Instantaneous Correlation and Cyclical Convergence in the Euro Zone*

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Abstract:

This paper introduces the measure of instantaneous correlation to study the effects of a common currency on cyclical correlation and convergence in the euro zone. Conventional, backward-looking measures of correlation are not appropriate for a dynamic currency union. An accurate measure of cyclical correlation must account for the change in economic structures due to a common currency and the convergent effects of these changing structures. In addition to accurately reporting cyclical correlation, the measure of instantaneous correlation allows the convergent effects of increased trade, demand spillovers and industrial specialization to be isolated and measured through counterfactual situations.

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When the euro became the common European currency, the national central banks of the euro zone ceded monetary independence to the European Central Bank. Each country agreed that a monetary policy should be adopted that is best for the entire euro zone, even if it is not best for their own individual economies. Since governments use monetary policy to smooth business cycle fluctuations and stabilize economies, the loss of an independent monetary policy puts the country at risk for real instability in the short and medium term. This is the cost of a common currency. When the various national governments approved the euro they believed the benefits of a common currency outweighed the costs. These benefits and costs are difficult to quantify and impossible to compare, but convergence towards a common European business cycle makes this comparison moot as the costs of a common currency tend towards zero. But will these costs tend towards zero? Will the euro in fact induce cyclical convergence between the euro zone economies? A common currency will lead to increased trade and a common distribution of monetary shocks, but does this trade and distribution of shocks lead to cyclical convergence?

In his original work on the theory of optimum currency areas, Mundell (1961) emphasized the importance of labor mobility in correcting for asymmetric shocks. Various treaties of the last 50 years have removed statutory barriers to the free movement of labor across Europe, but significant lingual and cultural barriers still remain. Because of these barriers, labor mobility within Europe is limited. In 1999, at the adoption of the euro, only 1.5% of Europeans were taking advantage of the free movement of labor enabled by the Treaty of Rome (OECD Observer 1999), and that number will not rise as the EU's lingual and cultural diversity increases in the coming years. Eichengreen, in 1991 and again with Bayoumi, in 1993 found that there is much less labor mobility in the euro zone than in comparable currency areas like the United States. Therefore if Europe is to function as an optimum currency area given the lack of labor mobility to correct for low business cycle correlation, the correlation between euro zone business cycles needs to be high. The study of instantaneous correlation in the euro zone is the study of various shocks that drive business cycle fluctuations, and the role of economic structures in controlling the manifestation of those shocks.

Many scholars have theorized about the path of cyclical convergence in the euro zone. Many of these theoretical works are controversial and contradict one another, and the various theories and arguments are presented throughout this paper. The existing empirical literature on the topic is just as contradictory. Kalemli-Ozcan, Sørensen, and Yosha (2001) find evidence that the divergence arising from industrial specialization is greater than the cyclical convergence that comes from the distribution of common shocks through increased international trade. Using different econometric techniques, Altavilla (2004) finds the opposite. He states that there is currently some difference in the business cycle fluctuations between the euro zone economies, but with time the members of the EMU should see their business cycles converge to a common European business cycle. Others have accepted that in a 12 nation currency block like the euro zone, it is possible for cyclical convergence to exist between some economies and cyclical divergence to exist between others. This has lead to the core-periphery hypothesis that is common in the literature. Bayoumi and Eichengreen (1993), von Hagen and Neumann (1994), and De Grauwe (1996) have all speculated or tested empirically to find the existence of a core of euro zone countries (including Germany, France, Belgium, The Netherlands, and Luxemburg) that should cyclically converge with the euro zone average in the future, and a periphery of countries (Italy, Portugal, Spain, Greece, Austria, Finland, and Ireland) which should see their business cycles diverge from a euro zone average.

This paper does what the empirical papers on this subject have not. Other studies have used various correlation models that are inherently backward looking. A backward looking measure is not appropriate in a dynamic economic and monetary union like the euro zone. By assigning a stochastic functional form to business cycle fluctuations, this paper will find the instantaneous correlation between business cycle fluctuations. This instantaneous correlation is not a backward looking correlation coefficient based on past observations, but a measure based on the current economic structures of two economies.

With this model of instantaneous correlation, I am able to isolate the demand spillover and industrial specialization effects of increased trade in various counterfactual situations. I can then compare the converging properties of the two. I find the results to be mixed and rather intuitive. Cyclical correlation between the euro zone average and the small, open, core economies of the euro zone is very susceptible to the effects of demand spillovers. And cyclical correlation between the euro zone average and the economies of the periphery is decreasing because of industrial specialization everywhere except Italy. These mixed results show that trade in and of itself will not cause cyclical convergence, for some countries see the convergent impact of demand spillovers trump the potentially divergent impact of industrial specialization, but some see the opposite.

