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***The Shrinking Endogeneity of Optimum Currency Areas  
Criteria: Evidence from the European Monetary Union –  
A Beta Regression Approach.***

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# **The Shrinking Endogeneity of Optimum Currency Areas Criteria: Evidence from the European Monetary Union – a Beta Regression Approach**

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First Draft<sup>2</sup>

## **Abstract**

The endogeneity of optimum currency areas criteria has been widely studied since Frankel and Rose (1998) seminal paper. Literature normally suggests that there is a positive relationship between trade and business cycles correlation. This paper develops work on this subject (Silvestre and Mendonça, 2007) where we confirm this hypothesis in euro area countries and UE-15 for 1967-2003 period using OLS and 2SLS estimates. However, we also find then that trade influence on cycles synchronization diminished in the last years.

Now our goal was precisely to evaluate this question. Using a non-linear model based on Beta distribution in the same sample, we concluded that trade has a decreasing marginal effect on business cycles correlation. This result shows that trade flows are important in the first stages of economic integration, but become less important as trade intensity increases. Other factors must then be considered.

**JEL classification numbers:** E32; E42

**Keywords:** European and Monetary Union (EMU); Business Cycles Correlation; Optimum Currency Areas; International Trade; Beta Regression.

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## **1. Introduction**

Economic and Monetary Union (EMU) in Europe provides an excellent research field to economists interested in currency unions. Despite its youth, that should be regarded as an incentive to be cautious in any analysis, is a unique event and has several reasons of interest. Of course, in economic science, as in many other areas, eight years is very short period of time and all the conclusions obtained should not be considered as final ones. No one can assure, definitely, that are not just a product of some initial overshooting that often appears in economics.

This paper is the follow up of our previous work on endogeneity of optimum currency areas criteria. Silvestre and Mendonça (2007) applied Frankel and Rose model (1996) to European Union and Eurozone and confirmed the hypothesis that business cycles correlation and bilateral trade intensities are positively related. But, when we split, the sample (1967-2003) in four sub-samples (1967-1975; 1976-1985; 1986-1992; 1993-2003) endogeneity just holds in the first two. This suggests that with stronger economic integration, trade role in business cycles correlation tends to decrease.

Probably, when other factors beyond trade are helping business cycles to have closer ties like, for instance, Single European Act that created an European single market or all the Maastricht criteria that countries had to meet to advance to EMU last stage. Now, our goal is precisely to evaluate this specific situation. For that, we replace the linear model (OLS and 2SLS) used then for a non-linear model, based on a beta distribution, in order to estimate the marginal contributions of trade to business cycles correlation.

Beyond this improvement, we use Baxter-King filter (1995) instead of the classic Hodrick-Prescott (1980). Despite the fact that Baxter-King has also some problems with spurious cycles, is normally more appropriate to annual data.

## **2. The endogeneity of optimum currency areas criteria**

The concept of endogeneity of optimum currency areas criteria was first introduced by Frankel and Rose (1998) and has motivated a broad discussion since its publication. In their article, they analysed the business cycles and trade intensities in 20 countries between 1959 and 1993 and found a positive statistical relationship between this two important criteria to define an optimum currency area.

This results lead to the conclusion that the introduction of a common currency could help it to meet the optimum currency areas criteria ex-post even if they were not verified ex-ante. They say it is just an application of “Lucas Critique” (Lucas, 1976) to optimum currency areas, since both business cycles correlation and trade intensities are affected by policies. In fact, if trade could help to closer business cycles, countries with strong bilateral trade ties have a smaller need of monetary integration and could share a common currency.

At the same time, the adoption of a common currency will help to increase trade flows between its members. This is known as the Rose effect, with empirical estimates

ranging from very low levels to 376%. For a review of this estimates see, for instance, Rose (2004).

In European experience, long before EMU third phase, member states advanced to previous stages of economic integration, such as free trade arrangements and custom unions. In the nineties, after Maastricht Treaty defined the convergence criteria, countries were forced to meet some conditions to be accepted in euro club. Those included fiscal deficit, public debt, short and long run interest rates, inflation and exchange rate fluctuations. The goal was, precisely, to improve as possible economic integration before adopt a common monetary policy.

