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Price Impacts of Non-Adoption of the Euro for Small European Countries

E. Sibel Yelten and Harald Anderson

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Price Impacts of Non-Adoption of the Euro for Small European Countries

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Abstract

Debates surrounding the adoption of a common currency have focused on its benefits weighed against the long-term costs of losing monetary independence. These debates have assumed that the penalty for not adopting a common currency is the maintenance of the status quo. This paper uses the Sjaastad model to analyze the price-making power of major currencies with regard to the prices of traded goods in small countries that have not adopted the euro and uses the Bayoumi-Eichengreen OCA index methodology to shed further light on changes in Europe. The empirical evidence suggests that small countries that have not adopted the euro have increasingly seen a change in the determinants of their traded goods prices. This seems to contrast with the experience of small countries that adopted the euro. The results need to be interpreted carefully, given the short time series.

JEL Classification Numbers: E32, F31

Keywords: Optimal Currency Area, Exchange Rate Policy, Major World Currency, Currency Peg, Self-Enforcing Currency Area

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I. INTRODUCTION

One of the foundations of the theory of optimal currency areas (OCAs) is that countries that enter into a monetary union without satisfying the appropriate preconditions would experience large asymmetric external shocks to which they would not be able to respond after losing their monetary independence. All of these studies imply that the choice for countries was to enter into the benefits (or problems) of an OCA versus remaining at the status quo. Hence, it is assumed that the effects of adopting a common currency are intrinsic to the currency area only. More recent studies suggest that, under certain conditions, an area can be a self-validating or self-enforcing optimal currency area[2]—that is, a monetary union may become optimal ex post, even though the individual countries that join it do not meet the optimality criteria ex ante. This paper focuses on a related subject: what happens in countries that do not adopt a currency union? There have been no empirical studies that investigate this question.

The euro area provides a unique opportunity to examine this issue. The introduction of the euro was a unique phenomenon and in many ways functions as an experiment in exchange rate policy. In January 1999, 11 European countries at different stages of economic development—and that most of the literature concluded did not constitute an OCA—simultaneously changed their exchange rate policies and adopted a single currency, the euro. The situation is unique in that a large number of countries are involved, new data are emerging from before and after the change, and several similar and comparable countries in the region did not adopt the currency and their data can be used to enable analysts to reflect on differences.

The most effective way of measuring the cost of adoption versus nonadoption would be to use the OCA measurements before and after 1999 and to note evidence of divergence among the nonmembers. Unfortunately, much of the data used in these analyses, such as the time series on GDP, are not long enough to indicate whether any changes are significant. Sufficient data on a limited number of variables, such as prices, are available, however, to permit us to examine the question of whether the introduction of the euro has led to any changes.

This paper cannot assess whether non-adoption of the euro is good or bad for a country. However, using the Sjaastad model, it analyzes whether the adoption or non-adoption of the euro has led to any changes in the price-making power of major currencies with regard to the prices of internationally traded goods for small countries in Europe. The results given in this paper are tentative and limited by the short time series; however, they are interesting and warrant further research in the area. The intention of the authors is therefore to encourage future

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[2] On a theoretical basis, Corsetti and Pesenti (2002) show that monetary unification can lead to a self-validating optimal policy regime even when the unification does not foster real economic integration. Allington, Kattuman, and Waldmann (2005) argue, on the basis of price dispersion between countries in the euro zone compared with a control group of European Union (EU) countries outside the euro zone, that the euro has had a significant integrating effect on the countries that have adopted it.

work that would focus not only on whether the euro area has become a better currency area but also on its possible effects on countries that have chosen not to adopt.

The estimations assume that countries are price takers in world markets and therefore only small countries are included in the estimations. In addition, there were data limitations that led to the exclusion of several countries.[3] The Sjaastad model is estimated for Belgium, Finland, the Netherlands, Sweden, and Switzerland. According to the regression results, the price-making power of the major European currencies on the prices of traded goods was approximately 80 percent prior to 1999 and approximately 20 percent for that of the U.S. dollar. Since 2000, for Sweden and Switzerland, the price-making power of the U.S. dollar has increased, while that of the euro has decreased. In contrast, the price-making power of the euro has increased for Belgium, Finland, and the Netherlands. These results were unexpected. Given the data limitations and short time series, the authors compared these results against those obtained using the Bayoumi-Eichengreen OCA index, which is also characterized by short time series. This secondary analysis supported the same conclusions.