The model of instantaneous correlation and how it differs from conventional, backward looking correlation measures is presented in the first section of this paper. In the second section a stochastic functional form is given to business cycle fluctuations, and with this functional form I estimate the variance of and covariance between the various shocks to an economy. In the third section I examine the effect of increased trade on cyclical correlation in Europe. I use counterfactual situations to isolate the effects of demand spillovers and industrial specialization. Through these 3 sections it becomes clear that a common currency alone will not lead to higher cyclical correlation or cyclical convergence in the euro zone, and may lead to lower cyclical correlation and cyclical divergence. The euro alone will not ease and eliminate the costs of a common currency, and it may increase the costs as divergence pushes euro zone economies away from a common European business cycle.

Section 1: The Model of Instantaneous Correlation

The correlation coefficient is commonly gauged by measuring the covariance between and standard deviations of lagged observations. The formula for the correlation coefficient between two variables, X and Y, is as follows:

$$\rho_{T,XY} = \frac{\sum_{i=1}^{T}\left(X_{t-i}-\mu_X\right)\left(Y_{t-i}-\mu_Y\right)}{\sqrt{\left[\sum_{i=1}^{T}\left(X_{t-i}-\mu_X\right)^2\right]\left[\sum_{i=1}^{T}\left(Y_{t-i}-\mu_Y\right)^2\right]}} \tag{1}$$

Equation 1 shows that the measurement of the correlation coefficient will depend on past observations, in this case T observations. For many applications this measure of the correlation coefficient is appropriate, but for some applications, especially measuring cyclical convergence in the euro zone, it is not.

To analyze cyclical convergence in the euro zone it is necessary to measure the correlation between business cycle fluctuations that is not based on lagged information, the instantaneous correlation. This is because, on average, the correlation between two countries' business cycles will depend on the inherent structures of those economies. Cyclical correlation should be high between economies with similar industrial structures, similar degrees of trade openness, and similar monetary policies. Some scholars studying the common currency maintain that increased trade and demand spillovers will induce cyclical convergence, yet some maintain that increased trade and industrial specialization could induce cyclical divergence. While they may disagree on the exact path of cyclical correlation in the euro zone, they agree that the euro will fundamentally alter the economic structures of the euro zone economies. Therefore any measure of the correlation coefficient that relies on lagged observations will incorporate information from both before and after that alteration. An instantaneous correlation based only on current economic structures can more accurately measure the cyclical correlation and thus cyclical convergence/divergence in a currency union where trade openness and industrial structures are subject to rapid change.

To measure the instantaneous correlation between two economies' business cycle fluctuations it is necessary to characterize those business cycle fluctuations as a function of various economic shocks. Equation (2) writes country A's output gap in period t as a function of various shocks:

$$\frac{Y_{A,t}}{Y^*_{A,t}} = \boldsymbol{\lambda}'_{A,t}\mathbf{S}_t + v_{A,t} \qquad (2)$$

where the scalar Y_{At} is the actual output of country A in period t, and the scalar $Y^*_{A,t}$ is the potential output of country A at time t. $\mathbf{S}_t$ is the Nx1 vector of shocks common to all countries, and the scalar $v_{A,t}$ is a shock specific to country A at time t. The actual manifestation of a common shock in the business cycle fluctuations of country A depends on the Nx1 vector $\boldsymbol{\lambda}_{A,t}$. This vector is both country and period specific. $\boldsymbol{\lambda}_{A,t}$ is a vector of parameters that represent the structure of country A's economy at time t. The individual components $\lambda_{i,A,t}$ for some $i = 1...N$ could be the size of industrial sector i in country A's economy at time t, or it could be a measure of how open country A is to international trade at time t. For certain common shocks, $\lambda_{i,A,t}$ could be a binary variable. If the shock $S_{i,t}$ is the result of a common union wide monetary policy, then $\lambda_{i,A,t}$ will take a value of one if country A is a member of that monetary union at time t and zero if not.

If one believes that the country specific shocks, v, account for only a small portion of the overall variance of business cycle fluctuations once the many common shocks, S, and their country-specific manifestations, λS, are accounted for, then the model in equation (2) can be used to characterize multiple countries' business cycle fluctuations as a function of the same common shocks. Therefore it is possible algebraically to represent the instantaneous correlation between the business cycle fluctuations in countries A and B in time t as a function of the economic structure vectors $\boldsymbol{\lambda}_{j,t}$ for $j = A,B$ and the variance-covariance matrix related to the vector of common shocks $\mathbf{S}_t$. Various statistical identities yield the following algebraic representation of the instantaneous correlation between the business cycle fluctuations in countries A and B at time T:

$$\rho_{AB,T} = \frac{\boldsymbol{\lambda}'_{A,T}\mathbf{M}\boldsymbol{\lambda}_{B,T}}{\sqrt{\left(\boldsymbol{\lambda}'_{A,T}\mathbf{M}\boldsymbol{\lambda}_{A,T}\right)\left(\boldsymbol{\lambda}'_{B,T}\mathbf{M}\boldsymbol{\lambda}_{B,T}\right)}} \tag{3}$$

where $\mathbf{M}$ is the NxN variance-covariance matrix associated with the vector of common shocks $\mathbf{S}_t$.