However, theoretically speaking, this relationship between trade and cycles correlation could assume positive or negative signs. In other words, an increase in trade flows does not necessary leads to large business cycles synchronization. It depends on the kind of specialization that exists in that region. If there is an inter-industry specialization, i.e., different sectors in different regions, as defended by Krugman (1993) or Kenen (1969), cycles tend to be less symmetrical and coefficient should be negative. On the opposite side, if the specialization process is mainly intra-industry, i.e., the bulk of trade flows are within the same sector, cycles will be more correlated and coefficient is positive. The famous “One Market, One Money” published by European Comission (1992) in the same year Maastricht Treaty defined the path to EMU gave support to this latter view.

Although trade influence in business cycles correlation seems to be unchallenged, of course considering different sign possibilities, many other factors are explaining shock transmission across monetary union members. Events like expansionary fiscal policies, shifts in aggregate supply or private investment increases in a country has unavoidable consequences in other states.

### **3. Previous empirical results**

Relation between business cycles correlation and bilateral trade flows have been empirically tested several times. Considered the two main criteria to evaluate *ex-ante* the expected success of a monetary integration are object of many works with different data samples and methodology.

The most frequent method used to measure the business cycles symmetry is the VAR model presented by Blanchard and Quah (1989). With VAR model, Bayoumi and Eichengreen (1993) showed that assimetric shocks in Europe are larger than US. De Grauwe and Vanhaverbeke (1991) found that idiosyncratic shocks in Europe tend to be more persistent between regions inside same country than between countries. Artis and Zhang (1997) have found a European business cycle. Kenen (2000) argued that trade could lead to more business cycles correlation but that does not means that shocks need to be more symmetric. Hughes, Hallet and Piscitelli (1999), showed that monetary unions only increase cycles convergence when exists a simmetric monetary transmission mechanism.

Fridmuc (2001) tested the endogeneity hypothesis including also intra-industry trade as explaining variable in the same model used by Frankel and Rose and found a positive relation between this variable and business cycles correlation. This confirms the endogeneity hypothesis, i.e., there is a statistical relationship between trade and cycles correlation, but with a Krugman-type specialization process.

In our previous work (Silvestre and Mendonça, 2007), the estimates for European Union and Eurozone for 1967-2003 period confirmed the endogeneity hypothesis. However, despite the fact that business cycles correlation increased in this period, when we splat the sample in four this only occur in the first two (1967-1975 and 1976-1985). This could mean that, after Single European Act in 1986, other factors beyond trade were contributing to business cycles correlation.

## 4. Data and Model

### 4.1. Data

The data comprises 10 countries of the eurozone (Belgium-Luxembourg, Germany, Italy, Netherlands, Ireland, Finland, Austria, Spain, Greece and Portugal) collected from Chelem Database through the period 1967-2003. To construct the variables the sample was splat in four sub-samples: 1967-1976, 1977-1985, 1986-1992 and 1993-2003. Total trade ( $TIt$ ) and business cycles correlation ( $y$ ) were calculated for each one of the four sub-periods. For total trade between countries  $i, j$  in period  $t$ , we consider the ratio,

$$TIt_{ijt} = \frac{X_{ijt} + M_{ijt}}{X_{it} + X_{jt} + M_{it} + M_{jt}},$$

where  $X_{it}$ ,  $X_{jt}$ ,  $M_{it}$ ,  $M_{jt}$  are, respectively, the total exports of countries  $i$  and  $j$  in period  $t$  and the total imports of countries  $i$  and  $j$  in period  $t$  and  $X_{ijt}$ ,  $M_{ijt}$  are the exports and imports from country  $i$  to country  $j$  in period  $t$ , respectively.

For the GDP data, we extracted the cycle from the series (in logarithms) using the Baxter-King (1999) filter ( $Q$ ) and calculated bilateral correlation coefficients,  $y_{ijt} = corr(Q_{it}, Q_{jt})$ , in each of the four sub-periods. Table 1 presents some summary statistics for the variables considered in the estimation. Figure 1 and 2 present histograms of business cycles correlation and total trade for each sub-period.

