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Convergence in the Core Euro Zone under the Global Financial Crisis

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Abstract

A lack of economic convergence among euro member countries seems to be feeding euro-skepticism. Using a Structural Vector Auto Regression model combined with a time varying correlation analysis, we attempt to test the endogeneity theory for the three core euro members, i.e., France, Germany, and Italy. We provide evidence that the adoption of the euro has increased the symmetry of underlying shocks and accelerated the convergence process within this group. Even though the global crisis of 2007~2009 disturbed the European convergence process, the expected endogeneity effects continue to be generated, and the euro-skepticism is not corroborated.

JEL Classifications: C32, E42, F44, O52
Key words: Endogeneity Effect, Convergence, Euro, Structural VAR, Dynamic Correlation

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I. Introduction

Triggered by the Greek crisis and fed by a feeling of economic divergence, skepticism seems to be growing in the euro zone. If the cleavage within the euro group, i.e., so-called 'North' and 'South', were formally confirmed, keeping the common currency would make no sense for many economists. In the 1990s, before the launch of the euro, many economists were rather skeptical about the monetary union, arguing that Europe was not an Optimum Currency Area (OCA). Their conclusions were often based on an ex ante application of OCA criteria.[1] In contrast, Frankel and Rose (1998) argued that it was more likely for the member countries to satisfy *ex post* the OCA criteria than *ex ante*. They highlighted the desirable self-fulfilling characteristics of the integration process as a common currency might intensify trade integration and thus business cycle synchronization.

Meanwhile, Frankel and Rose (1998) recognized that, theoretically, monetary and trade integration could also result in a desynchronization of business cycles: if a country joins a currency union and thus increases its trade with other member countries, its business cycle could become more idiosyncratic due to a stronger specialization in the sectors in which it has a comparative advantage (Krugman, 1993; Kenen, 1969). Furthermore, increased specialization is likely to make the country more sensitive to industry-specific shocks, which is in turn likely to lead to a greater divergence in business cycles. Empirical evidence in favor of this prediction was reported by Camacho *et al*. (2006), Canova *et al*. (2007), and Azomahou *et al*. (2011), among others. In general, this assumption holds when *inter*-industry trade prevails with a higher degree of specialization. However, if *intra*-industry trade prevails with a lower degree of specialization and less asymmetric shocks, then trade and monetary integration could strengthen business cycle correlation. Empirical evidence of this assumption was also provided by Caporale *et al*. (1999), Kose and Yi (2001), Corsetti and Pesenti (2002), Rose and Engel (2002), Artis *et al*. (2004), and Kose and Yi (2006), among others. In addition, recent findings on so-called vertical specialization are consistent with this positive link between monetary and trade integration and business

[1] Traditional OCA criteria comprise factor (labor) mobility (Mundell, 1961), economic openness (McKinnon, 1963), degree of industrial diversification (Kenen, 1969) and inflation similarity (Fleming, 1971); while some other criteria have been proposed in the literature, including fiscal integration (Bayoumi and Masson, 1995; De Grauwe, 1997) and capital market or financial integration (Mylonidis and Kollias, 2010; Schiavo, 2008).

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cycle synchronization (Giovanni and Levchenko, 2010), even though, according to Arkolakis and Ramanarayanan (2009), the effects of vertical specialization on the relationship between trade integration and business cycle synchronization depend on model specification.

Given this theoretical ambiguity, Frankel and Rose (1998) focused on empirical tests and found a strong positive link between trade and monetary integration and business cycle synchronization in Europe. Endogeneity theory served then as an academic support to the euro project. Today, 14 years after the adoption of the single currency, we attempt to examine whether expected endogeneity effects have been effectively generated in the euro area. In particular, we focus on the dynamic of convergence, considering endogeneity effects as an ongoing increase in economic convergence. In addition, we focus on the dynamic of convergence among three core euro countries: France, Germany, and Italy. Given their predominant weight in the group, if their multilateral convergence has been accelerated with the single currency, the endogeneity assumption would be confirmed, which would lead to a conclusion in favor of the euro system. In contrast, if they converge less than before, then endogeneity theory would be challenged and euro-skepticism could be justified.