The remainder of this paper is structured as follows. Since the studies that have come closest to this topic have focused on OCAs, Section II reviews OCA literature before 1999. Section III summarizes the Sjaastad (1998 and 2000) models. Section IV describes the data. Section V presents the estimation results using the Sjaastad model. This is followed by some key statistics of European countries before and after the introduction of the euro and the results from the Bayoumi-Eichengreen model (Section VI). The conclusions follow in Section VII.

II. Optimal Currency Area Literature Before 1999

In early studies of Europe as an OCA, following the idea in Mundell's original work,[4] researchers focused on labor mobility. Since labor mobility was higher within the United States than among European countries, their investigations came to the conclusion that Europe was not an optimal currency area. Other researchers criticized this methodology, arguing that the United States was not a good benchmark. Switzerland, it was argued, was a better benchmark, both because it was considered an optimal currency area and because the unemployment differentials between the German and French parts were 3 to 4 percentage points. When Switzerland was used as a benchmark, the unemployment differentials in Europe were not necessarily as high.

Another avenue of research was to use optimization functions to address optimal taxation decisions. Dornbusch (1988), among others, argued that countries that need higher inflation rates to finance a budget deficit should not enter into a currency union with countries that do not

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[3] Import and export price data were not available for all countries. Also, owing to the shortness of the time series after 1999, it was possible to include only countries that collect those data on a monthly basis. Estimations with quarterly series did not have sufficient degrees of freedom.

[4] Mundell (1961).

rely on seigniorage for that purpose. That is, a country whose efficient tax structure implies the use of an inflation tax should not merge with others for which zero inflation is the policy objective. Dornbucsh's comments inspired further work in this direction, developing models for OCAs based on optimal taxation decisions. Canzoneri and Rogers (1990), for example, calibrated a model using strong assumptions regarding the social welfare function and the cost function. The main critique of this approach was that the analyses were heavily dependent on assumptions regarding the form of those functions and thus varied strongly when the underlying assumptions were modified. In addition, those models implicitly assumed no external shocks to an economy.

Eichengreen (1990), also concentrating on the cost side, compared changes in real exchange rates between regions of the United States and between individual European countries. He concluded that since changes in real exchange rates within the European countries were more variable, the European countries did not constitute an OCA. However, Bayoumi and Eichengreen (1997) later noted a strong correlation between economic and monetary integration. They argued that the stable exchange rates brought on by the exchange rate mechanism (ERM) of the European Monetary System led to an increase in bilateral trade among European countries, and that this increased economic interdependency would create a self-reinforcing mechanism.

More recent literature has concentrated on the effects of differences in shocks to individual European countries, based on the assumption that the cost of a single currency is higher if a region experiences larger asymmetric shocks and cannot accommodate those shocks due to the loss of monetary independence. Jansson (1997), for example, estimated the percentage of annual fluctuations in the GDP that could be attributed to common (symmetric) shocks and to country-specific (asymmetric) shocks, respectively, for 11 European Union countries. Jansson's results suggested, on the other hand, that Austria, Belgium, France, Germany, and the Netherlands faced similar shocks and that they would therefore have fewer problems introducing the single currency.[5] Denmark, Finland, Sweden, and the United Kingdom, on the other hand, would most likely suffer from asymmetric shocks, which would make their economies more sensitive to the loss of monetary independence. It was hence argued that these countries should not adopt the euro.

Although most of the measurements above suffer from a lack of available data, enough data are currently available to satisfy the requirements for one model that can be used to measure the cost of non-adoption of the euro: the Sjaastad model of price-making power. This model can be used to determine the source of price shocks on the countries in question and, hence, will indicate whether their susceptibility to different price shocks has changed, thus showing whether the adoption of the euro has had any effect on the prices of the non-adoption countries.

[5] Many studies used different methods for measuring and comparing shocks. See, for example, Uri (1996), Hassler (1997), Melitz (1997), and Jansson (1997).

III. Estimation Method for Sjaastad Model

The Sjaastad model can only be estimated for small countries since it is necessary to assume that countries are price takers. Therefore, the analysis includes the following European countries that adopted the euro as their legal tender: Belgium, Finland, and the Netherlands. The empirical methodology that follows uses the same as Sjaastad (1998b and 2000) to estimate the price-making power.

