected value of the change in welfare for region *j* (and similarly for region *k*) is

$$\begin{aligned} E(\Delta U_j) &= \beta_{jk} \log (1 - T) - \alpha\beta_{jj} E(\varepsilon_j - \varepsilon_k \mid \varepsilon_j < \varepsilon_k) P(\varepsilon_j < \varepsilon_k) - \alpha\beta_{jk} E(\varepsilon_k - \varepsilon_j \mid \varepsilon_j > \varepsilon_k) P(\varepsilon_j > \varepsilon_k) \\ &= \beta_{jk} \log (1 - T) - \alpha\beta_{jj} 2\phi(0) \sqrt{(\sigma_j^2 - 2\sigma_{jk} + \sigma_k^2)}\tfrac{1}{2} - \alpha\beta_{jk} 2\phi(0) \sqrt{(\sigma_j^2 - 2\sigma_{jk} + \sigma_k^2)}\tfrac{1}{2} \\ &= \beta_{jk} \log (1 - T) - \alpha(\beta_{jj} + \beta_{jk})\phi(0) \sqrt{(\sigma_j^2 - 2\sigma_{jk} + \sigma_k^2)} \end{aligned} \qquad (11)$$

where $\phi(.)$ is the density function for a standard normal variate with mean 0 and standard deviation 1, σ_j^2 and σ_k^2 are the variance of the productivity shocks in regions *j* and *k*, and σ_{jk} the covariance of the two.

The preceding equation clearly illustrates the gains and losses associated with joining a currency union. The first term, as above, is the gain in welfare from lower transactions costs, as influenced by the

degree to which home consumers desire goods from the other region[4]. Welfare losses are incurred from the likely size of asymmetric disturbances (the second term). The expected change in utility for the final equation of (10) is

$$E(\Delta U_j) = -(\beta_{lj} + \beta_{lk})\phi(0)\sqrt{(\sigma_j^2 - 2\sigma_{jk} + \sigma_k^2)} \qquad (12)$$

The reduction in welfare is thus largest for regions whose consumption is most closely connected with the currency union.

The model explicitly addresses the three main criteria for an optimum currency area, that of the size and correlation of asymmetric shocks (captured by $\sigma_j^2 - 2\sigma_{jk} + \sigma_k^2$), the openness of an economy (captured by the βs), and industrial diversification (captured by the correlation term σ_{jk}).

Two additional criteria deserve brief mention: that of wage and price flexibility, and that of labour mobility (Mundell 1961). These will be considered in tandem, using a simple graphical model (De Grauwe 1994). Consider an asymmetric shock that affects two regions, *j* and *k*. The shock leads to an increase in aggregate demand in region *j*, but a decrease in region *k*, and is shown as a rightward shift of the D_j schedule to D_j' (and a corresponding leftward shift of the D_k' schedule to D_k).

There exist two mechanisms to automatically restore equilibrium in the two regions. With wage and price flexibility, prices and wages in region *j* will rise (fall), such that full employment is restored in region *j* (region *k*). This is captured by a leftward (rightward) shift of the aggregate supply schedule to S_j' (S_k'). With labour mobility, the free movement of labour will likewise reduce unemployment in region *k* and relieve wage/price pressures in region *j*. This analysis suggests that the greater are these two factors, the greater the incentive to establish a monetary union. This is shown in Figure 1.

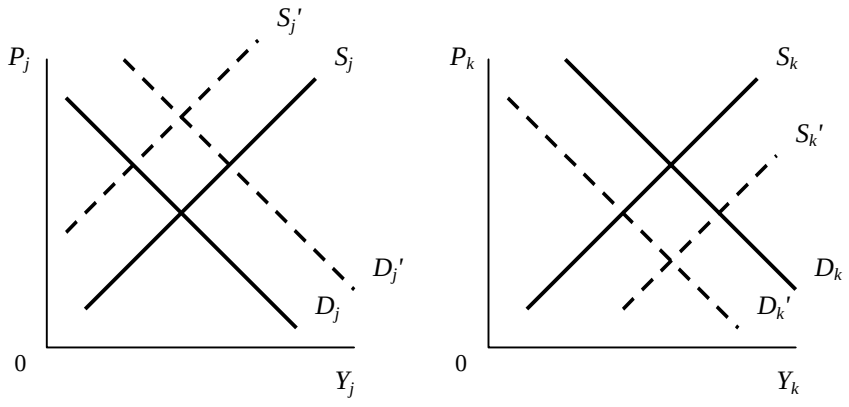


Figure 1. Role of wage and price flexibility in restoring equilibrium

There is a general consensus that the full European Union of 15 members is not an optimum currency area (Bayoumi & Eichengreen 1991; De Grauwe & Vanhaverbeke 1991), although individual studies

[4] The larger the degree – implying a more open economy – the greater the welfare gain.

of different criteria are often divided in opinion[5]. A summary of the consensus view is neatly captured in Figure 2.

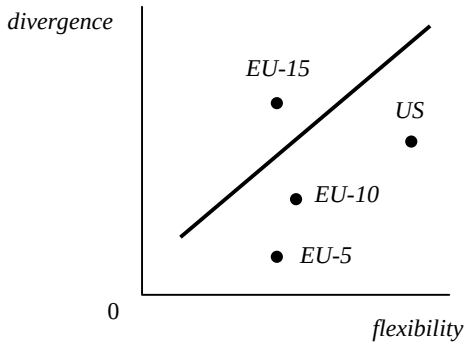


Figure 2. Consensus view on optimal currency areas for EU countries

A final point to note is that a country may satisfy or fail the OCA criterion *ex post*, even if this were not so not *ex ante*. Therefore, OCA criteria may be *endogenous*. This arises because upon entry into a monetary union, a country experiences changes in its structure of trade and income correlations. One view argues that as trade becomes more highly integrated, countries specialise more in production, and this in turn reduces the correlation of income (Eichengreen 1992; Krugman 1993). This moves a country that participates in a monetary union further away from the OCA criterion, leading to increased divergence *ex post*. The alternative view is that increased trade will lead to greater correlation of incomes, since the economies become more tightly integrated, and increase convergence *ex post* (Emerson *et al* 1992; Frankel 1999). The two opposing views are presented in Figure 3. Econometric evidence suggests that the EMU might indeed be more justifiable *ex post* (Frankel & Rose 1997).

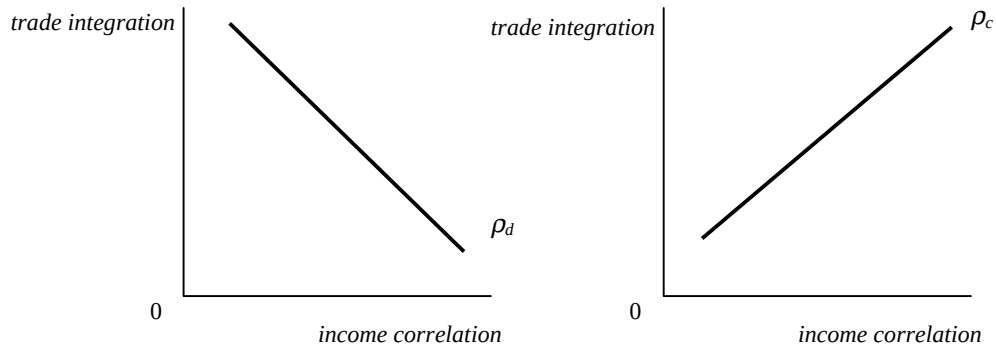


Figure 3. Correlation functions for converging and diverging cases

[5] For example, Bini-Smaghi & Vori (1993) and Taylor (1995) find evidence in favour of the EC being an OCA with respect to the openness and industrial diversity criteria, whereas Boltho (1998) and Bruno & Sachs (1985) believe otherwise with respect to openness and wage and price flexibility. The issue of labour mobility has also been hotly debated, again with some rejecting the EMU as an OCA on this criterion (Layard, Nickell & Jackman 1991) and others not (Gros & Thygesen 1998). Note also that not all economists share the consensus view. See Emerson *et al* (1992) and Gros & Thygesen (1998).

Asymmetric shocks and exchange rate policy

The discussion naturally flows into one where it becomes necessary to examine the importance of asymmetric shocks to an economy within a monetary union, and the loss of the exchange rate as a policy instrument. These issues are interrelated, as exchange rate adjustments are often a primary method of adjustment to the asymmetric shocks faced by an economy. A key question that arises is whether nominal exchange rate changes can permanently alter the real exchange rates for the country, and hence correct for shocks.