Our analysis will be performed as follows. First, we consider not only the supply-side but also the demand-side convergence, whereas many analyses focus only on synchronization of short-term fluctuations in output.[2] As suggested by Frankel and Rose (1998, p.1010), a simple assumption that the demand side of the economy can prevail, especially in the short run, may fully justify the importance of considering demand-based convergence. Indeed, if shocks on the demand side of the economy prevail and if they are symmetric (due to, for example, high similarity in consumption, investment, public spending, fiscal and monetary policy, strong co-movement in capital and financial markets), then business cycles would tend to synchronize. Some empirical evidence of demand-side-led convergence in the euro zone has been reported in the literature. For example, Schiavo (2008) finds that the adoption of the euro has intensified financial and trade integration, which has resulted in a stronger convergence in output, while Inklaar *et al*. (2008) find that convergence in monetary and fiscal policies has a significant impact on business cycle synchronization. More recently, Mylonidis and Kollias (2010), Worthington and Higgs (2010), and Pozzi and Wolswijk

[2] Indeed, although the question of convergence in Europe has been widely discussed among policy makers and academics, the convergence in output has often been highlighted. Frankel and Rose (1998) also use the correlation of short-term fluctuations in output (GDP, industrial production, employment, and unemployment) as the (unique) measure of convergence.

(2012) examine capital market convergence among major euro member countries and confirm a higher convergence resulting from the single currency.

To take the growing importance of monetary and financial market integration in the European convergence process into account, we furthermore decompose the demand-side convergence into real (demand) convergence and monetary convergence. Thus, we distinguish between supply-side convergence and demand-side convergence on the one hand and between real convergence and nominal convergence on the other. This twofold distinction leads us to consider three types of macrostructural variables that we will attempt to identify and recover using a Structural Vector Autoregressive (SVAR) model.[3] In line with open economy macroeconomic theories, this approach allows us to generate time series of underlying shocks that are not observable initially but represent structural aspects of the economy. Following Clarida and Gali (1994), but using a one-country model, we will attempt to recover three types of shocks: supply shocks, real demand shocks, and monetary shocks. Once recovered, each of these series will be used to estimate cross-country correlations, which will in turn serve to assess the degree of convergence.[4]

Second, considering convergence in the euro zone as an ongoing and time-varying process, we focus on the dynamic feature of convergence. In the literature, the dynamic of the European convergence process has been highlighted in many analyses using diverse approaches. Among others, Artis *et al*. (2004) use Markov switching vector autoregressive models to extract a common factor from the dynamics of business cycles, while Forni *et al*. (2000) establish an index of common activity using a dynamic factor model. Xu (2006) uses a SVAR approach and proposes to decompose the already-recovered underlying shocks into two components, common shocks and specific shocks. In his approach, the nature of the former assesses the dynamic of convergence. More recently, Mylonidis and Kolias (2010) suggest the time-varying number of cointegration relationships as a measure of convergence.

This paper prefers to use a sliding window technique when estimating correlation

[3] We use an extension of the Blanchard-Quah's structural vector autoregressive (SVAR) approach. The very first applications of the Blanchard-Quah (1989) approach include Shapiro and Watson (1988), Gali (1992), Lastrapes (1992), Bayoumi and Eichengreen (1993, 1994), and Clarida and Gali (1994). Recently, this method was used in Cover and Mallick (2012), Lee and Koh (2012), Bashar (2011), Barsky and Sims (2011), Mertens (2010) and Laopodis (2009), among others.