**Table 1: Summary statistics**

Period	Variable	Obs	Mean	Std. Dev.	Min	Max
	$y_{ij}$	220	0.51913	0.33230	-0.72560	0.98820
	$TIt_{ij}$	220	0.02939	0.06296	0.00022	0.33185
1967-2003	$ling$	220	0.03636	0.18762	0	1
	$dist$	220	1990.6	1029.582	210	4530
	$adj$	220	0.18182	0.38657	0	1
1967-1976	$y_{ij}$	55	0.49715	0.35823	-0.35390	0.95170

	$TIt_{ij}$	55	0.00806	0.01197	0.00022	0.04309
1977-1985	$y_{ij}$	55	0.30947	0.31036	-0.54360	0.92940
	$TIt_{ij}$	55	0.00791	0.01113	0.00050	0.04113
1986-1992	$y_{ij}$	55	0.52111	0.32512	-0.72560	0.95550
	$TIt_{ij}$	55	0.00934	0.01147	0.00063	0.03775
1993-2003	$y_{ij}$	55	0.74879	0.13598	0.46170	0.98820
	$TIt_{ij}$	55	0.09226	0.10153	0.00760	0.33185

**Note:** a)  $y_{ij} = corr(Q_i, Q_j)$  where  $Q_i$  is the filtered economic activity cycle obtained from the GDP with Baxter-King filter for country  $i$ .

b)  $TIt_{ij}$  is the total trade between countries  $i$  and  $j$ .

c)  $ling$ ,  $dist$  and  $adj$  are, respectively, common language, distance and common border.

From Figure 1 we conclude that business cycles correlation is higher on average and much more concentrated around its mean in the last sub-period. From Figure 2 we can also observe an increase in the total trade for the last sub-period.

**Figure 1: Histogram of business cycles correlation (y)**

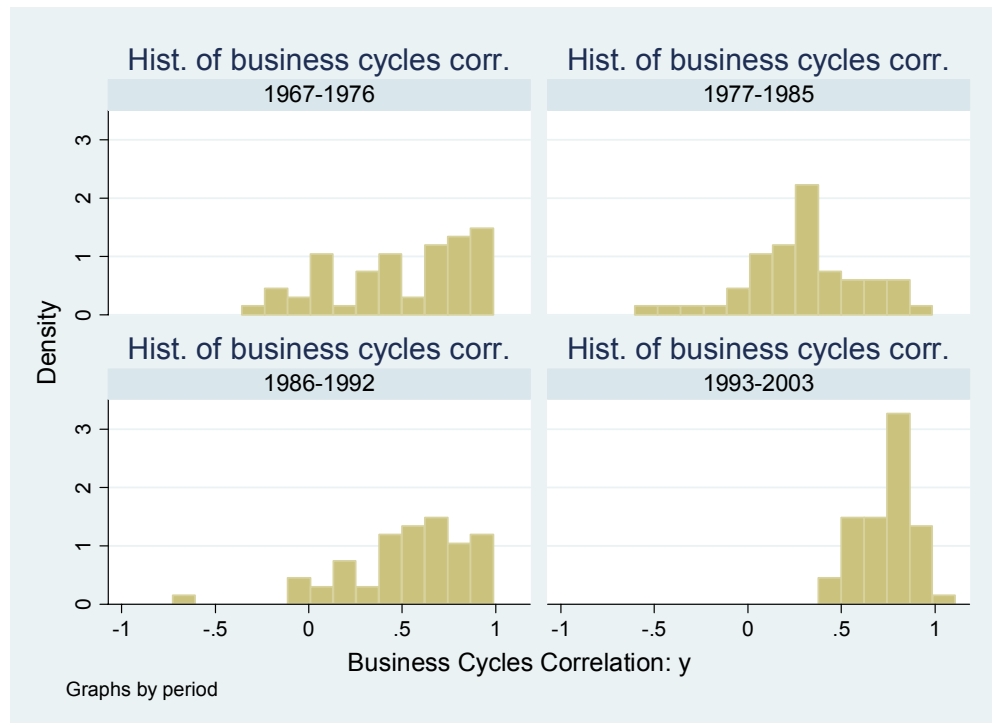


Figure 2: Histogram of total trade (TIt)



## 4.2. Model

Traditional empirical studies relating business cycles correlation and trade intensity employ linear regression models. However business cycles correlation is a limited variable in the interval  $(-1,1)$  and the linear regression model is not appropriated since it may yield fitted values outside its range.

In this paper we consider modelling this relationship using the standard beta distribution. A random variable  $z$  is said to follow a beta distribution, with the parameterization suggested by Ferrari and Cribari-Neto (2004), if its probability density function can be written as,

$$f(z; \mu(x), \phi) = \frac{\Gamma(\phi)}{\Gamma(\mu(x)\phi)\Gamma((1-\mu(x))\phi)} z^{\mu(x)\phi-1} (1-z)^{(1-\mu(x))\phi-1},$$

where  $0 < z < 1$ ,  $0 < \mu(x) < 1$  and  $\phi > 0$ . The conditional mean and variance of  $z$  are given respectively by,

$$E(z | x) = \mu(x),$$

and

$$\text{Var}(z | x) = \frac{\mu(x)(1-\mu(x))}{1+\phi}.$$

so that  $\mu(x)$  is the mean of the response variable and  $\phi$  can be interpreted as a precision parameter.