To examine this issue more formally, consider a simple example of an economy, based on the model introduced by Dornbusch (1980). Assuming an economy where employment L_t is determined by demand and where the unit labour requirement is a constant, α, the labour market is determined by

$$L_t = \alpha(D_t + M_t^*) \tag{13}$$

where D_t and M_t^* denote the domestic and foreign demand for home output, respectively. The domestic price level P_t is determined by unit labour costs

$$P_t = \alpha W_t \tag{14}$$

where W_t is the wage rate. Trade balance is equal to the excess of export receipts over import spending

$$T_t = P_t D_t^* - P_t^* e_t \cdot M \tag{15}$$

where P_t^* is the foreign currency price of home imports, and e_t is the exchange rate. Using import prices as the numeraire, P_t^* will be constant and equal to unity. Making the behavioural assumption that foreign demand depends on the relative price of home exports P_t/e_t, it is possible to define the implicit function signifying domestic demand as dependent on income $W_t L_t$, money balances H_t and relative prices P_t/e_t. Writing this in terms of relative prices, obtain

$$D_t = D(P_t/e_t,\ W_t L_t/e_t,\ H_t/e_t) \tag{16}$$

Accordingly, it is possible to write the real value of money and labour income in terms of import prices

$$M_t = M(P_t/e_t,\ W_t L_t/e_t,\ H_t/e_t) \tag{17}$$
$$M_t^* = M^*(P_t/e_t) \tag{18}$$

The behavioural equations, together with the price equation, can be used to solve for the levels of employment and its associated trade balance. These are

$$\begin{aligned} L_t &= L(W_t/e_t,\ H_t/e_t) \quad , \quad \partial L/\partial(W_t/e_t) < 0, \quad \partial L/\partial(H_t/e_t) > 0 \\ T_t &= T(W_t/e_t,\ H_t/e_t) \quad , \quad \partial T/\partial(W_t/e_t) < 0, \quad \partial T/\partial(H_t/e_t) > 0 \end{aligned} \tag{19}$$

The classical adjustment process relies on money wage changes induced by unemployment and money supply changes induced by the balance of payments. The managed system, however, attempts to attain internal and external balance along preferred paths. Without exchange rate realignments, the system is characterised by

$$\Delta H_t/e_t = T(W_t/e_t, H_t/e_t)$$
$$\Delta W_t/e_t = \phi[L(W_t/e_t, H_t/e_t) - L^*] \quad (20)$$

where the first equation indicates how money balances rise at a rate equal to the balance of payments surplus, and the second shows how the rate of wage change is proportional to the difference between employment and the labour force L^*. The managed system is characterised by the equations

$$\Delta H_t/e_t = T(W_t/e_t, H_t/e_t) + k[L^* - l(W_t/e_t, H_t/e_t)]$$
$$\Delta W_t/e_t = \phi[L(W_t/e_t, H_t/e_t) - L^*] \quad (21)$$

The additional term in equation (21a) clearly shows that depreciation supplements nominal wage changes in moving the real wage, and so the real money stock is managed with both a view to trade balance but also with regard to employment.

The phase-plane diagram (Figure 4) shows the dynamics of the adjustment process without exchange rate policy as opposed to a one with such a policy.

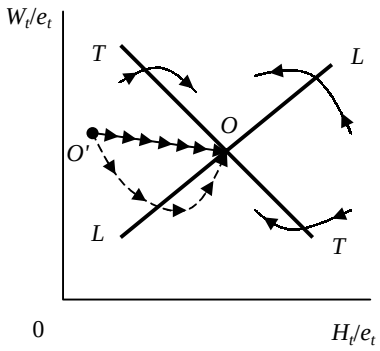


Figure 4. Phase diagram for exchange rate adjustment with and without policy

An initial disequilibrium at point *O'* adjusts along the dashed path to re-attain equilibrium at *O* via the non-interventionist mechanism. In contrast, the managed system supplements the wage dynamics so as to attain the solid path, which is clearly preferable as it avoids the over-depreciation of the real exchange rate and is potentially faster. The key assumption involves whether prices and wages are sticky, which would then render exchange rate realignments a useful macroeconomic stabilisation tool[6].

[6] This harks back to the familiar New Keynesian-New Classical debate on the stickiness of wages and prices. This essay shall leave the reader to his own convictions and instead focus on the specific empirical work that has been performed with regard to asymmetric shocks in EU countries.

If so, then the loss of this instrument would mean very real costs for an economy which faced asymmetric shocks.

Empirical studies on the issue of asymmetric shocks have adopted three main approaches: first, by that of case studies that study the effects of exchange rate realignments on economic recovery (De Grauwe 1997; De Grauwe & Vanhaverbeke 1990; Sachs & Wyplosz 1986); second, by testing for the statistical impact of shocks on various economies[7] (Canzioneri *et al* 1996; Demertzis, Hallett & Rummel 1997; Erkel-Rousse & Mélitz 1997; Schuberth & Wehinger 1999); third, by model simulations[8] (Emerson *et al* 1992; Masson & Symansky 1992; Minford, Rastogi & Hughes-Hallet 1992).

Policy credibility and time inconsistency

The 'new' view of monetary integration stresses issues of credibility (De Grauwe 1995). This is primarily an extension of the Kydland-Prescott (1977) and Barro-Gordon (1983) model to the context of monetary union. The discussion that follows is based on that of Alesina & Grilli (1993).

Consider a group of countries $i = 1,\ldots, n$ where output y is given by the expectations-adjusted Phillips curve relation

$$y_i = (\pi - \pi^e) + \varepsilon_I \tag{22}$$

where π is the rate of inflation, π^e is the expected rate and ε_i is an independent, identically distributed shock with variance σ^2 that occurs after the formation of private sector expectations. The monetary authority aims to minimise a loss function given by

$$L_i = \tfrac{1}{2} E\,[\pi^2 + \gamma_i(y_i - y^*)^2] \tag{23}$$

where y^* is the target level of output. Economies are assumed two differ in two dimensions: their preferences as reflected in γ_i, and the nature of the shocks, ε_i. The time consistent inflation policy is thus given by

$$\pi^* = \gamma_i y^* - [\gamma_i/(1 + \gamma_i)]\varepsilon_I \tag{24}$$

with the corresponding output level

$$y_i = [1/(1 + \gamma_i)]\varepsilon_I \tag{25}$$

[7] Canzioneri *et al* (1996) and Erkel-Rousse & Mélitz (1997) find, in general, that the loss of the exchange rate as a policy instrument yields minimal impact on both the core and periphery countries that they studied; in contrast, Demertzis, Hallett & Rummel (1997) and Schuberth & Wehinger (1999), using structural vector autoregression approaches, find that there are in fact significant costs involved in relinquishing domestic monetary policy.

[8] Emerson *et al* (1992) ran simulations based on the IMF Multimod model and the EC Quest model; Minford, Rastogi & Hughes-Hallet (1992) used the Liverpool world model and Masson & Symansky (1992) with the IMF Multimod model. Interestingly, the conclusions of Emerson *et al* were in opposition to that of Masson & Symansky, despite the same model being used.

This would yield a variance of output σ_i^2 given by

$$\sigma_i^2 = \sigma_i^2/(1 + \gamma_i)^2 \tag{26}$$

However, it can be shown that were the authority be able to commit to a policy of

$$\pi^c = -[\gamma_i/(1 + \gamma_i)]\varepsilon_I \tag{27}$$

it is then possible to attain values of average inflation and output of zero, with output variance the remaining the same as (26). The policy given by (27) is therefore superior as it improves on inflation with no cost to output.

A monetary union leads to a situation where the inflation rate is the same across all countries (due to the same monetary policy being adopted for all countries). The union central bank will aim to minimise the loss function

$$L^U = \tfrac{1}{2} E[\Pi_t^2 + \Gamma(Y - Y^*)^2] \tag{28}$$

where capitalised variables indicate union values. Likewise, output is given by

$$Y_t = (\Pi - \Pi^e) + \xi_t \tag{29}$$

Solving the optimisation problem will yield the inflation, output and output variance equations

$$\begin{aligned}
&\Pi = \Gamma Y^* - [\Gamma/(1 + \Gamma)]\xi \\
&Y = [1/(1 + \Gamma)]\xi \\
&\sigma_Y^2 = \sigma_\xi^2/(1 + \Gamma)^2
\end{aligned} \tag{30}$$

It can be shown that the net gain of joining the union is

$$\begin{aligned}
L_i - L_i^U = \tfrac{1}{2}\{&- y^{*2}(\Gamma^2 - \gamma_i^2) + (1 + \gamma_i)\{[\gamma_i/(1 + \gamma_i)]^2\sigma_{\varepsilon i}^2 - \Gamma/(1 + \Gamma)]^2\sigma_\xi^2\} + 2\gamma_i\{[\Gamma/(1 + \\
&\Gamma)]\sigma_{\varepsilon\xi} - [\gamma_i/(1 + \gamma_i)]\sigma_\varepsilon\}\}
\end{aligned} \tag{31}$$

where $\sigma_{\varepsilon\xi}$ is the covariance between ε and ξ. Here, the difference in welfare is captured by the two components, one representing differences in preferences (Γ and γ_i) and another representing economic dissimilarities ($\sigma_{\varepsilon i}^2$, σ_ξ^2 and $\sigma_{\varepsilon\xi}$). By assuming $\varepsilon_i = \xi$ in all states of the world, such that $\sigma_{\varepsilon i}^2 = \sigma_\xi^2 = \sigma_{\varepsilon\xi} = \sigma^2$, (30) simplifies to

$$L_i - L_i^U = \tfrac{1}{2}\{- y^{*2}(\Gamma^2 - \gamma_i^2) + \sigma^2[\gamma_i/(1 + \gamma_i) - \Gamma/(1 + \Gamma)][(1 + \gamma_i)/(1 + \Gamma)\cdot\Gamma - \gamma_i]\} \tag{32}$$

Re-expressing (31) as a 'gain' function,

$$L_i - L_i^U = G_i(\Gamma, \gamma_i) \tag{33}$$

This function takes a parabola-like shape, and Figure 5 graphs (33) for the cases $y^{*2}(1 + \gamma_i) < \sigma_\varepsilon^2$ and $y^{*2}(1 + \gamma_i) > \sigma_\varepsilon^2$.