[4] Correlation of supply shocks measures the degree of convergence in productivity, technology, export competitiveness, and/or industry specialization (however, it should be noted that the similarity in industry specialization can be high either when two countries are specialized in a same sector, or when they are equally not specialized in any sector, indicating that their economies are well diversified simultaneously); correlation of demand shocks assesses the degree of convergence in consumption, investment, import, public spending and/or fiscal policy; correlation of monetary shocks measures the degree of convergence in prices, financial markets, demand for money, money supply, and/or other monetary policy.

coefficients of underlying shocks, considering that the time-varying feature of convergence can be better represented by a 'rolling' measure than a 'recursive' one. In addition, we will use five different (Two-, Three-, Five-, Seven-, and Ten-year) time spans of the sliding window in order to distinguish between convergence processes in different time horizons. At the same time, the use of these different time lengths may serve as a first sensitivity analysis when results based on a sliding window are highly dependent on the length of window. In terms of a second sensitivity analysis, we also employ the Dynamic Conditional Correlation (DCC) model of Engle (2002) to see whether considering volatility in the variances of the shocks series significantly affects the dynamic of the correlations.

In general, our empirical results show that the nature of underlying shocks to the core euro countries has clearly become more symmetric since the adoption of the euro, whereas we also find some disturbance in the convergence process, clearly attributable to the global crisis of 2007~2009. It is especially the case for supply-based convergence (and monetary convergence to some limited extent), while demand-based convergence has continued to increase despite the global crisis. And more surprisingly, there is no evidence that the euro crisis of 2010~2012 has disturbed the euro-group's convergence process. On the contrary, our results suggest that 'multilaterality' has been enhanced during the last three years. Another interesting finding is that Italy has converged more rapidly and closely with Germany than France, while its correlations with Germany were either close to zero or negative before the adoption of the euro.

Our results confirm the traditional idea that France and Germany are the core of the euro zone, the most closely integrated countries to each other. However, our findings also suggest that the supply-side convergence process is led by Germany, while France continues to lead demand-side convergence. In all, we provide clear-cut evidence that the expected endogeneity effects have been actually generated within the core group, and consequently euro-skepticism is not corroborated at least. The remainder of the paper is organized as follows. Section II describes the methodology. Section III reports and discusses data and empirical results. Section IV presents results of the sensitivity analysis. Section V presents a conclusion.

II. Methodology

We use a three-step methodology : (1) to recover three types of underlying shocks using a SVAR model;[5] (2) to estimate time-varying correlations of shocks using a sliding window technique ; (3) to test the sensitivity of results using both diverse time spans of the sliding window and the DCC models.

A. Extracting the Series of Underlying Shocks

In order to recover three types of underlying shocks, we first construct a standard three-variable VAR model including the Industrial Production index (IP), the trade-weighted Real Effective Exchange Rate (REER), and the Consumption Price Index (CPI). We specifically prefer the country-by-country estimation approach because the relative aspect will be analyzed in terms of a cross-country correlation of shocks. Our choice to use the effective exchange rates, instead of the bilateral rates, is also consistent with this country-by-country estimation approach.

Our three-variable VAR model with k lags can be written as follows:

$$A(L)X_t = e_t \tag{1}$$

where X_t is the vector of the three variables in first (log) differences,[6] that is, $X_t=[\Delta IP_t, \Delta REER_t, \Delta CPI_t]'$; e_t is the vector of the estimated residuals in the standard VAR, that is, $e_t=[e_{\Delta IP,t}, e_{\Delta REER,t}, e_{\Delta CPI,t}]'$ with $var(e_t) = \Omega$; A_i are the 3x3 matrices of autoregressive coefficients with $A(L)=\sum A_i L^i$ $(i=0,..,k)$ and $A_0=I$; Δ is the difference operator, and L is the lag operator. Then, because the vector X_t is stationary, the Autoregressive (AR) representation can be written in a Moving Average (MA) form as:

$$X_t = B(L)e_t \tag{2}$$

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[5] The SVAR model was first applied in an OCA context by Bayoumi and Eichengreen (1994), followed by Frankel and Romer (1999), Chow and Kim (2003), Fidrmuc (2004), Zhang *et al*. (2004), Frenkel and Nickel (2005), Xu (2006), and Jeon and Zhang (2007), among others.

[6] As mentioned in the following section, the ADF test shows that all our variables are I(1).

where B_i is the 3x3 matrices of coefficients with $B(L)=\Sigma B_i L^i$ $(i=0,..,k)$ and $B_0=I$. By definition, we also have $B(L)=A(L)^{-1}$. In this reduced form (that is, $A_0=B_0=I$), the endogenous variables are functions of the residuals e_t. This VAR system can be easily estimated by the OLS method.