$$\mathbf{M} = E\left(\mathbf{S}_t\mathbf{S}'_t\right) \tag{4}$$

This equation gives an accurate measure of cyclical correlation based on current economic structures. In equation (3) the measure of cyclical correlation is based on the variances and covariances of the various shocks and $\boldsymbol{\lambda}_{j,t}$ for $j = A,B$ and for some T. The commonly used, backward looking measure of cyclical correlation in equation (1) is based on the variances and covariances of the various shocks and $\boldsymbol{\lambda}_{j,t}$ for $j = A,B$ and for all $t = 1...T$. The instantaneous correlation is based on $\boldsymbol{\lambda}$ for some T while the backward looking correlation is based on $\boldsymbol{\lambda}$ for all $t = 1...\ T$. Therefore if $\boldsymbol{\lambda}$ is changing in t, the instantaneous correlation measure in equation (3) yields an accurate measure at time T, but the backward looking measure in equation (1) does not. This distinction is important in the study of European integration, for the common currency's effects on the economic structures of the euro zone economies is well modeled and documented. Over time, with the common currency, the economies of the euro zone will trade more, and this increased trade will lead to industrial specialization. Thus the euro will change $\boldsymbol{\lambda}$

in ways that make it impossible to measure cyclical correlation by some backward looking measure.

Section 2: Measuring Business Cycle Shocks

2.1 The Business Cycle in a Stochastic Functional Form

The model utilized in this paper is a variation of a model suggested, but not explored by Frankel and Rose (1998). Their model divides GDP growth rates into three parts: a long run growth trend, common shocks that are distributed across all open economies, and industry specific shocks that are localized and not evenly distributed. The even distribution of common shocks across the entire currency union leads to greater cyclical convergence. The uneven distribution of industry specific shocks can lead to cyclical divergence. This section identifies the different common and industry-specific shocks in each period and then estimates the variance-covariance matrix associated with these shocks. This variance-covariance matrix is then combined with time varying vectors of economic structures, λ for some T, to find the instantaneous correlation between business cycle fluctuations in the euro zone.

In this model, the common shocks take four forms forms, the European common shock, the euro zone common shock, the worldwide shock, and shocks linked to specific industries. The European common shock is part of a general European business cycle. Its effects are distributed evenly across all countries regardless of the currency used. The euro zone common shock is part of a euro zone business cycle. Its effects are distributed evenly across all EMU member economies. The worldwide shock affects all countries, but it is linked to international trade. The extent to which the worldwide shock will affect the economy of a particular country depends on the openness of that country. The industrial shocks are linked to specific industries and relate to anything from a change in preferences for that industry's product to a technological change in that industry. The manifestation of an industry-specific shock in a particular economy depends on the size of that industry in a particular economy. Thus industrial specialization will lead to an uneven distribution of these shocks. The country-specific shock explains any part of the business cycle fluctuation not explained by the common and industry-specific shocks. Thus the model of business cycle fluctuations can be written as:

$$\frac{Y_{A,t}}{Y^{*}_{A,t}} = \sum_{i=1}^{n}\left(\alpha_{i,A,t}U_{i,t}\right) + Z_t + E_t + \theta_{A,t}X_t + V_{A,t} \tag{5}$$

The industry specific shocks, U_i, have a coefficient $\alpha_{i,A}$, which is the share of country A's total output that comes from industry i. Z is a common European shock, and E is a common euro zone shock. These shocks are distributed equally, so a coefficient is not necessary. X is the world-wide economic shock linked to international trade. In the model the coefficient of X is θ_A, which is a measure of the relative openness of a country's economy. θ_A is the sum of exports and imports of country A divided by the total GDP of country A. Finally any random disturbance not identified as the country-specific manifestation of a common shock is considered a country specific shock, V_A.

2.2 Computing the Variance of and the Covariance between Economic Shocks

This linear model of business cycle fluctuations allows for the identification and analysis of the different shocks that can affect a nation's economy. Before these shocks are found, it is helpful to identify exactly what type of data is used in the empirical analysis. The data is obtained from Eurostat. The empirical results are found using the data from 29 countries and 2 averages. The countries included are 11 euro zone counties, 9 of the new member states[1], and 9

[1] A lack of necessary data forced the exclusion of Ireland and Malta from the study.

other notable European countries[2]. This provides nearly a complete sample of European economies. The two averages are for the EU-25 and for the EU-12. These averages provide an economic picture for all of Europe and for the euro zone. This data is analyzed over 43 quarters, from the second quarter of 1995 until the fourth quarter of 2005. As mentioned earlier, the statistic for relative openness is constructed by combining a country's total imports for the quarter with its total exports for the quarter and then dividing by the GDP for the quarter. The statistics for industrial shares are constructed by dividing the quarter's total output in a specific industry by the GDP from that quarter. To construct these statistics on industrial specialization, the GDP of each country in each quarter was separated into 6 industrial categories. These six industrial categories are: Agriculture, Manufacturing, Construction, Wholesale and Retail Trade, Financial Services, and Healthcare and Public Services.