In both cases, if $\Gamma > \gamma_i$, country *i* is worse off with the union, since the union central bank is even less credible than the country's central bank. Further, if $\Gamma < \Gamma_{min}$, country *i* also loses from the union because the union central bank is too conservative and does not stabilise enough, leading to higher losses from output variance than gains from reduced inflation. If $\Gamma \in (\Gamma_{min}, \gamma_i)$, then country *i* is strictly better off with the union. The optimal level of γ_i is given by γ_i^*.

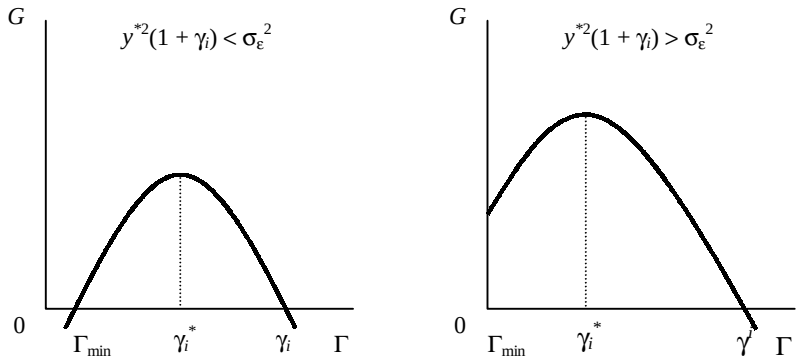


Figure 5. Welfare gain functions for $y^{*2}(1 + \gamma_i) < \sigma_\varepsilon^2$ and $y^{*2}(1 + \gamma_i) > \sigma_\varepsilon^2$

Since credibility as a concept is immeasurable, no conclusive empirical work is possible in this area. *Ad hoc* data based on the comparison of inflation differentials, however, suggests that inflation-prone countries, such as Italy, Ireland and Spain, might benefit from a monetary union that has a European Central Bank modelled after the Bundesbank in Germany (De Grauwe 1995; Honohan 1991). The benefits of price stability are estimated to be about 0.3% of community GDP (Emerson *et al* 1992).

Elimination of exchange rate variability

The introduction of a common currency would imply the elimination of variability between the exchange rates of all countries participating in the monetary union. This has effects on the welfare of both individuals as well as firms. Baldwin (1991) finds no less than seven different areas in which static and dynamic efficiency gains from the elimination of exchange rate variability may be realised. The discussion here will limit itself to the gains due to the reduction of systematic risk, whilst the subsections that follow will address the effects of the elimination of transactions costs and the effects of a stable exchange rate on trade.

As a preliminary, it is useful to examine the common argument that monetary unification provides a fixed exchange rate that offers greater stability to output as compared to a regime of free floats. This argument in general is fallacious, as can de demonstrated easily by considering modification of the model first introduced by Poole (1970).

Consider an economy represented by a modified *IS-LM* framework (Figure 6) that faces two types of shocks, real and monetary. When a real shock occurs (a shift in the *IS* curve), a flexible exchange rate would fluctuate between e_{1-} and e_{1+}, and output variation would vary between y_{1-} and y_{1+}. A fixed rate in this case would lead to higher output variability, between y_{2-} and y_{2+}. When a monetary shock occurs (a shift in the *LM* curve), a flexible rate would cause output variability but there is no output variation with a fixed rate, since authorities will intervene in the money market to maintain the fixed rate. Thus, if real shocks dominate, then a fixed exchange rate is preferable. However, if monetary shocks dominate, then floating is preferred.

The implication of the above analysis is that elimination of exchange rate volatility does not necessarily imply greater output stability, but instead depends on the nature of the shocks (which shift the *IS* or *LM* curves) and the underlying structure of the economy (which determines the slope of the curves).

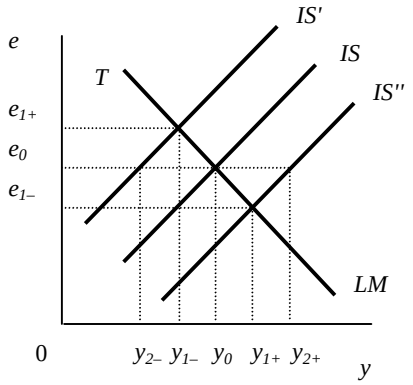


Figure 6. Modified IS-LM framework illustrating real and monetary shocks

At a microeconomic level, the gains from the elimination of exchange rate risk are likewise questionable. Despite the general support of the business community (Association for the Monetary Union of Europe 1998), economic theory does not provide a cut-and-dried case for increased profits due to the elimination of exchange rate variability. The model here is adapted from that of Pindyck (1982)[9].

Consider a case where there exists demand uncertainty due to the possibility of exchange rate (and hence price) fluctuations. Demand is

$$p = p[q, \theta(t)] \quad , \quad \partial p/\partial q \leq 0, \partial p/\partial \theta > 0 \tag{34}$$

with q as output determined by the quasi-concave production function $q = f(k, l)$ and $\theta(t)$ a stochastic process of the form

$$d\theta = \sigma(\theta)\varepsilon(t)\sqrt{dt} \tag{35}$$

[9] Less general graphical treatments can also be found in Oi (1961) and De Grauwe (1997). Pindick's (1982) contribution is particularly insightful as it yields robust results as compared to earlier treatments.

where $\varepsilon(t)$ is a serially uncorrelated normal random variable with mean zero and variance one. The firm's instantaneous profit is

$$\pi(t) = p(q, \theta)q - wl - vi - c(i) \tag{36}$$

where w are wages paid to labour L, and $vi + c(i)$ is the cost of capital setup, v being the purchase price of a unit of capital equipment, invested in at rate i. $c(i)$ is the full adjustment cost of changing capital, which is assumed to be semi-fixed[10]. Capital stock accumulates at a rate

$$\Delta k = i - \delta k \tag{37}$$

where δ is the depreciation rate. The risk-neutral firm maximises the expected sum of discounted (at rate r) profits according to

$$max\ E_0 \int_0^{\infty} \pi(t)e^{-rt}\, dt \tag{38}$$

subject to (35), (37) and nonzero factor inputs. In the deterministic case, $\theta = \theta_0$ and

$$\Delta i = 1/c''(i)\ \{(r + \delta)[v + c'(i)] - [p + q(\partial p/\partial q)]\cdot \partial f/\partial k\} \tag{39}$$

Equations (37) and (39) describe the dynamics of k and i, and are described by the phase diagram in Figure 7; equilibrium is attained at k^* and i^*.

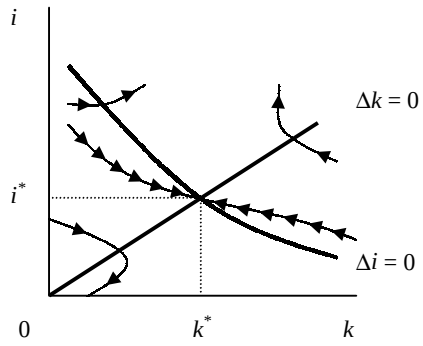


Figure 7. Phase diagram for the deterministic solution

Consider the model in the presence of demand uncertainty. Define the value function as

$$J(k, \theta, t) = max\ E_t \int_t^{\infty} \pi(\tau)e^{-r\tau}\, d\tau \tag{40}$$

This will lead to the fundamental equation of optimality

$$max\ [\pi(t)e^{-rt} + \partial J/\partial t + (i - \delta k)\cdot \partial J/\partial k + \tfrac{1}{2}\sigma^2(\theta)\cdot \partial^2 J/\partial \theta^2 \tag{41}$$

[10] That is, changeable over time at a cost. In addition, assume $c(0) = 0$, $c'(i) > (<)\ 0\ \forall\ i > (<)\ 0$, $c''(i) > 0$.