The standard beta distribution is constrained to the unit interval. However it can be generalized to any interval  $(a,b)$ . In our case  $y$  is a correlation and therefore one would model  $z = (y-a)/(b-a) = (y+1)/2$  instead of  $y$ , directly. With this transformation the relationship between conditional mean functions of  $y$  and  $z$  are given by,

$$E(y | x) = 2E(z | x) - 1$$

To model the mean function,  $E(z | x) = \mu(x)$ , we should consider a specification that assures it is constrained in the interval (0,1). For this, a useful link is the logit link,

$$\mu(x) = \frac{\exp(x' \beta)}{1 + \exp(x' \beta)},$$

where  $x$  is a vector of explanatory variables and  $\beta$  a vector of parameters.

Given a sample of  $n$  independent observations, the parameters are estimated by maximizing the log likelihood function,

$$l(\beta, \phi) = \sum_{i=1}^n f(y_i; \mu(x_i), \phi)$$

The estimated coefficients are presented in Table 2.

**Table 2: Estimated model**

Variables ( $x$ )	Coef	p-value
<i>TIt</i>	1.5582	0.0190
$d_{t=1977-1985}$	-0.5238	0.0010
$d_{t=1986-1992}$	0.0019	0.9910
$d_{t=1993-2003}$	0.4279	0.0060
<i>Cons</i>	1.1533	0.0000
$\ln(\phi)$	2.0179	0.0000
$\phi$	7.5217	
<i>Wald</i> $\chi^2(q)$	107.80	0.0000

Because this is a nonlinear model the estimated coefficient associated with total trade, *TIt*, cannot be interpreted as a marginal effect. Since

$$E(z | x) = \mu(x) = \frac{\exp(x' \beta)}{1 + \exp(x' \beta)},$$

and  $x$  is assumed continuous, the marginal effect of total trade on business cycles correlation is computed from the derivative,

$$\frac{\delta E(y | \bar{x})}{\delta x_j} = 2 \frac{\delta E(z | \bar{x})}{\delta x_j},$$

evaluated at the means of  $x$ ,  $\bar{x}$ , whose value is given in Table 3, for the whole period.

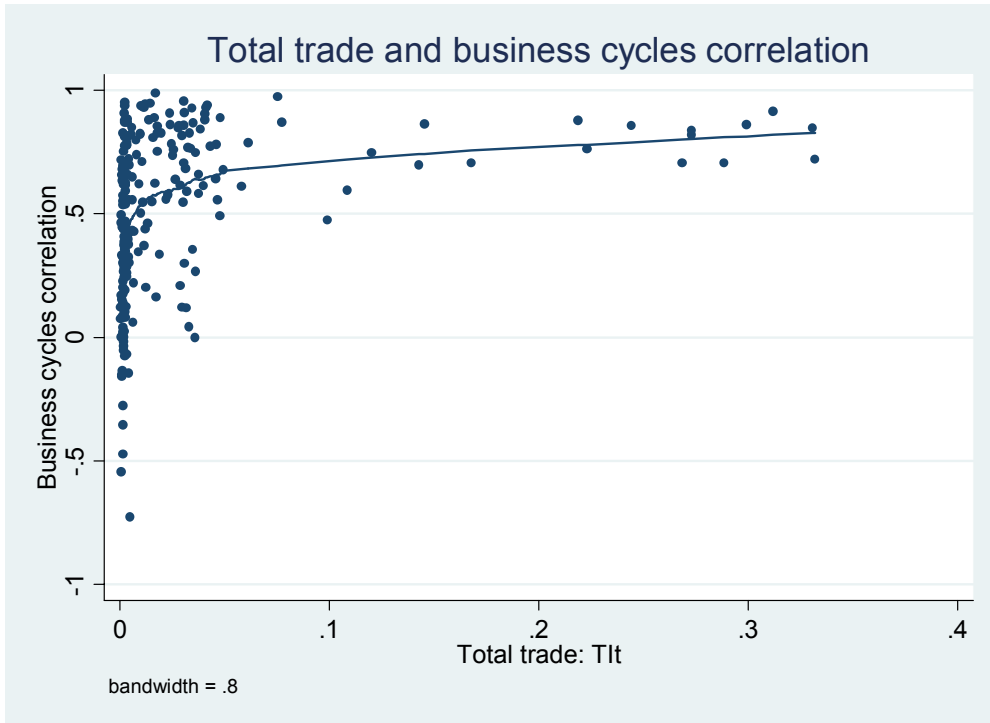
**Table 3: Marginal effect at mean values (1967-2003)**

Variable	dE(y x)/dxj	
	Coef.	Std Err
TIt	0.5616	0.2418

Figure 5 shows this marginal effect for each sub-period. The effect is positive, however marginally decreasing with total trade.