For notational brevity and convenience, the equation for the output gap as a function of these 10 particular shocks (9 common and 1 country-specific) can be written in a vector form like equation (2)

$$\frac{Y_{A,t}}{Y^*_{A,t}} = \boldsymbol{\lambda}'_{A,t}\mathbf{S}_t + v_{A,t} \tag{6}$$

where:

$$\boldsymbol{\lambda}'_{A,t} = \left[\theta_{A,t} \quad D_A \quad 1 \quad \alpha_{i,A,t} \textit{ for } i = 1..6\right]$$
$$\textit{and}$$
$$S'_t = \left[X_t \quad E_t \quad Z_t \quad U_{it} \textit{ for } i = 1..6\right]$$

where D_A is a dummy variable equal to one if country A is a member of the euro zone and zero if not. Taking the first difference of equation (6) gives the change in the output gap as a function of changes in country-specific shocks and country-specific manifestations of common shocks.

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[2] Switzerland, Denmark, Norway, Croatia, Romania, Iceland, Turkey, Sweden, and Britain

$$\left(\frac{Y_{A,t}}{Y^*_{A,t}} - \frac{Y_{A,t-1}}{Y^*_{A,t-1}}\right) = \left(\boldsymbol{\lambda}^{'}_{A,t}\mathbf{S}_t - \boldsymbol{\lambda}^{'}_{A,t-1}\mathbf{S}_{t-1}\right) + \left(v_{A,t} - v_{A,t-1}\right) \tag{7}$$

We will approximate and say that the country and time specific parameter vector, $\boldsymbol{\lambda}$, stays relatively constant between two sequential quarters, so the expression for the change in the output gap can be written as:

$$\Delta y_{A,t} \approx \boldsymbol{\lambda}^{'}_{A,t}\Delta\mathbf{S}_t + \Delta v_{A,t} \tag{8}$$

where $\Delta y_{A,t}, \Delta\mathbf{S}_t,$ and $\Delta v_{A,t}$ represent the change in the output gap, the change in the vector of common shocks, and the change in the country specific shocks, respectively. Given observable data on quarterly changes in each country's output gap, $\Delta y_{j,t}$ for all $\text{j} = 1...31$, and country and period specific observations of the parameter vector $\boldsymbol{\lambda}_{j,t}$ for all $\text{j} = 1...31$, an OLS regression is run to find the incidence of the common and country specific shocks, $\Delta\mathbf{S}_t$ and $\Delta v_{A,t}$, in each of the 43 quarters from 1995:2 to 2005:4.

Once the quarterly incidences of the vector of common shocks, $\Delta\mathbf{S}_t$, are estimated then they can be used to find a consistent estimate for the common shock's variance-covariance matrix.

$$\hat{\mathbf{M}} = \frac{1}{T}\sum_{t=1}^{T}\left(\Delta\mathbf{S}_t\Delta\mathbf{S}^{'}_t\right) \tag{9}$$

where $\hat{\mathbf{M}}$ is an estimate of the variance-covariance matrix of the common shocks $\mathbf{M}$. The consistency of the OLS estimate ensures the consistency of this variance-covariance matrix:

$$\hat{\mathbf{M}} \xrightarrow{T} \mathbf{M} \tag{10}$$

The following 9x9 matrix is the estimate for the variance-covariance matrix **M** obtained after running the regression in (8) for 31 countries over 43 quarters. The headings A, M, C, T, F, and P represent the industry-specific shocks and correspond to **A**griculture, **M**anufacturing, **C**onstruction, wholesale and retail **T**rade, **F**inancial services, and **P**ublic services and healthcare.