This equation can be solved[11] to yield the stochastic investment analogue to equation (39)

$$1/dt \cdot E_t\, di = 1/c''(i)\{(r + \delta)[v + c'(i)] - [p + q(\partial p/\partial q)] \cdot \partial f/\partial k - \sigma^2(\theta) \cdot (\partial i/\partial \theta)^2 \cdot c'''(i)\} \qquad (42)$$

The result depends crucially on whether marginal adjustment costs are rising at an increasing ($c'''(i) > 0$) or decreasing ($c'''(i) < 0$) rate. With $c'''(i) > 0$, in the presence of uncertainty ($\sigma > 0$), stochastic fluctuations create a positive expected semi-fixed cost of adjustment, which is reduced – though not eliminated – by maintaining a larger capital stock and output level. Stochastic demand fluctuations thus reduce the long-run marginal cost of production, but *raises* the average cost – profits are squeezed. The effect is converse for the case where $c'''(i) < 0$. A graphical exposition of the argument is shown in Figure 8, for the former case, with $MC_{sr}^{\ 0}$ being the short-run marginal cost with $\sigma = 0$, $MC_{sr}^{\ 1}$ when $\sigma > 0$, $MC_{lr}^{\ 0}$ and $MC_{sr}^{\ 1}$ their long-run equivalents, and $AC_{lr}^{\ 0}$ and $AC_{lr}^{\ 1}$ the corresponding long-run average costs. p^* is the long-run price level. Thus, the removal of exchange rate volatility could have either a profit enhancing or eroding effect for firms[12].

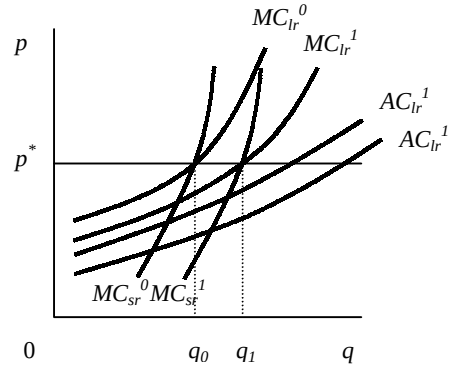


Figure 8. Expected output and costs for stochastic solution with C''' > 0

Empirical estimation of the effects of a removal of exchange rate volatility has proceeded by studying the risk premia attached to securities. *Ceteris paribus*, this should lead to the elimination, or at least a significant reduction, of interest rate differentials between EMU countries. Welfare gains due to the elimination of such residual interest rates might be as small as 0.05% of EC GDP (Price Waterhouse 1988) to as much as 5-10% in the long-run due to multiplier effects (Baldwin 1991).

Elimination of transactions costs

[11] The solution procedure is quite involved and the trick is the application of Ito's lemma to the differentiated fundamental equation of optimality. The steps are secondary to the discussion here and the interested reader is referred back to Pindyck's (1982) original paper.

[12] Intuitively, this is easy to justify. Changes in the exchange rate not only represent a risk, but also a profit opportunity. With variability of the exchange rate, the firm has the option to export in order to exploit the favourable exchange rate (through demand conditions).

The most commonly quoted[13] gain from using a common currency involves the elimination of transactions costs. Two aspects will be considered: the static gain from the elimination of costs due to currency exchange, and the dynamic gain accruing to investment on growth.

The possibly significant economic effects that hark from seemingly small transactions costs can best be understood by the literature on 'menu costs' (Akerlof and Yellen 1985). For an economy with firms under imperfect competition, the profit function for firm i is

$$\pi_i = \pi(P_i; P, W, Y) \tag{43}$$

where P_i; P, W, Y are the prices charged by firm i, the general price level, wages and aggregate demand, respectively. Firm i will optimise such that $\partial\pi_i/\partial P_i = 0$. For a change in aggregate demand we have, via application of the Envelope Theorem,

$$\partial\pi_i/\partial Y = \partial\pi_i/\partial Y + \partial\pi_i/\partial P_i \cdot \partial P_i/\partial Y = \partial\pi_i/\partial Y \tag{44}$$

Thus the effect of a change in aggregate demand on profits will be approximately equal whether or not a firm chooses to change its price – they are of second order. Extending this case where there are different countries in a region, each with different aggregate demands, price rigidity might result due to small transactions costs, which in turn induce large macroeconomic effects. An extension of this strand of literature explores the reduced transactions costs that are involved when the single currency introduced is a major world currency. This approach, adopted by Deveruex, Engel & Tille (1999), finds that there are major welfare gains to be made due to the introduction of the euro.

Estimates of transactions costs for the EMU countries place the figure at between 0.25% (Emerson *et al* 1992) to 1% (Cukierman 1990; Dumke *et al* 1997) of Community GDP. This figure, although small, implies that the deadweight loss of transactions costs might very well have significant macroeconomic effects, if one subscribes to the New-Keynesian world view. In addition, there might be indirect benefits such as increased transparency of prices, which effectively reduces transaction costs between EMU nations (Thygesen 1993; De Grauwe 1997). The elimination of transactions costs together with exchange rate volatility is thus expected to spur foreign direct investment.

The dynamic effect of the elimination of transactions costs can be understood in the context of the basic Solow (1956) growth model. Consider a constant returns production function where per capita output y_t is determined by per capita capital stock k_t, and influenced by exogenous productivity growth A_t

$$y_t = A_t f(k/A) \qquad , \qquad f' > 0, f'' < 0 \tag{45}$$

With accumulation of capital K_t given by

[13] Indeed, the story of a tourist who went on a tour of all 15 European Union member countries, exchanging all his cash each time, and lost more than half his money without having even bought anything, has almost attained folklore status.

$$\Delta K_t = \tau Y_t - \delta K_t \qquad (46)$$

where τ and δ are the fraction of output Y_t due to taxation and the depreciation rate, respectively, it is straightforward to derive the long-run steady state output per capita

$$\begin{aligned} \log y_t &= \log f(k/A)^* + \log A_0 + \varepsilon \cdot t \\ &= g[(\delta + \nu + \varepsilon)^{-1}\tau] + \log A_0 + \varepsilon \cdot t \qquad , \qquad g' > 0 \end{aligned} \qquad (47)$$

where ν and ε are the population and productivity growth rates, respectively. As can be clearly seen from equation (54), economic growth is possible only if there is technological growth, i.e. $\varepsilon > 0$. The savings in transactions costs is broadly equivalent to an increase in overall productivity; indeed, the output increase could very well exceed the productivity increase due to the presence of a multiplier effect (Baldwin 1989).

This is summarised in Figure 9. A reduction in transactions costs (an increase in productivity) shifts the production function from $A_tF(k)$ to $A_{t+1}F(k)$, with capital stock increasing from k_t to k_{t+1}. Output increases more than proportionately from y_t to y_{t+1}. In addition, reductions in the interest rate from r_t (as discussed above) lead to a change in the slope of r_t' to r_{t+1}.

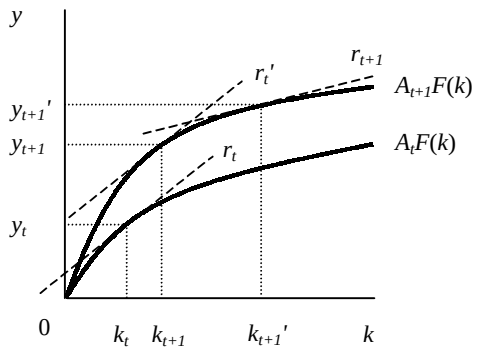


Figure 9. Dynamic effects of monetary integration on economic growth

As dynamic gains involve forecasting, quantitative evidence tends to be conjectural at best. Indeed, the inability to subject dynamic gains to rigorous econometric testing *ex ante* is a major limitation in the analysis. Estimates by Emerson *et al* (1992) and Taylor (1995) place the figure at about 5%.

International trade theory and the new economic geography

International trade theory and economic geography can be used to provide two pillars for a framework whereby monetary integration may be analysed. A full integration would imply that impediments to trade would disappear, and that the location of industries in space would be the only response available to economic agents. Thus these two complementary disciplines attempt to model formally the influence of monetary union due to changes in transportation and transaction costs, relative production costs and advantages accruing to agglomeration.

Studies on the effects of exchange rate uncertainty on trade yield mixed results[14], although there is a bias towards a belief that the effects are small (Hooper & Kohlhagen 1978; Kenen & Rodrick 1986). However, in a recent paper, Rose (1999) finds robust results that suggest that the effect of a common currency might indeed be large[15]. In particular, he applies a gravity approach to panel data for almost 34,000 observations and estimates

$$\ln(X_{ijt}) = \beta_0 + \beta_1 \ln(Y_i Y_j)_t + \beta_2 \ln(Y_i Y_j / Pop_i Pop_j) + \beta_3 \ln D_{ij} + \beta_4 Cont_{ij} + \beta_5 Lang_{ij} + \beta_6 FTA_{ijt} + \beta_7 ComNat_{ij} + \beta_8 ComCol_{ij} + \beta_9 Colony_{ij} + \gamma CU_{ijt} + \delta V(e_{ij})_t + \varepsilon_{ijt}$$

where *i* and *j* subscripts denote countries and *t* time. The dependent variable is the value of bilateral trade and the regressors are, in the order above, a constant term, real GDP, population, distance, and dummies for a common border, common language, existence of a trade agreement, common mother nation, existence of colonial history by the same coloniser and colonies of each other. The final two terms are the volatility of the nominal exchange rate and a well-behaved error term.