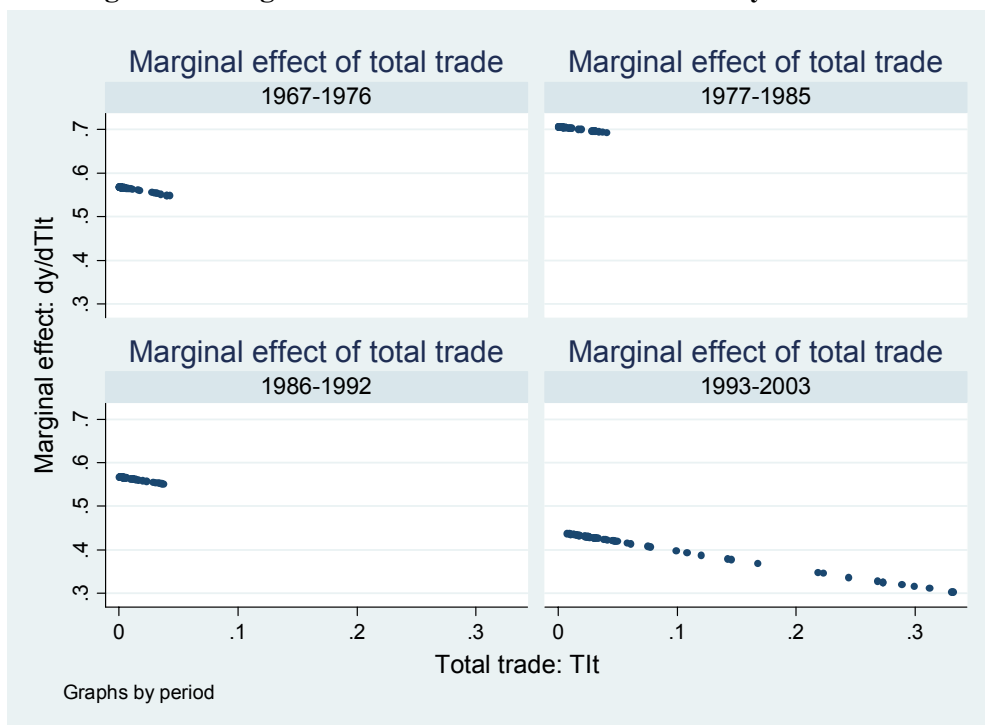
**Figure 3: Bilateral trade and business cycles correlation**



**Figure 4: Estimated business cycles correlation versus total trade**



**Figure 5: Marginal effect of total trade on business cycles correlation**



## 5. Conclusions

In the last four decades, business cycles in eurozone became much more correlated. Europe experienced a unique project of economic and monetary integration with no known precedents in World and the economies gained closer ties. Before the beginning of EMU last stage, in 1999, several other previous steps were taken: free trade arrangements, custom union and, more recently, convergence criteria defined in Maastricht Treaty.

In all this process, trade always was one of the most important variables. An importance justified in the late nineties with the publication of Frankel and Rose “Endogeneity of Optimum Currency Areas Criteria”: This paper showed that trade is positively related with business cycles correlation and, for that reason, a group of countries could become an optimum currency area ex-post, i.e., after the introduction of a common currency. The debate, since then, was about the specific kind of specialization. If it is inter-industry, this relation is negative, but if it is intra-industry, should be positive.

Using a non-linear model based on a Beta distribution, we find that trade as decreasing returns on scale as business cycles correlation explaining variable. Our

estimates reveal a negative marginal effect with a slope that became more negative in the last decade. This model was applied to eurozone data between 1967 and 2003. Though this result confirmed the endogeneity hypothesis proposed by Frankel and Rose, it suggests that trade is losing importance in explaining business cycle synchronization, despite the fact that this correlation is increasing.

Future research should try to evaluate what other factors are behind business cycle correlation in EMU.

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