Figure 1, Variance-Covariance Matrix for the 1995:2 to 2005:4 period:

	X	E	Z	A	M	C	T	F	P
X	4.5E-05	4.7E-06	-2.6E-04	7.4E-04	1.8E-04	1.3E-04	5.5E-06	2.7E-04	4.2E-04
E	4.7E-06	1.4E-05	-7.2E-05	-3.6E-05	6.1E-05	-2.3E-04	9.0E-05	-1.8E-05	2.0E-04
Z	-2.6E-04	-7.2E-05	5.4E-03	-2.1E-02	-3.7E-03	3.1E-03	-1.0E-03	-7.2E-03	-9.0E-03
A	7.4E-04	-3.6E-05	-2.1E-02	1.2E-01	1.2E-02	-1.1E-02	2.0E-03	3.4E-02	2.9E-02
M	1.8E-04	6.1E-05	-3.7E-03	1.2E-02	3.6E-03	8.1E-04	-7.5E-05	4.7E-03	5.5E-03
C	1.3E-04	-2.3E-04	3.1E-03	-1.1E-02	8.1E-04	3.2E-02	-8.3E-03	-9.4E-04	-1.2E-02
T	5.5E-06	9.0E-05	-1.0E-03	2.0E-03	-7.5E-05	-8.3E-03	2.5E-03	3.7E-04	3.2E-03
F	2.7E-04	-1.8E-05	-7.2E-03	3.4E-02	4.7E-03	-9.4E-04	3.7E-04	1.3E-02	8.8E-03
P	4.2E-04	2.0E-04	-9.0E-03	2.9E-02	5.5E-03	-1.2E-02	3.2E-03	8.8E-03	2.0E-02

In the regressions that generated this matrix, the country specific shocks acted as the residual. The assumption that the country-specific shocks do not contribute much towards the variance of the business cycle fluctuations once the country-specific manifestations of common shocks are accounted for requires a high R^2. This linear model has an R^2 of approximately 0.7. Thus the linear model without country specific shocks is able to explain 70% of the variance of observed business cycle fluctuations.

The data in figure 1 is the variance-covariance matrix that will be combined with the vectors of economic structure to find the instantaneous correlation between the business cycle fluctuations of the euro zone economies. The formula for instantaneous correlation in (3) assumes that the variances and covariances do not vary over time. When the variances of and the covariances between the shocks are computed for two different time periods and compared, it becomes clear that the assumption of constant variance-covariance is not unreasonable. Figure 1 shows the variances and covariances for the entire 1995:2 to 2005:4 time period, but figures 2 and 3 show the variances and covariances for the 1995:2 to 1998:4 and the 1999:1 to 2005:4 time periods, respectively.

Figure 2, Variance-Covariance Matrix for the 1995:2 to 1998:4 period:

	X	E	Z	A	M	C	T	F	P
X	9.1E-05	1.1E-05	-5.4E-04	1.6E-03	4.6E-04	-2.2E-05	7.1E-05	4.6E-04	8.8E-04
E	1.1E-05	1.8E-05	-1.1E-04	-7.1E-06	1.3E-04	-1.2E-04	8.1E-05	1.9E-05	2.2E-04
Z	-5.4E-04	-1.1E-04	5.2E-03	-1.5E-02	-4.8E-03	-1.7E-03	-4.2E-04	-6.0E-03	-7.6E-03
A	1.6E-03	-7.1E-06	-1.5E-02	5.9E-02	1.1E-02	4.0E-03	1.3E-03	2.0E-02	2.1E-02
M	4.6E-04	1.3E-04	-4.8E-03	1.1E-02	5.9E-03	5.0E-03	-7.3E-04	5.1E-03	6.4E-03
C	-2.2E-05	-1.2E-04	-1.7E-03	4.0E-03	5.0E-03	2.5E-02	-7.5E-03	5.3E-03	-2.5E-03
T	7.1E-05	8.1E-05	-4.2E-04	1.3E-03	-7.3E-04	-7.5E-03	2.6E-03	-3.2E-04	1.8E-03
F	4.6E-04	1.9E-05	-6.0E-03	2.0E-02	5.1E-03	5.3E-03	-3.2E-04	1.0E-02	5.6E-03
P	8.8E-04	2.2E-04	-7.6E-03	2.1E-02	6.4E-03	-2.5E-03	1.8E-03	5.6E-03	1.5E-02

Figure 3, Variance-Covariance Matrix for the 1999:1 to 2004:1 period:

	X	E	Z	A	M	C	T	F	P
X	1.9E-05	3.1E-07	-1.1E-04	3.0E-04	4.6E-05	2.2E-04	-3.6E-05	1.8E-04	1.6E-04
E	3.1E-07	1.2E-05	-5.2E-05	-3.7E-05	2.9E-05	-2.8E-04	9.3E-05	-3.5E-05	1.9E-04
Z	-1.1E-04	-5.2E-05	5.5E-03	-2.4E-02	-3.1E-03	5.7E-03	-1.3E-03	-7.9E-03	-9.8E-03
A	3.0E-04	-3.7E-05	-2.4E-02	1.4E-01	1.2E-02	-1.9E-02	2.4E-03	4.2E-02	3.3E-02
M	4.6E-05	2.9E-05	-3.1E-03	1.2E-02	2.4E-03	-1.5E-03	3.1E-04	4.4E-03	5.1E-03
C	2.2E-04	-2.8E-04	5.7E-03	-1.9E-02	-1.5E-03	3.5E-02	-8.7E-03	-4.3E-03	-1.7E-02
T	-3.6E-05	9.3E-05	-1.3E-03	2.4E-03	3.1E-04	-8.7E-03	2.5E-03	7.7E-04	3.9E-03
F	1.8E-04	-3.5E-05	-7.9E-03	4.2E-02	4.4E-03	-4.3E-03	7.7E-04	1.4E-02	1.0E-02
P	1.6E-04	1.9E-04	-9.8E-03	3.3E-02	5.1E-03	-1.7E-02	3.9E-03	1.0E-02	2.3E-02