The main findings are that there is a strong negative effect of exchange rate volatility on trade, a large positive effect of a common currency on trade and that this effect is much larger than the hypothetical effect of reducing exchange rate volatility to zero.

The area of economic geography as applied to economic integration remains a largely unexplored and exciting field. The seminal works in this area are Krugman and Venables (1990) and Krugman (1991), who provide a rigorous theoretical framework for the study of economic integration on the location of industries. Empirical work remains sparse; however, Nijkamp & Wang (1999) perform a neural network analysis of industrial spatial shifts that tests whether monetary integration leads to industrial concentration and hence unequal benefits for participating countries. They find that due to the endogenous nature of the single currency, participating countries will tend to become more heterogeneous, instead of homogenous, and that EMU will result in doubtful effects on the EU as a whole. However, as Krugman (1991) himself pointed out, one should be wary of such results, which often tend to be highly sensitive to small changes in the key parameters of the economy.

Financial market integration

A short note is in order concerning the issue of financial market integration. The introduction of a single common currency brings to completion the process of financial market integration first begun with the implementation of a common market (Servais 1995). This is believed to yield increased benefits due to the complete removal of controls over foreign direct investment, improve economies of scale due to increased market size and increase the efficiency of financing due to the increased number of financial instruments available (Robson 1998).

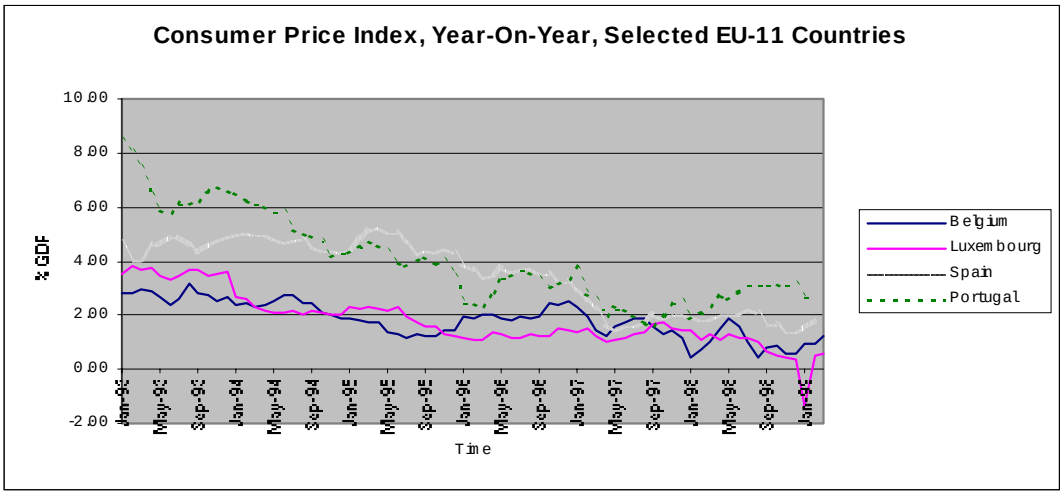
[14] See International Monetary Fund (1984) for a survey.

[15] The closest precedents are Helliwell (1996) and McCallum (1995), although these studies focus exclusively on US-Canadian trade and do not specifically address the effect of a monetary union on trade.

Studies aiming to quantify the impact of EMU on foreign direct investment estimate that gains will be significant, and even larger than the stimulus in trade (Molle & Morsink 1990). There have also been studies on the impact of the euro on fixed income (Nielsen 1999), equity (Biais 1999; Hardouvelis, Priestley & Malliaropulos 1999) and derivatives markets (Steinherr 1999), usually yielding results that indicate an improvement in financial market efficiency, at least in the medium term. However, skeptics believe that the deepening of financial markets has little to do with the euro, attributing it instead to other factors (Feldstein 2000).

III. Empirical Analysis

This section aims to concretise theory with fact by providing a basic empirical appraisal of the EMU. It draws from data for the period January 1990 to December 1999, using both monthly and quarterly data, for the 11 member countries of the EMU that have adopted the euro as of 1st January 1999 (EU-11)[16] as well as the larger European Union of 15 countries (EU-15)[17]. The primary aim is to use short-term main macroeconomic indicators as assessment devices for whether the gains (or losses) to EMU are realised.



Source: OECD Main Economic Indicators

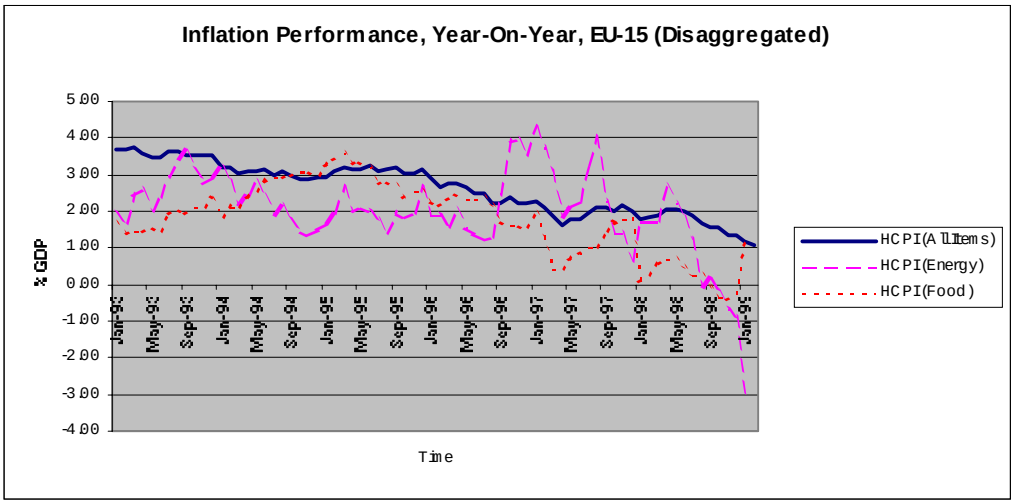
Figure 10. Inflation convergence

Prices

[16] Namely, Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain.

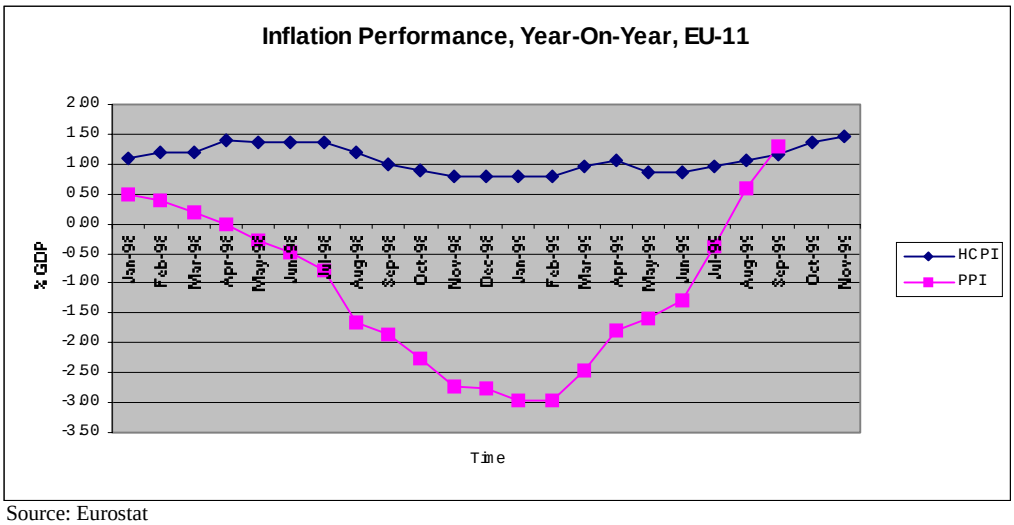
[17] The EU-11 plus Denmark, Greece, Norway, Sweden and the UK.

Two main issues will be examined here: the ability of inflation-prone countries to 'borrow' credibility from a low-inflation country such as Germany; and the success (or failure) of the ECB to maintain price stability. Figure 10 shows that inflation did indeed converge prior to monetary union, notably for high-inflation countries such as Portugal and Spain, supporting the thesis that credibility can be imported by participating in a monetary union and free-riding off the reputation of a hard-nosed central bank such as the Bundesbank.