To estimate Sjaastad's model, the price-making power Θ is estimated for the five countries (for the derivation, refer to Sjaastad (2000) or (1998b) or see Appendix I for a summary)

$$PT_x = \sum_j \Theta_x^j \cdot (P_j + E_{x,j}) \text{, where } \sum_j \Theta_x^j = 1 \qquad (1)$$

In this text, capital letters indicate natural logarithms. PT_x, P_j, $E_{x,j}$, represent the price index for traded goods in country *x*, an index of the price level of country *j*, and country *j*'s currency in terms of country *x*'s currency, respectively.

As indicated in equation (1) the sum of Θ_x^j over *j* is equal to one. An intuitive explanation for this is the following hypothetical experiment. Keeping all exchange rates constant, if the price levels of the countries of the world were to double, then the prices of country *x*'s traded goods would also have to double.

Using the identities $E_{x,j} = E_{x,i} + E_{i,j}$, $E_{x,i} = -E_{i,x}$, $\sum \Theta_x^j = 1$ and adding $E_{i,x}$ on both sides of the equation (1), we can rewrite the equation as

$$PT_x + E_{i,x} = \sum_j \Theta_x^j \cdot (P_j + E_{i,j}) \qquad (2)$$

The term $PT_x + E_{i,x}$ in equation (2) is the price of traded goods of country *x* converted to the currency of country *i*. For notational simplicity we define $PTF_x \equiv PT_x + E_{i,x}$, where the capital F after the variable indicates that the variable is expressed in the currency of country *i*. Similarly, the term $P_j + E_{i,j}$ is the price level of country *j* expressed in currency *i*. Again, to simplify the notation, we define $PF_j \equiv P_j + E_{i,j}$. Using these definitions equation (2) becomes

$$PTF_x = \sum_{j=1}^{M} \Theta_x^j \cdot PF_j \text{,} \quad \text{where } \sum_j \Theta_x^j = 1 \qquad (3)$$

In the following estimations the U.S. dollar is used as currency *i*, and all variables are transformed to U.S. dollar terms using equation (2). Since price data are available as a monthly variable, monthly exchange rate averages are used for the conversion of the prices. Note that the derivation does not depend on what currency is chosen as currency *i*. As long as the left-hand-side and the right-hand-side variables in equation (3) are expressed in a common currency, the choice of currency *i* does not affect the estimation of the Θ_x^j's.

The Θ_x^j's can be estimated using equation (3).

Equation (3) is parameterized using an autoregressive distributed lag (ARDL) model, which permits taking into account that price changes do not affect the economy instantaneously. Equation (3) is rewritten as

$$A_x(L) \cdot PTF_{x,t} = \sum_j [B_x^j(L) \cdot PF_{j,t}]$$
$$where \quad A_x(L) = \sum_{i=0}^{N} a_{x,i} \cdot L^i \; and \; B_x^j(L) = \sum_{i=0}^{M} b_{x,i}^j L^i \tag{4}$$

Writing out the details of equation (4) we get

$$PTF_{x,t} = \tilde{a}_{x,1} \cdot PTF_{x,t-1} \ldots + \tilde{a}_{x,n} \cdot PTF_{x,t-N} + \sum_j [\tilde{B}_x^j(L) \cdot PF_{j,t}] \tag{5}$$

where we define: $-a_{x,i} / a_{x,0} \equiv \tilde{a}_{x,i}$, $-A_x(L)/a_{x,0} \equiv \tilde{A}_x(L), and \; B_x^j(L)/a_{x,0} \equiv \tilde{B}_x^j(L)$. Using the estimation coefficients, we can calculate the Θ_x^j's as

$$\Theta_x^j = \frac{B_x^j(1)}{A_x(1)} = \frac{\tilde{B}_x^j(1)}{1 - \sum_{i=1}^{N} \tilde{a}_{x,i}},$$
$$where \; \tilde{B}_x^j(1) = \sum_{i=0}^{M} \tilde{b}_{x,i}^j, A_x(1) = \sum_{i=0}^{N} a_{x,i}, B_x^j(1) = \sum_{i=0}^{M} b_{x,i}^j \tag{6}$$

IV. DATA

As noted above, since the Sjaastad model can be estimated only for small countries, the analysis includes Belgium, Finland, and the Netherlands. For purposes of comparison, the same estimations are also performed for two European countries that did not adopt the euro as their legal tender: Sweden and Switzerland. Most countries changed their legal tender to the euro in 2002; however, their currencies were fixed to the euro at the beginning of 1999. Therefore, the estimations are performed for all countries using the time period 1999–2004 to see whether the price-making power of major currencies over the prices of traded goods of small European countries changed since the beginning of 1999. This time period is compared with the period prior to the introduction of the euro; the coefficients are estimated for the periods 1991–98 and 1999–2004.