Now, we assume that fluctuations in the economy result from diverse types of underlying shocks (ε) that are not observable with macroeconomic data. It is also assumed that any underlying shocks series follows a white noise process. Their variance can be then normalized to unity, i.e., $var(\varepsilon)=I$. Under these assumptions and following Clarida and Gali (1994), we distinguish three types of underlying shocks: supply shocks, demand shocks, and monetary shocks. Supply shocks (ε_{AS}) refer to any shocks to the supply side of the economy, such as shifts in technology and changes in productivity. Demand shocks (ε_{IS}) refer to any shocks on the real demand side of the economy, such as changes in consumption, investment, government spending, and fiscal policy; while monetary shocks (ε_{LM}) represent any shocks to monetary demand or disturbance in financial markets, and changes in monetary policy.

If the economy is represented by the standard VAR system described above, the assumptions imply that fluctuations in the three variables of the VAR model result from the three types of underlying shocks. In other words, if each of the three variables is expressed as a function of the three white noise shocks (ε_t), the initial standard VAR model can be converted into a structural VAR model as:

$$X_t = C(L)\varepsilon_t \tag{3}$$

where ε_t is the vector of the white noise shocks, that is, $\varepsilon_t=[\varepsilon_{AS,t}, \varepsilon_{IS,t}, \varepsilon_{LM,t}]'$ with $var(\varepsilon_t)=I$. Here, ε_{AS} is the series of supply shocks, ε_{IS} the series of demand shocks, and ε_{LM} the series of monetary shocks; C_i is the 3x3 matrices of coefficients with $C(L) = \Sigma C_i L^i$ $(i=0,..,k)$, which represent the effects of the underlying shocks on the three variables.

Now, we can use the relationship between the two MA representations of X_t, that is, Equation (2) and (3), in order to recover the series of underlying shocks, ε_t, from the data and the estimated regression errors, e_t. In fact, the contemporaneous effects of the stochastic errors on the variables−reflecting $\{X_t=B_0 e_t=e_t\}$− should, by definition of the reduced form of the model, coincide with the contemporaneous effects of the white noise shocks on the variables – reflecting $\{X_t=C_0\varepsilon_t\}$. This means that $\{e_t=C_0\varepsilon_t\}$ should hold for every t. More formally, if S denotes the unique lower triangular Choleski factor of Ω, then we have $\{e_t = S\varepsilon_t = C_0\varepsilon_t\}$.[7] Hence, we only need to identify C_0 in order to recover the underlying shocks using $\{\varepsilon_t = C_0^{-1} e_t\}$, as e_t is already known. And because C_0 has nine unknown elements, we need nine restrictions to identify it. But we have $\{C_0 C_0' = \Omega\}$[8] and Ω is already known, so we already have six restrictions for identification of C_0. It follows that only three additional restrictions are needed to identify C_0.

In the empirical literature relative to structural VAR modeling, there are in general two approaches that allow us to obtain additional identification restrictions. The first one, proposed by Sims (1980) and Bernanke (1981), is to impose restrictions directly on the matrix C_0. For example, a restriction $C_0\{1,2\}=0$ means that the simultaneous effects of the second underlying shocks on the first variable are assumed to be zero. While this method can make sense mathematically, there are few economic foundations. The second approach, proposed by Blanchard and Quah (1989), is to impose restrictions in the long run. If C_S refers to the matrix of sums of all matrices C_i with $i=1,\ldots,k$, where k is the number of lags (that is, $C_S = C_0 + C_1 + C_2 + \ldots + C_k$), the long-run restrictions are imposed on C_S. Then, a restriction $C_S\{1,2\}=0$, for example, means that the accumulated effects of the second underlying shocks on the first variable are assumed to be zero. In general, this approach is considered as being more in line with economic theories. This is why we choose this approach for our SVAR modeling.