Source: OECD Main Economic Indicators

Figure 11. Inflation performance, EU-15

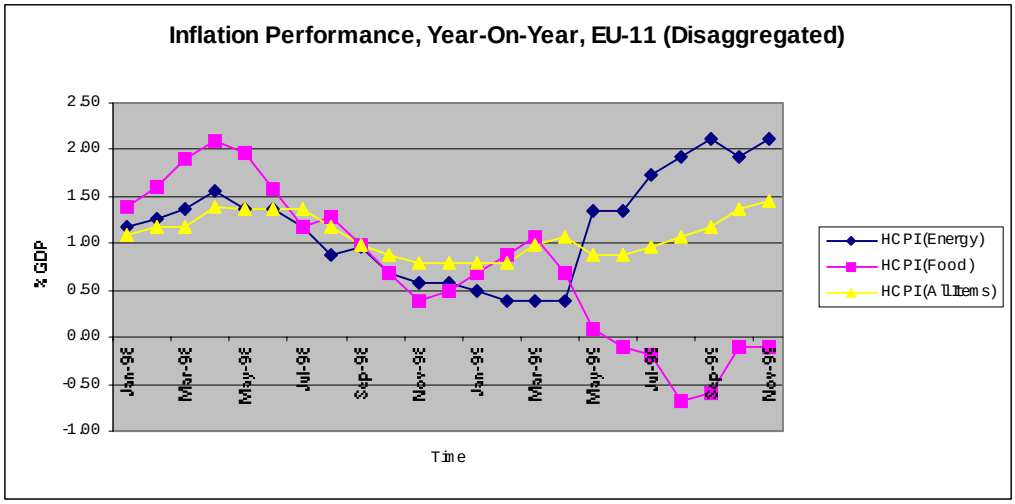


Source: Eurostat

Figure 12. Inflation performance, EU-11

Price stability is an essential issue that is widely debated; the main point of contention being whether the ECB should target a price or money target (Gerlach & Svensson 1999). The inflation picture for the larger EU-15 (Figure 11) appears to be positive, with the Harmonised Consumer Price Index (HCPI) trending downwards since the ERM crisis in 1993. Surprisingly, this has resisted upward pressure from energy price rises but its steep decline in recent history might be cause for a continued downward trend.

To see how well the EMU has performed relatively, however, it is necessary to examine data for the EU-11 countries. Figures 12 and 13 show inflation in the euro-zone for the period just prior to EMU till the end of its first year.



Source: Eurostat

Figure 13. Inflation performance, disaggregated, EU-11

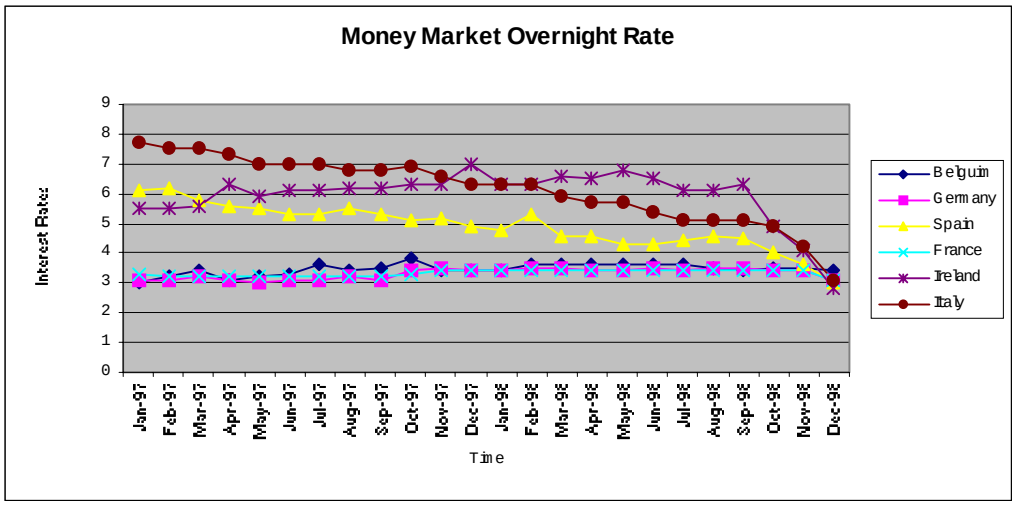
An interesting observation emerges: whilst HCPI has kept within a relatively narrow band, the Producer Price Index (PPI) has experienced large year-on-year changes. Likewise, the disaggregated food and energy prices show a divergence after January 1999[18]. However, prices have remained stable and the gain of stable prices from monetary union seems to have been borne out.

Two points are in order. First, the mere coincidence of convergence may be due to other factors other than monetary integration – a close parallel may be found between the implementation experiences of the EMU and EMS; in the latter case, Collins (1988) argues persuasively that other factors were instrumental in leading to the observed inflation convergence. Second, regional divergences in inflation may occur over the medium- and long-term (Krugman 1993); a longer time period and more cross-sectional data is required to explore this possibility.

Interest rates

In the absence of exchange rate variability, interest rates differentials are expected to disappear. This will be studied via interest rate convergence and differentials.

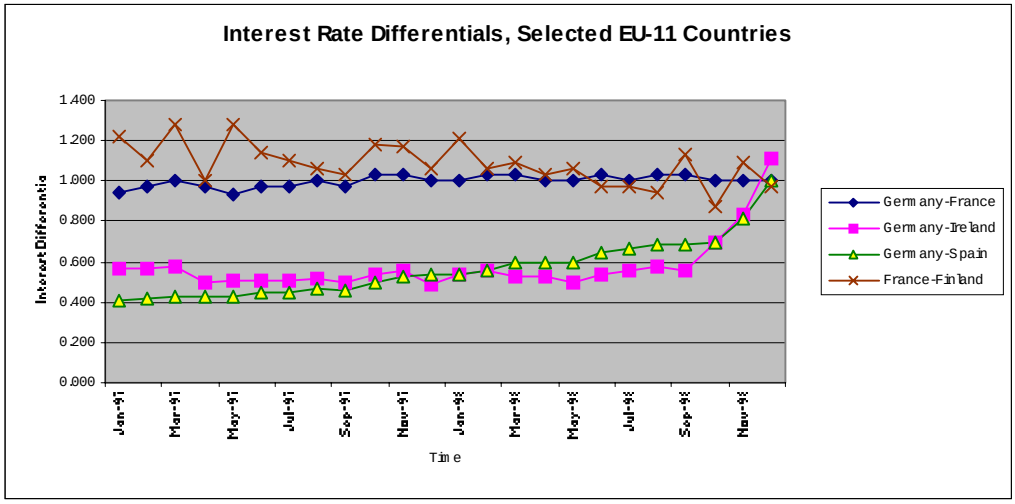
[18] The first observation might be the result of the ECB implicitly targeting the CPI instead of the PPI, hence the relative stability of the HCPI. The ECB's primary target is the money supply. The second observation is probably coincidental, as oil prices have been increasing steadily over the period due to OPEC production quotas while world food prices have been falling. Both are external and are secondary to the current study. For a commentary on EMU inflation in the euro's first year, see Hayo, Neumann & von Hagen (2000).



Source: Eurostat

Figure 14. Interest Rate Convergence

Figure 14 illustrates the official money market overnight rates for selected EU-11 countries. Whilst convergence will eventually attained in the three months just prior to EMU, it should be noted that there were significant differentials between 'core' countries such as Germany and Belgium and 'peripheral' ones such as Italy and Ireland. This is summarised in Figure 15, which shows interest rate differentials between selected pairs of countries.



Source: Eurostat

Figure 15. Interest rate differentials

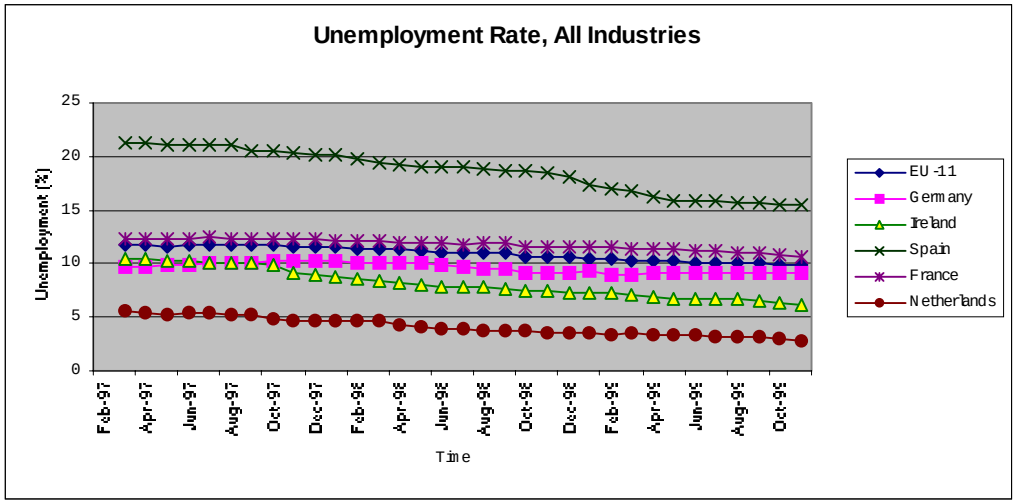
The relatively large interest rate differential does eventually settle at one, suggesting that the predicted elimination of differentials does take place. There are two caveats to this, however: first, the data is based on *official* rates; it will be interesting to see how private agents react to the removal of exchange rate risk. One would expect a significant reduction, but a complete disappearance of interest differentials would be surprising, given the different economic structures of each country (and correspondingly different risk levels). Second, a comparison of short and long rates before and after

EMU might yield yet more insights. OECD (1999) estimates that long and short nominal rates were in fact converging in 1998.