Monthly series for the prices of import and export goods, and the exchange rates for Belgium, Finland, the Netherlands, Sweden, and Switzerland are used. Further monthly series for the consumer price index for the euro area countries, Japan, and the United States are used.

V. Estimation Results

In this section, the regression results—the price-making power Θ_x^j—are presented. The Dickey Fuller (DF) test was performed to test for stationarity. The appropriate lag length for the augmented DF test was determined using the Akaike Information Criteria (AIC). According to the DF test all variables in levels are either I(1), therefore to achieve stationarity, the data are first differentiated.

The AIC was used to determine the appropriate lag length for the regressions in equation (7). For this estimation, various countries are used as the right-hand-side variables, including Japan, the euro area, the United Kingdom, the United States, and various other countries. In addition, the oil prices were added as a right-hand-side variable, since oil prices have fluctuated dramatically over this period. None of these countries—with the exception of the United States, the euro area, and, in some cases, Japan—had a significant impact and were dropped from the regression.

Table 1 presents the regression results using the United States, the Euro area, and Japan as explanatory variables. According to the model, the price-making power Θ_x^j's for those three countries must add up to one. The hypothesis that the basket weights add up to one could not be rejected for any of the countries. Therefore, it was possible to impose the following unit sum restriction:

$$\Theta_x^{USA} + \Theta_x^{Euro} + \Theta_x^{Japan} = 1 = \frac{\tilde{B}_x^{USA}(1) + \tilde{B}_x^{Euro}(1) + \tilde{B}_x^{Japan}(1)}{1 - \sum_{i+1}^{N} \tilde{a}_{x,i}} \tag{7}$$

Table 1 shows the regression results for the Θs before and after the introduction of the euro. Oil prices were included as a right-hand-side variable since large fluctuations in oil prices in the sample period had also an impact on the import and export prices of countries. The coefficient for Japan was significant for Sweden and Switzerland and could not be dropped for the estimations for the period after the introduction of the euro; however, for all other countries and time periods, it was not significant and was dropped from the estimations.

Table 1. Price-Making Power of Major Currencies on Small European Countries
(Sample: Before 01/1991–12/1998 and after 10/1999–12/2004)

Coefficients	Before	After
Θ United States / Finland	0.13 (0.05)	-
Θ Euro area / Finland	0.86 (0.05)	1.00
Θ Japan / Finland	-	-
Θ United States / Netherlands	0.12 (0.07)	-
Θ Euro area / Netherlands	0.87 (0.08)	1.00
Θ Japan / Netherlands	-	-
Θ United States / Belgium	0.15 (0.08)	-
Θ Euro area / Belgium	0.86 (0.08)	1.00
Θ Japan / Belgium	-	-
Θ United States / Sweden		0.60 (0.09)
Θ Euro area / Sweden	1.00	-
Θ Japan / Sweden	-	0.39 (0.09)
Θ United States / Switzerland	0.25 (0.09)	0.65 (0.08)
Θ Euro area / Switzerland	0.75 (0.09)	-
Θ Japan / Switzerland	-	0.35 (0.07)

Source: Regression results.

Prior to the introduction of the euro, the price-making power of the euro area on the European countries included in this analysis is similar, with values of 0.86 for Belgium, 0.86 for Finland, 0.87 for the Netherlands, 1.00 for Sweden, and 0.75 for Switzerland. These estimates are in line with previous estimates of these coefficients by a number of researchers[6].

According to out estimates, after the introduction of the euro, prices in Belgium, Finland, and the Netherlands were fully determined by the euro,[7] and the test of whether the coefficient for the euro area is 1.00 could not be rejected. The results for Switzerland and Sweden are surprising. After the introduction of the euro, for both countries the price-making power of the U.S. dollar seems to have increased.

VI. European Economies Before and After the Introduction of the Euro, and the Bayoumi-Eichengreen Model

As we noted above, these results are surprising, and warrant additional investigation. Trade data are not yet available in long enough time series and as yet do not seem to provide conclusive evidence for significant changes. However, one assumption in OCA literature has been that, given the deutsche mark's prominent role in the ERM, the ERM area and the euro area are largely comparable and that, in essence, there was little change in 1999 when the euro was adopted. There are some indications, however, that the role of the euro is different from that of the deutsche mark.