The results from the test over the entire period remain intact when the period is divided in two. Only two of the 45 different variances and covariances increase or decrease by a factor of 10 between the two periods. This implies that while there may be marginal statistical changes, over 95% of the variances and covariances are of the same magnitude in both periods. This supports the claim that the variances and covariances are reasonably constant over time, and thus the formula in (3) is appropriate for finding the instantaneous correlation between cyclical fluctuations in the euro zone.

Section 3: Cyclical Correlation in the Euro Zone

3.1 Computing Instantaneous Correlation in the Euro Zone

The constant and consistent estimates of the variances of and covariances between the various shocks and the time and country specific measures of economic structure can be used as inputs in the instantaneous correlation model. The result is a correlation between European business cycles that is not based on backward looking observations of the country–specific parameter vector $\boldsymbol{\lambda}$. If the instantaneous correlation formula is applied to the linear model of European business cycle fluctuations in (5) and (6), and using the matrix $\hat{\mathbf{M}}$, the 9x9 variance-covariance matrix in figure 1 in the last section, the instantaneous correlation between the business cycles of countries A and B is:

$$\rho_{AB,t} = \frac{\boldsymbol{\lambda}'_{A,t}\hat{\mathbf{M}}\boldsymbol{\lambda}_{B,t}}{\sqrt{\left(\boldsymbol{\lambda}'_{A,t}\hat{\mathbf{M}}\boldsymbol{\lambda}_{A,t}\right)\left(\boldsymbol{\lambda}'_{B,t}\hat{\mathbf{M}}\boldsymbol{\lambda}_{B,t}\right)}} \qquad (11)$$
$$\text{where}: \boldsymbol{\lambda}'_{j,t} = \left[\theta_{j,t} \quad D_j \quad 1 \quad \alpha_{i,j,t}\ for\ i = 1..6\right] for\ j = A,B$$

From the formula in (11) it is easy to calculate the instantaneous correlation between the business cycles of any two euro zone countries given their respective economic structure vectors, $\boldsymbol{\lambda}_{j,t}$. The beauty of the instantaneous correlation is that it is specific to a given time period and pair of countries, so thousands of correlations exist. For reporting purposes, I will only report the correlation between each euro zone country and the euro zone average for the first quarter of 1999 and the last quarter of 2005. The correlation between a country and the euro zone average is important because the ECB tailors monetary policy for the euro zone average, so if a country's business cycles are highly correlated with the euro zone average there is a high probability that they will receive the correct monetary policy for their economic conditions. The correlations between the business cycles of any two euro zone countries are available and interesting, but it is the lack of a perfect correlation between a country's business cycles and those of the entire euro zone measures the cost of a common currency. Table 1 reports these instantaneous correlations for a number of euro zone and notable Western European countries for the first quarter of 1999 and the last quarter of 2005.

Table 1, Euro zone instantaneous correlations for 2005:4

Correlation in 1999:1	Country	Correlation in 2005:4
0.718	Belgium	0.801
0.740	France	0.743
0.729	Germany	0.879
0.726	The Netherlands	0.649
0.160	Austria	0.235
0.567	Finland	0.423
0.425	Greece	0.254
0.495	Italy	0.402
0.754	Portugal	0.682
0.439	Spain	0.307
0.069	Britain	0.214
0.485	Denmark	0.294
0.360	Sweden	0.393
-0.095	Norway	0.042
0.351	Switzerland	0.193

These 15 countries are separated into 4 groups for reporting purposes. The first group in the table is the group of countries considered the core of the euro zone. The second group is considered the periphery of the euro zone. The third group is simply a group of EU member countries that are not members of the euro zone. And the fourth group is a selection of a few Western European countries that are not EU members. Clearly, these instantaneous correlations seem to comply with anecdotal evidence in favor of a two-tiered euro zone with a core and a periphery. The results imply that the countries in the industrial heartland of Europe have high correlation between their business cycles and those of the euro zone average, but countries away from that industrial heartland have business cycles that are less correlated. Similarly countries outside the euro zone have correlations at or below those of the periphery.