Now, we shall clarify how restrictions on C_S can help identify C_0. If B_S refers to the matrix of sums of all matrices B_i with $i=1,\ldots,k$, where k is the number of lags (that is, $B_S = B_0 + B_1 + B_2 + \ldots + B_k$), one can write $B_S \Omega B_S' = C_S C_S'$. At the same time, if H denotes the unique lower triangular Choleski factor of $B_S \Omega B_S'$, we can impose the long-run restrictions in such a way that C_S also be a lower triangular matrix. This gives us $\{H \equiv C_S\}$. Then, because $C_S C_S' = HH' = B_S \Omega B_S' = B_S C_0 C_0' B_S'$, we can write $\{B_S C_0 = H\}$, which gives $\{C_0 = B_S^{-1} H\}$. These equations show that restrictions on C_S provide additional information on C_0 through B_S and H. For example, a restriction such as $C_S\{1,2\}=0$ gives information on $C_0\{1,2\}$ and thus provides an additional condition for the identification of C_0.

In order to identify C_0, we use the following three theoretical restrictions that are consistent with standard long run properties of an open economy macroeconomic

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[7] Because $ee' = \Omega = SS' = S/S' = S\varepsilon\varepsilon' S' = S\varepsilon(S\varepsilon)' \equiv C_0\varepsilon(C_0\varepsilon)'$ and the equality $S\varepsilon(S\varepsilon)' \equiv C_0\varepsilon(C_0\varepsilon)'$ comes from the fact that any non-singular matrix C_0 such that $C_0 C_0' = \Omega$, is an orthonormal transformation of S.

[8] With $\{var(e_t) = \Omega\}$, $\{var(\varepsilon_t) = I\}$, and $\{e_t = C_0\varepsilon_t\}$, we have $\Omega = (e_t)(e_t)' = (C_0\varepsilon_t)(C_0\varepsilon_t)' = (C_0)(\varepsilon_t)(\varepsilon_t)'(C_0)' = (C_0)(C_0)'$, which gives us $\{C_0 C_0' = \Omega\}$.

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equilibrium (Obstfeld, 1985), which do not challenge the key assumptions in the short run either[9]: (1) supply shocks have permanent effects on the change in industrial production, whereas demand and monetary shocks have only transitory effects;[10] (2) supply and demand shocks have permanent effects on the variation of real effective exchange rates, whereas monetary shocks have only transitory effects;[11] (3) all the three types of shocks have permanent effects on the variation of prices. These restrictions imply $C_S\{1,2\}=0$, $C_S\{1,3\}=0$, and $C_S\{2,3\}=0$. Under the assumption that the three types of underlying shocks affect the economy in this way, the matrix C_0 can be now identified, and the series of shocks can be recovered using $\{\varepsilon_t=C_0^{-1}e_t\}$ for each of the examined countries.

B. Measuring Time-Varying Convergence

Once the series of underlying shocks are recovered for each country examined, the second step is to estimate the dynamic cross-country correlations of shocks. While there exist several methods designed to examine time-varying correlations, we mainly employ a (month-by-month) sliding window technique. That is, the sample period for which the correlation is estimated slides month by month, while the sample size remains unchanged. For example, with a five-year window using monthly data, a first correlation coefficient is estimated for observations 1 through 60, and a second coefficient is estimated for observations 2 through 61, and so forth. It follows that, if we examine a total period of n months using a k-month-long sliding window, we will estimate $(n-k+1)$ correlation coefficients for a given bilateral relationship.

The resulting time series of correlations captures any variation in the bilateral symmetry of shocks over time. Hereby, we treat economic convergence as an ongoing process, which can allow us to identify some possible exogenous disturbances such as the global crisis of 2007~2009 and the euro crisis of 2010~2012, for example. A clearer picture of the time-varying convergence process can be then provided, leading to a more appropriate interpretation of results and thus more useful policy implications.

This sliding-window-based correlation analysis will be then complemented using

[9] For example, the assumption of sluggish price adjustment in the short run (Mundell-Fleming-Dornbusch model) is allowed with these long run restrictions.