While the individual European currencies were never as widely used as the U.S. dollar prior to 1999, the euro has now emerged as a more prevalent international currency than the deutsche mark had been. For example, many central banks now hold a significant portion of their reserves in euros—the first time in recent history that this role has been played by a currency other than the U.S. dollar on such a large scale. In some countries, such as Switzerland (Figure 1), the euro has surpassed the U.S. dollar as a reserve currency.

In addition, the number of private euro-denominated foreign-exchange accounts is reportedly increasing, and has supplanted U.S. dollar-denominated accounts in some countries, particularly the former Soviet Union and other Eastern European countries. Although the evidence for this is more anecdotal at present, data show that although the value of euros in circulation has increased by 44 percent since the introduction of the currency, frequency of the use of euros in foreign exchange transactions has remained steady (Figure 2a) and velocity has decreased (Figure 2b), suggesting that a large number of notes have been taken out of circulation. The use of the euro as a reserve currency or as a store of value impacts the price-making power that the euro exercises compared with the U.S. dollar.

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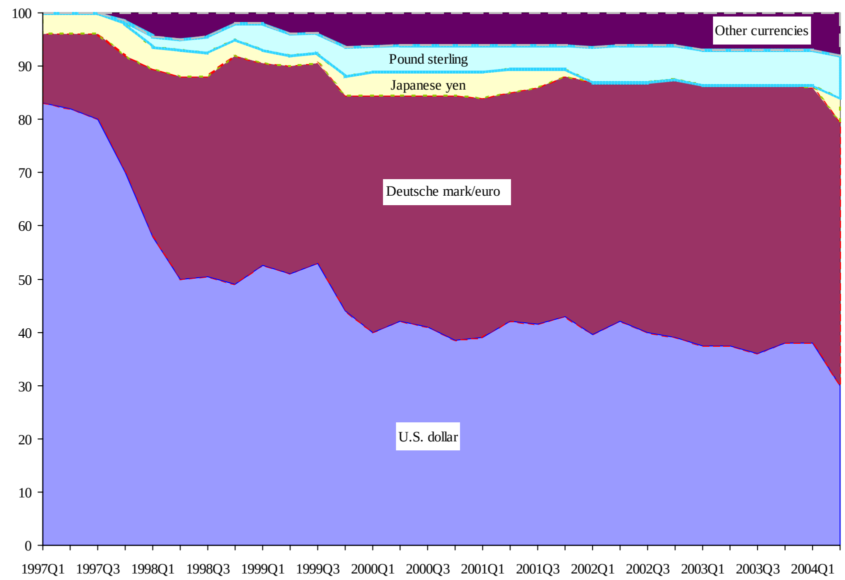
[6] See, for example, Sjaastad (1998a and 1998b).

[7] The coefficients for the yen and the U.S. dollar were not significant for Belgium, Finland, and the Netherlands after 1999 and were dropped from the estimations.

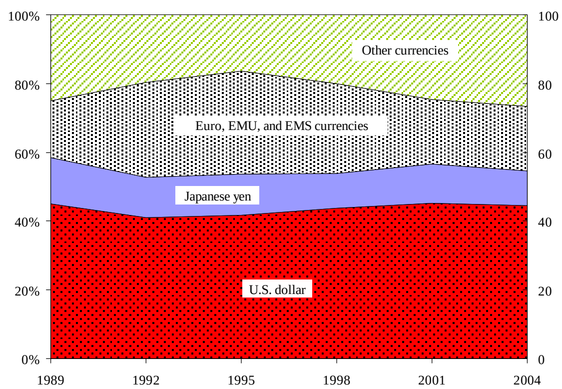
This evidence suggests that the Sjaastad model, which focuses on the price-making power rather than trade, may also reflect the wider use of the euro in global trade.

Figure 1. Switzerland: Composition of Foreign Exchange Reserves, January 1997–June 2004
(Percent share of total; Quarterly data)



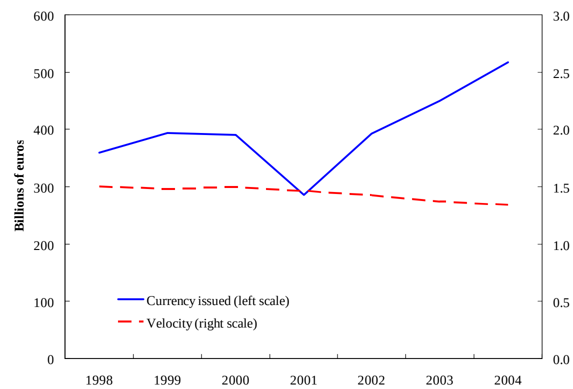
Source: Swiss National Bank.