3.2 Measuring Cyclical Correlation through Counterfactual Situations

Business cycle correlation measures the cost of a common currency. Instantaneous correlations are particularly useful because they allow one to study the effect of changing particular parts of a country's economic structure on correlation. One can isolate the effect on cyclical correlation that comes from a changing economic structure by calculating the instantaneous correlation under various, imposed vectors, $\boldsymbol{\lambda}_{j,t}$. One can isolate the effect of increased trade openness on cyclical correlation by calculating the instantaneous correlation under different levels of trade openness, or one can estimate the effect of industrial specialization by calculating the instantaneous correlation under different, hypothetical, industrial structures.

A common currency will induce more trade between the member economies. Since currency exchange is a barrier to trade, removing that barrier facilitates increased trade between the euro zone countries. Frankel and Rose (2002) found that a country that enters into a currency union will see a threefold increase in its volume of trade with other members of that union. These numbers have since been downgraded, but it is commonly accepted that a common currency will lead to increased trade between the member countries. Given that a common currency will lead to more trade, the debate focuses on the effect of trade on business cycle correlation. This debate revolves around two distinct and mutually exclusive theories. Krugman (1993) contends that increased trade between two economies will not in and of itself cause business cycle convergence between the two. He speculates that increased trade will cause the economies to specialize in the industries for which they have a comparative advantage. Thus when the economies of the currency union are struck by certain industry specific shocks, the effects of those shocks will be localized and not distributed across all countries in the currency union. These asymmetric reactions to symmetric shocks will create more cyclical divergence between the members of the currency union. Frankel and Rose (1998) contend that common and demand side shocks will be better distributed through the entire currency union through the increased trade of goods and services. They acknowledge the fact that increased trade can lead to industrial specialization and more asymmetric shocks, but they believe that symmetric responses to common and demand side shocks will dominate the asymmetric responses to industry-specific shocks, so the economies of the currency union should see their business cycles converge to a common, union-wide, business cycle.[3]

3.2.1 The Effect of Increased Trade on Cyclical Correlation

The effect of increased trade openness on cyclical correlation can be found by calculating instantaneous correlations twice. First the correlations are calculated in each quarter using the observed levels of trade openness, and then it is calculated in each quarter using the levels of trade openness from the first quarter of 1999.

$$\begin{array}{l} \text{with increased trade}: \boldsymbol{\lambda}'_{j,t} = \left[\theta_{j,t} \quad D_j \quad 1 \quad \alpha_{i,j,t} \; for \; i = 1..6\right] \\ \text{without increased trade}: \boldsymbol{\lambda}'_{j,t} = \left[\theta_{j,1999:1} \quad D_j \quad 1 \quad \alpha_{i,j,t} \; for \; i = 1..6\right] \end{array} \qquad (12)$$

Thus the two vectors $\boldsymbol{\lambda}_{j,t}$ for $j = A,B$ will be used to compute the instantaneous correlations once given that the euro induced greater trade openness and once given that the euro did not affect trade openness. The left hand column of table 2 reports the instantaneous correlations in the fourth quarter of 2005 if the euro zone countries do not become more open to trade after the

[3] It should be noted however that while Frankel and Rose advocate the theory that membership in a currency union will lead to cyclical converge, they accept that there can be other views and consider it an open question.

first quarter of 1999, and the right hand column of table 2 then reports the absolute change in the correlations due to increased trade

Table 2, Instantaneous correlations in 2005:4 given θ from 1999:1, and the absolute change in correlation due to increased trade.

Trade Controled Correlation in 2005:4	Country	Change in Correlation due to Increased Openness
0.682	Belgium	0.120
0.727	France	0.016
0.845	Germany	0.034
0.529	The Netherlands	0.121
0.180	Austria	0.056
0.331	Finland	0.093
0.324	Greece	-0.070
0.554	Italy	-0.152
0.647	Portugal	0.035
0.320	Spain	-0.012
0.252	Britain	-0.037
0.272	Denmark	0.022
0.246	Sweden	0.146
0.082	Norway	-0.039
0.105	Switzerland	0.088

In most cases, increased trade has lead to increased correlation, but some countries have notice a decrease in their correlation with the euro zone average as a result of increased international trade over the past 7 years. Also the magnitude of the absolute change in correlation is varied across the sample of countries. The increased trade has greatly improved correlation in small, open, core economies like Belgium and The Netherlands. At the same time the impact is not that great in larger, less open economies like France and Germany.