Unemployment

Unemployment has always been a chronic problem for the euro-zone (Layard, Nickell & Jackman 1991). The loss of exchange rate policy as an instrument for macroeconomic stabilisation could theoretically lead to an increase in unemployment due to the increased severity of asymmetric shocks.

Figure 16 examines the unemployment rate for all industries. With the exception of Spain, and to a lesser extent, the Netherlands, unemployment has remained fairly constant post-EMU. Although the EMU has not experienced any major shock since its advent, it has weathered both the Asian Financial Crisis as well as the Latin American Debt Crisis admirably well.



Source: Eurostat

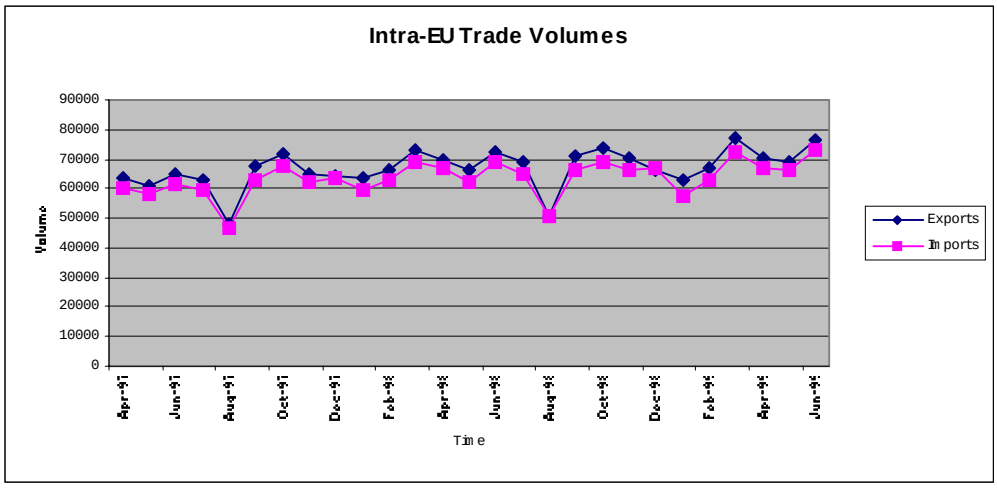
Figure 16. Unemployment rate

It should be noted that these do not really constitute a large shock for the euro-zone due to their limited impact on Europe[19], and it remains to be seen whether the loss of exchange rate policy in cushioning asymmetric shocks does have a significant effect.

Trade

The effect of a common currency on trade in the EU-11 nations is illustrated by intra-EU trade data. Figure 17 shows a slight upward trend in intra-EU trade volumes; this, of course, could be the result of a host of other factors, such as increased market integration due to economic integration in the EU in general, not necessarily due to a common currency. Nonetheless, based on this preliminary evidence it is possible that EMU has indeed spurred a growth in trade.

[19] One could of course argue that European banks did indeed have a significant amount of exposure to Asian emerging markets, and the potential for a large shock to the euro-zone most definitely existed.

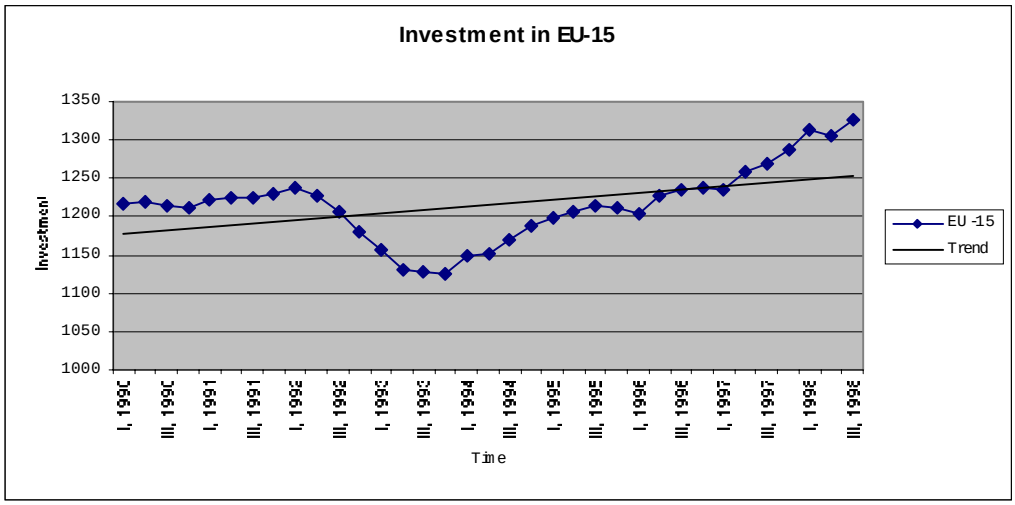


Source: Eurostat

Figure 17. Intra-EU Trade Volumes

Investment

Investment statistics[20] shed light on the static gains due to the removal of transactions cost and exchange rate uncertainty; *ceteris paribus*, investment should increase due to EMU. Dynamic growth effects should be examined in tandem with productivity; these should show up in both investment and productivity improvements. Finally, foreign direct investment[21] should also increase under EMU due to the reasons already mentioned.

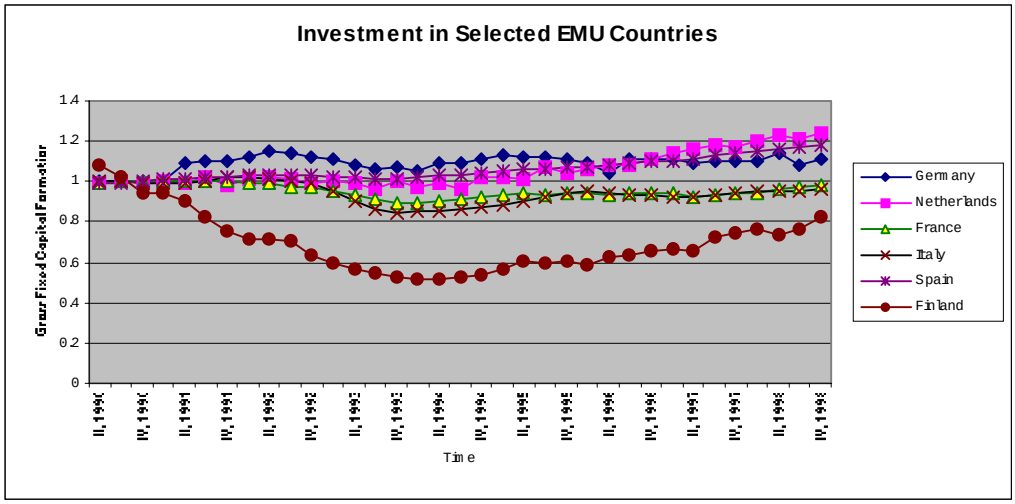


Source: OECD Government Statistics

Figure 18. Investment

[20] Gross fixed capital formation is used as a proxy for investment.

[21] Unfortunately, due to the limited data available on FDI, an extremely small sample is utilised.