Figure 2a. Currency Distribution of Reported Foreign Exchange Market Turnover, 1989–2004
(Percent share of average daily turnover, April; Triennial data)



Source: Bank for International Settlements, *Triennial Central Bank Survey* (Basel), various issues.

Figure 2b. Euro: Currency Issued and Velocity, 1998–2004
(As at year-end)



Source: IMF, *International Financial Statistics*, various issues.

In order to more directly address trade, we reconstructed the Bayoumi-Eichengreen OCA index, which measures the suitability for an OCA on the basis of asymmetric shocks, competing trade systems, bilateral trade, and size (see Appendix II). Bayoumi and Eichengreen originally showed a convergence toward an OCA. However, a reconstruction of the index using data through the end of 2003 showed that while the convergence in some countries has continued (Belgium and the Netherlands), the trend toward integration seen in Sweden and Switzerland prior to 1999 has now been reversed (Table 2).

Table 2. Bayoumi-Eichengreen OCA Indices Versus Germany: Selected Years, 1987–2004 1/

	1987	1991	1995	1999	2003
Belgium	0.003	–0.008	0.007	0.004	0.005
Finland	0.097	0.094	0.088	0.090	0.096
Netherlands	0.003	–0.008	–0.006	–0.005	–0.001
Sweden	0.068	0.060	0.048	0.043	0.050
Switzerland	0.040	0.033	0.026	0.036	0.043

1/ On the derivation, see Appendix II.

These results are similar to those reported using the Sjaastad model. However, the validity of this finding is questionable, both because the post-1999 series is still relatively short and the weight of bilateral trade in the index formula gives Finland an artificially high score.

VII. Conclusions

The estimation results suggest that, according to the Sjaastad model, since the introduction of the euro, the price-making power of major currencies for small European countries that did not adopt the common currency shifted from the euro toward the U.S. dollar. This is in contrast to Belgium, Finland, and the Netherlands, which adopted the euro and on which the euro has had a greater impact.

The Sjaastad model uses prices of traded goods and exchange rates, both of which are available at a higher frequency, and therefore allows for a more immediate analysis than the more data-intensive OCA literature. However, the empirical evidence should be interpreted cautiously, since it provides a partial analysis of traded goods prices and uses a short time series for the period following the euro adoption. To test the hypothesis and provide a full answer to the questions of whether it can be confirmed that (i) Europe has ex post become an optimal currency area or (ii) non–euro adopting countries are drifting away from the euro area, it would be necessary to repeat several of the optimum currency area models and test whether coefficients before and after the introduction of the euro have changed significantly. In the absence of sufficient data, this paper is a first attempt at assessing any changes.

A. Suggestions for Future Research

The authors intended with this paper to encourage future research that would not only address the question of whether the euro area has become a better currency area ex post but would also analyze what the impact of non-adoption could be. This question is particularly interesting in light of the number of countries contemplating joining a currency area, not only in Europe but also in Africa and Asia. This study is limited by data availability and a limited choice of models. It cannot answer the question of whether non-adoption may have had negative consequences. Nonetheless, it may be important to provide a limited analysis early on to encourage future research rather than wait for the perfect model. In this regard, several facets of this paper invite future research:

(1) These estimations should be repeated as more data become available to see whether they are robust.

(2) As more data become available, additional and more traditional OCA models can be used to confirm these results.

(3) What is the implication of having two major world currencies? Prior to the introduction of the euro, the U.S. dollar had monopoly power and dominated markets. Neither the yen nor the deutsche mark had ever challenged the U.S. dollar's position. What is the implication of having a second major currency? What are the implications on financial markets, exchange rate dynamics, and the balance in the international system?

(4) The emergence of the euro as a new and dominant *reserve currency* can be further researched. Central banks are, more and more, switching their holdings to reflect this phenomenon. How do these changes impact the demand for the euro and the relative price of the euro and the U.S. dollar?

(5) The euro has not only been gaining status as an official reserve currency for central banks, but individuals increasingly tend to hold bank accounts in euros. Staff reports and other sources of information can be used to identify trends and shifts in private foreign exchange holdings, such as foreign currency deposits in bank accounts. These trends can be used to analyze shifts in the demand for the euro versus the U.S. dollar.

(6) Previous studies of OCAs stressed the importance of bilateral trade. These results indicate that countries with less bilateral trade (i.e., Finland) can still be price takers in a currency union. Does this finding hold up under other tests?