3.2.2 The Effect of Industrial Specialization on Cyclical Correlation

Not only will a common currency cause increased trade in the euro zone, but this increased trade will lead to industrial specialization as countries specialize in the industries for which they have a comparative advantage. This industrial specialization leads to greater cyclical correlation if a country specializes like the rest of the euro zone, and it leads to less cyclical correlation if a country specializes differently from the rest of the euro zone. If the instantaneous correlations are calculated for 2005:4 given the industrial structures from 1999:1 it is like finding the correlation at the end of 2005 conditional on there having been no industrial specialization since the adoption of the euro. In terms of the model, the instantaneous correlations are calculated for two values of $\boldsymbol{\lambda}$:

$$\begin{aligned} &\text{with industrial specialization}: \boldsymbol{\lambda}'_{j,t} = \left[\theta_{j,t} \quad D_j \quad 1 \quad \alpha_{i,j,t} \; for \; i = 1..6\right] \\ &\text{without industrial specialization}: \boldsymbol{\lambda}'_{j,t} = \left[\theta_{j,t} \quad D_j \quad 1 \quad \alpha_{i,j,1999:1} \; for \; i = 1..6\right] \end{aligned} \tag{13}$$

The instantaneous correlation results given industrial specialization are contained in table 1, but correlations with no industrial specialization are given in the left hand column of table 3. The absolute change in the correlation as a result of industrial specialization is found in the right hand column of table 3.

Table 3, Instantaneous correlations in 2005:4 given the industrial structures from 1999:1, and the absolute change in correlation due to industrial specialization.

Specialization Controlled Correlation in 2005:4	Country	Change in Correlation due to Increased Specialization
0.818	Belgium	-0.016
0.749	France	-0.006
0.793	Germany	0.085
0.797	The Netherlands	-0.147
0.279	Austria	-0.044
0.654	Finland	-0.230
0.409	Greece	-0.156
0.376	Italy	0.026
0.782	Portugal	-0.100
0.455	Spain	-0.148
0.103	Britain	0.111
0.485	Denmark	-0.191
0.499	Sweden	-0.107
-0.104	Norway	0.147
0.465	Switzerland	-0.272

The numbers in the right hand column of table 3 represent the absolute increase or decrease in correlation due to industrial specialization. If this number is positive then the country's business cycles became more correlated with the euro zone average as a result of industrial specialization, and if this number is negative then the country's business cycle became less correlated with the euro zone average. As is to be expected, industrial specialization has lead to increased correlation in some countries and decreased correlation in others. This is because some countries are specializing more like the euro zone average and some are specializing away from the euro zone average. Of the countries in the core, the change in correlation is for the most part positive or negative and small. This is in direct contrast to the countries in the periphery where the change in correlation is quite significant and negative in every case except for Italy. Italy is a particularly interesting case. While many would place Italy in the periphery, many would argue that Italy is becoming more like the core. These calculations clearly show that industrial specialization is making Italy more like the core of the euro zone.

These results do not give a definitive answer as to which side effect of trade, the demand spillovers or the industrial specialization, has a greater impact on cyclical correlation. For the majority of the countries, the industrial specialization is found to have a greater absolute impact on cyclical correlation than demand spillovers, but a few notable exceptions challenge this rule. A few core countries like Belgium and France see the effect of demand spillovers trump the effect of industrial specialization; this is also true for Italy and Austria in the periphery, as well as Sweden outside the euro zone. Further theory is needed to explain why the converging effect of demand spillovers and industrial specialization differs so much across countries.

Summary and Conclusions

In order for the euro to function as a common European currency, the cost of monetary union in terms of real instability must come down. This real instability arises because a union-wide monetary policy can never be better than a country-specific monetary policy, but it has the possibility of being much worse. How much worse depends on the correlation between a country's business cycle fluctuations and those of the entire euro zone. This paper has shown, through the method of instantaneous correlation and various counterfactual calculations that a common currency will not systematically increase cyclical correlation. Increased trade between members has both cyclically converging and diverging effects, and the magnitude of those effects differs across countries. Therefore, for the euro to work as a common currency, something must be done to lessen the severity of the inevitable real instability.

The severity of this real instability can be lessened by either greater factor mobility or fiscal federalism. Greater factor mobility lessens the severity of real instability because factors of production can move between regions at different points in the cycle. The high unemployment and low capital utilization rates associated with a recession and the high input price inflation associated with a boom can be alleviated as factors move to the latter region from the former. The Treaty of Rome mandates that there are no statutory barriers to factor mobility within the EU, but national governments need to ensure that this mandate is actually satisfied, and provide the necessary tools for labor and capital to easily move between EU countries.

Fiscal federalism lessens the severity of real instability because money is directly transferred between countries at different points in the cycle. This smoothes the cycle as a boom (and resulting high inflation) is lessened by fiscal tightening, and a recession (and resulting high unemployment) is lessened by fiscal stimulus. This fiscal smoothing is possible in an EU with a federalist system with the power to transfer funds, but the current EU budget is so small that any attempts at federalist transfers would have only a marginal effect. A functioning monetary union in Europe is not possible without a functioning political union. Without a strong federal system with the power to tax, spend, and transfer funds, the cost of a common currency in terms of real instability will continue to far outweigh the benefits.

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