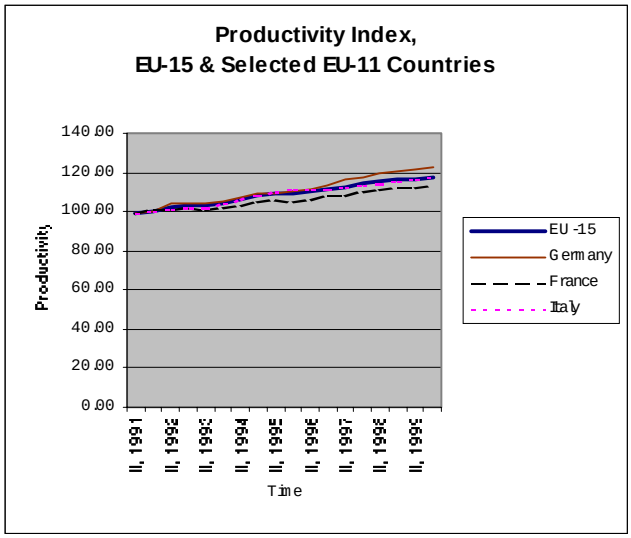


Source: OECD Government Statistics

Figure 19. Investment in Selected EU-11

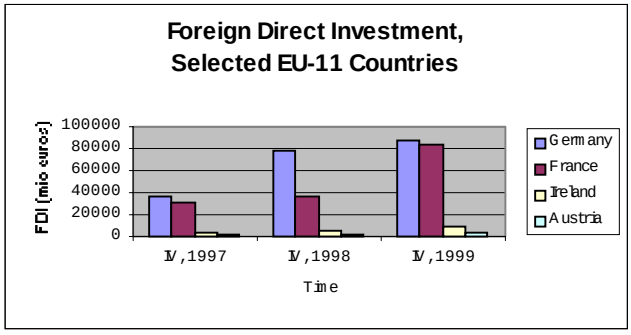
Figure 18 clearly shows an upward trend in EU-15 investment; however, upon disaggregation into individual countries (Figure 19), the trend is not as pronounced. A general upward trend arises after 1994, when Stage II went into operation, and this could be due to an improvement in expectations of a monetary union eventually occurring.

In order to make more informed judgements, it becomes necessary to look at both productivity and foreign direct investment indicators, both of which are expected to rise due to the removal of transactions costs. These are shown in Figures 20 and 21, respectively.



Source: OECD Business Indicators

Figure 20. Productivity index



Source: Deutsche Bundesbank, Banque de France, Central Statistics Office Ireland, Austrian National Bank

Figure 21. Foreign Direct Investment

Productivity indices show a slow improvement up till 1994, when they begin to improve markedly. This further strengthens the hypothesis that there has been a spur on economic growth due to improved expectations. However, productivity growth might also be attributed to other technological improvements as well, such as the proliferation of the Internet. Perhaps of concern is the fact that German productivity remains above the EU-15 average. In a monetary union, it would become necessary that German productivity growth slow in order to allow real exchange rate convergence[22], so as to prevent unsustainable asymmetries in real exchange rates across different regions of the EMU.

Foreign direct investment in all countries has improved since the implementation of EMU; however, these gains are modest and the true gains from improvements in dynamic efficiency might only be realised over a longer period of time. In the light of these data the conclusion would be that there have been some gains that has accrued to EMU, although structural changes might be necessary in some economies for these gains to be sustained.

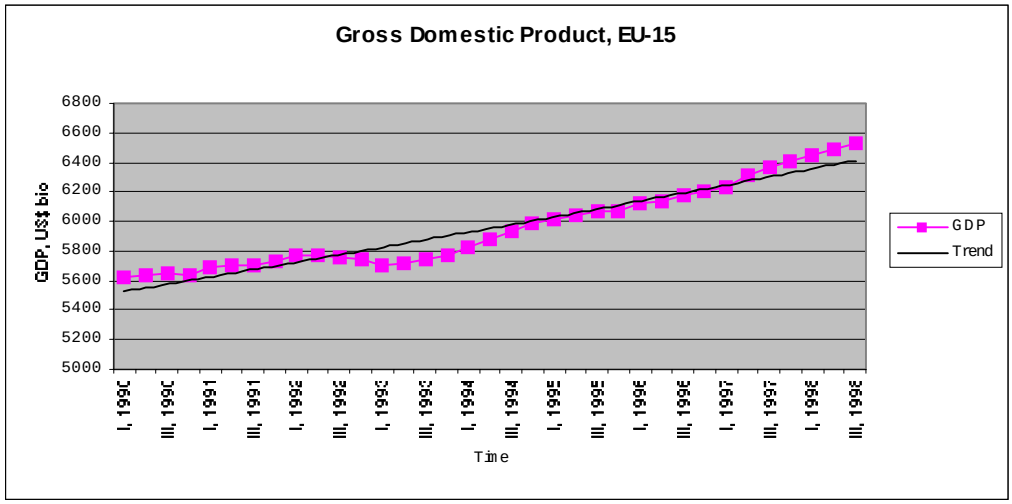
Gross Domestic Product

GDP growth has had a pronounced upward trend for the wider EU-15 (Figure 22). Likewise, data from selected EU-11 countries (Figure 23) indicates healthy upward trends in growth for most countries.

There has also been a convergence of GDP growth[23]. This bodes well for the euro area, since convergence would indicate that there is greater synchronisation of the member countries' business cycles, an important consideration when shocks are encountered. As per investment, the true dynamic gains from monetary union will only be realised over a longer time period.

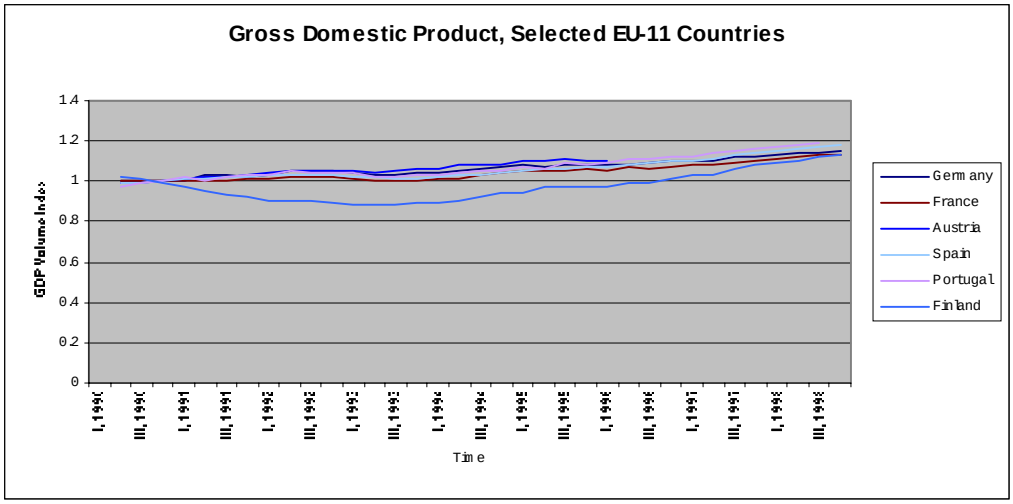
[22] This is because of the Harrod-Balassa-Samuelson effect, which predicts that a nation will experience a real exchange rate appreciation if its productivity-growth advantage in tradeables exceeds its productivity-growth advantage in non-tradeables.

[23] Note that Figure 23 shows GDP in terms of a volume index and hence the data are comparable.



Source: OECD Main Economic Indicators

Figure 22. Gross domestic product, EU-15



Source: OECD Main Economic Indicators

Figure 23. Gross domestic product, selected EU-11

Financial market indicators

Already, there is some anecdotal evidence that the introduction of the Euro has had an effect on financial market integration[24].

Further examination would involve looking at financial data such as bond yield spreads and stock market indices. As the focus of this paper is not on the financial market aspects of EMU, this exercise is best left for further research.

[24] Witness the recent high-profile merger of Vodafone AirTouch and Mannesmann, a cross-border deal that would have been unimaginable even a few years ago. The merger has also sparked off speculation of more deals among European telecommunications firms (The Wall Street Journal Europe, February 4-5, 2000). Also, the merger of the Paris, Brussels and Amsterdam stock exchanges has recently formed the euro-zone's largest exchange (Reuters, March 21, 2000).

V. Conclusion

It would seem that the EMU has indeed yielded many of its purported gains, with minimal cost, based on the study here. This is based on short-term analysis of preliminary data for the euro-zone economies.

Because this essay has endeavoured to be relatively concise, several limitations naturally arise. These include: first, the inability to cover all aspects concerning monetary integration in detail; second, a concentration on empirical work performed in the context of the EMU only; third, a fairly limited economic analysis. Specifically, the paper favoured a short-run approach; a fuller examination of the issues raised would naturally predicate a larger data set and more formal techniques.

The avenues for future research that naturally present themselves stem from the limitations already discussed; in particular, one can imagine research proceeding alone the same vein when more time has elapsed, yielding a larger data set and thus lending itself to more formal econometric tools.

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Data Sources

Most economic time series data was obtained either from Eurostat Eurostatistics (Commission of the European Communities, Brussels), various years or from the OECD Statistical Compendium (OECD, Paris). Where necessary, statistically comparable data were obtained, i.e. the HCPI was used to study inflation, and constant prices, constant PPP Gross Fixed Capital Formation for investment. Data for FDI was obtained from Deutsche Bundesbank Monthly Report, Feb 2000; Banque de France Bulletin Digest No. 75, Mar 2000; Central Statistics Office Statistics, Ireland, 11/1/2000 and the Austrian National Bank website. Where necessary, values given in national currencies were converted into either US dollars or the official fixing rates of national currencies to the euro. Trendlines for data were fitted with a linear trend for investment and an exponential trend for GDP. The full data set is available upon request.