(7) Can other models provide evidence for the implications of the adoption or non-adoption of a common currency?

(8) How has the behavior of nontraded goods prices and labor costs changed? Do models that include these factors lead to similar results?

I. The Sjaastad Model

The following is a summary of the derivation of the Sjaastad model from the Sjaastad (2000) and Sjaastad (1998b) papers. Capital letters indicate natural logarithms.

Notation:

P_q^j = (natural logarithm of the) price of good q in currency j

$E_{x,i}$ = price of currency x in terms of currency i

$D^{q,j}$ = excess demand for good q in country j

Z_q^j = a vector of all other relevant variabless – that is, the market fundamentals in country j

$PRER_x^j$ = Purchasing power parity real exchange rate between country X and j

P_x = Price index for the price level of country X

$E_{x,j}^R$ = Exchange rate between x and j in real terms

Π_x = Inflation in X

Π_x^T = Inflation in the prices of traded goods in country X

PT_x = Prices of traded goods in country X

Θ_x^j = price making power of country j on country X

Excess demand for good q is a function of its real price and a vector of other relevant variables:

$$D^{q,j} = D^{q,j}[P_q^j - P_j, Z_q^j]$$

Using

$$P_q^x = EX_i^x + P_q^j$$

$$= D^{q,j}[P_q^x - E_j^x - P_j]$$

$$= D^{q,j}[(P_q^x - P_x) - (E_j^x + P_j - P_x)]$$

$$= D^{q,j}[P_q^{x,R} - PRER_x^j]$$

If there are J countries in the world, the excess demands 1 to j add up to zero:

$$0 = \sum D^{q,j}[P_q^{x,R} - PRER_x^j, Z_q^j]$$

For simplicity in derivation, the variable *Z* is suppressed in the following derivations. Later in the empirical section, the variable *Z* can be used as a right-hand-side variable (for example as oil prices). Suppressing the variables in vector Z_q^j, and differentiating the equation totally with respect to time, we get the following (the variable *Z* can be introduced again later on)

$$0 = \frac{\sum D^{q,j}}{\partial[...]} d[P_q^{x,R} - PRER_x^j]$$

$$dP_q^{x,R} = \frac{\sum D_1^{q,j} dPRER_x^j}{D_1^q}$$

$$= \sum \nu_j^q PRER_x^j$$

$$P_q^{x,R} = \sum \nu_j^q PRER_x^j$$

Summing over all goods *q*

$$PT = \sum w_q^j P_q^{x,R}$$

$$PT_x^R = \sum_q w_q^j [\sum_j \nu_j^q PRER_x^j]$$

$$= \sum \Theta_x^j PRER_x^j$$

This can be defined on nominal prices as

$$PT_x = \sum \Theta_s^j (P_j + E_{x,j}) \qquad \text{(A1)}$$

Defining $E^R_{x,j} = P_j + E_{x,j} - P_x$ as the purchasing power parity (PPP) real exchange rate of country *X* vis-à-vis country *J*, we can write equation (A1) as

$$PT_x = P_x + \sum \Theta_x^j (E_x^j + P_j - P_x)\,. \qquad \text{(A2)}$$

We are assuming now that country S is a small country. And that it has adopted a credible exchange rate rule with respect to currency X. Than we can write

$$PT_s = PTF_{s,x} + E_{s,x}, \qquad \text{(A3)}$$

assuming that the law of one price is holding for traded goods, where $PTF_{s,x}$ is the price of traded goods of country *S* in the currency of country *X*. Plugging equation (A2) into equation (A3), we get

$$PT_s = E_{sx} + P_x + \sum \Theta_s^j E_{x,j}^R \tag{A4}$$

Equation (A4) can be written in terms of inflation as

$$\Pi_s^T = \dot{E}_s^X + \Pi_x + \sum_j \Theta_s^j \dot{E}_{x,j}^R \tag{A5}$$

where the notation is obvious.

The price level of a country is a weighted average of the prices for its traded and non-traded goods. Therefore equation (A5) can be extended to the overall price level of country *S*.

$$P_s = \alpha_s \cdot (PNT_s - PT_s) + (E_{s,x} + P_x) + \sum \Theta_s^j E_{x,j}^R \ . \tag{A6}$$

An important implication of equation (A6) is that, while a credible exchange rate rule may result in interest rate parity, that is not sufficient to assure equality of real rates of interest. The third term in equation (A6) will affect the short-run inflation rate in country *S*, which can give rise to potentially large real interest rate differentials. For simplification, we temporarily drop the first term in equation (A6), and writing it in terms of changes gives us

$$\Pi_s = \dot{E}_{s,x} + \Pi_x + \sum \Theta_s^j \dot{E}_{x,j}^R \ . \tag{A7}$$

The interest rate in a small country following an exchange rate rule can be written as

$$i_s = i_x + \dot{E}_{s,x} + spread \ . \tag{A8}$$

Using the Fisher equation and equation (A7) we get equation (A9):

$$r_s = i_s - \Pi_s$$

$$r_s = i_s - \dot{E}_{s,x} - \Pi_s - \sum_j \Theta_s^j \cdot \dot{E}_{x,j}^R$$

$$r_{s,x} = r_x - \sum_j \Theta_s^j E_{x,j}^R + spread \tag{A9}$$

where *i* denotes the nominal interest rate and *r* denotes the real interest rate.

Developing countries can suffer under high real interest rates; and even if the real interest rate may be low in the United States, a country that pegs its currency to the U.S. dollar does not necessarily profit from those rates. If changes in the real exchange rate are positive, a country that pegs its currency to the U.S. dollar will experience higher real rates.

The term Θ_x^j, measures the share of power possessed by country *j* in the world market for the goods traded internationally by country *x*. $\dot{E}_{k,j}^R$ are changes in the real exchange rate between countries *k* and *j*. In the standard analysis of sources of external inflation, only the first two terms on the right-hand-side of equation (A7) are taken into account. Indicating that the inflation in a small country is solely determined by the inflation in the anchor country (Π_k), and by changes to the exchange rate rule ($\dot{E}_{x,k}$).

For example, let's assume that for Austria the euro area is an ideal currency area. Then, according to Sjaastad's model, the price-making power of the euro area for Austria would be equal to one ($\Theta_{Austria}^{Euro}$=1) and all other Θ_x^j's would be equal to zero. Since $\dot{E}_{Euro,Euro}^R$=0. In addition, for a country that has the euro as its legal tender the level of the peg will not change and $\dot{E}_{x,k}$ is zero, as well. Therefore, for a country that has the euro as its legal tender and is completely in the optimal currency area of the euro, equation (A7) would simplify to

$$\Pi_x = \Pi_{Euro}$$
$$r_x = r_{Euro} \quad .$$

II. An Application of Bayoumi-Eichengreen Optimum-Currency-Area Index

Bayoumi and Eichengreen (1997) argued that exchange rate variability—rather than simple exchange arrangement selection—was one of the key factors underlying the viability of an optimal currency area and that the behavior of the exchange rate was a better measure of the underlying economic factors. They selected four variables that they then regressed against the standard deviation of the change in the logarithm of the end-year bilateral exchange rate between each potential euro currency and the major euro currency (the deutsche mark). They then forecast the independent variables over time using their model for each country, and the resulting exchange rate variability was treated as an optimum-currency-area (OCA) index.

The initial estimated formula, which was based on estimations for 1983–92, was

$$SD(e_{ij}) = -0.09 + 1.46\, SD(\Delta_{yi} - \Delta_{yj}) + 0.022\, DISSIM_{ij} - 0.054\, TRADE_{ij} + 0.012\, SIZE_{ij} \quad \text{(A10)}$$

where $SD(e_{ij})$ denotes the standard deviation of the change in the logarithm of the end-year bilateral exchange rate between countries *i* and *j*; $SD(\Delta_{yi} - \Delta_{yj})$ denotes the forecast of the standard deviation of the difference in the logarithm of real output between *i* and *j* based on observations for 1971–87, indicating asymmetric shocks; $DISSIM_{ij}$ denotes the sum of the absolute differences in the shares of agricultural, mineral, and manufacturing trade in total merchandize trade extrapolated over trends in the years 1990–92 and 1993–95, indicating similarity in output structures; $TRADE_{ij}$ denotes the mean of the ratio of bilateral exports to domestic GDP for the two countries; and $SIZE_{ij}$ denotes the mean of the logarithms of the two GDPs measured in millions of U.S. dollars. The index is the forecasts of $SD(e_{ij})$. The independent variables are measured as averages over the sample period. Because of a lack of available data, the measurement of asymmetric shocks after 1987 was based on projections. Although comprehensive data on all variables are now available through the end of 2003, the measurements contained herein were made using forecasted data for the sake of comparability.

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