[10] This restriction implies that the long-run effect of demand and monetary shocks on industrial production is zero.

[11] This restriction implies that the long run effect of monetary shocks on the real effective exchange rate is zero.

the Dynamic Conditional Correlation (DCC) model of Engle (2002). Based on the multivariate ARCH/GARCH[12] approach, the DCC model enables us to take into account possible impacts of the time-varying nature of the variance of underlying shock series on the dynamic cross-country relationships. Notice, however, that the DCC-based analysis is implemented here in a complementary way, i.e., in terms of a sensitivity analysis since we consider the moving-window approach better suited to distinguish possibly different time horizons from each type of European convergence process.

C. Sensitivity Analysis

Once the dynamic correlations using the five-year moving window have been estimated, we perform two sensitivity analyses to enhance the robustness of the results. First, to test if different time spans of the sliding window affect the estimates of the degree of the convergence, we evaluate the dynamic correlations using four other window spans: two-, three-, seven- and ten-year windows. This analysis also allows us to discuss explicitly the convergence in different time horizons. For example, two- or three-year window correlations would be more appropriate to denote demand-side convergence in the short run, while seven- or ten-year window correlations would be more appropriate to refer to the supply-side convergence in the long run. However, one may normally expect to obtain a more volatile correlation when using a shorter time span of window. For example, the evolution of the two-year correlations is likely to be much more volatile than that of the ten-year correlations.

In an effort to account for the different volatility observed in dynamic correlations estimated with different time-lengths of window, the DCC model is implemented as a second sensitivity analysis. In order to estimate *one* dynamic bilateral correlation series corresponding to each type of the three estimated underlying shock series (i.e., supply, demand and monetary shocks) for each of the three country-pairs (i.e., France-Germany, France-Italy, and Germany-Italy), we use a *bivariate* GARCH(p,q) model with two (k=2) underlying shock series (ε) of the same type for two countries.[13] Here, we briefly describe the DCC estimation method.

Let ε_t denote a 2×1 vector of the estimated underlying shock series. We further

[12] ARCH = Auto-Regressive Conditional Heteroskedasticity (Engle, 1982) ; GARCH = Generalized ARCH (Bollerslev, 1986).

[13] Because there are three country-pairs and three types of shocks, we set up and estimate nine bivariate GARCH(p,q) models.

assume that ε_t is conditionally multivariate normal, and H_t denotes its conditional variance-covariance matrix, and θ_{t-1} denotes information available at $t-1$. Following Engle (2002), the DCC model can be then written as follows:

$$
\begin{aligned}
&\varepsilon_t \mid \theta_{t-1} \sim N(0, H_t) \\
&H_t = D_t R_t D_t \\
&u_t = D_t^{-1} \varepsilon_t \\
&Q_t = S(1-\alpha-\beta) + \alpha u_{t-1} u'_{t-1} + \beta Q_{t-1} \\
&R_t = diag\{Q_t\}^{-1} Q_t diag\{Q_t\}^{-1}
\end{aligned} \tag{4}
$$

where R_t is a 2×2 matrix of time-varying correlations; u_t is the 2×1 vector of conditional standardized residuals obtained from the univariate GARCH models; D_t is the 2×2 diagonal matrix of u_t; S is the unconditional correlation matrix of u_t; Q_t is the conditional covariance matrix of u_t; α and β are the DCC parameters that govern Q_t.

Then, as the conditional normality of ε_t gives rise to a likelihood function, the likelihood of the DCC estimator with k=2 for our models may be written as follows:

$$L = -\frac{1}{2}\sum_{t=1}^{T}\left(k\log(2\pi) + 2\log(|D_t|) + \log(|R_t|) + u'_t R_t^{-1} u_t\right) \tag{5}$$

As shown in Engle (2002), there are two components in this function – a ‘volatility component’ with terms in D_t and a ‘correlation component’ with terms in R_t, which allows for a two-step Maximum Likelihood estimation. In the first step, R_t is replaced with a 2×2 identity matrix to maximize only the volatility component, D_t. In the second step, the correlation component (R_t), conditional on the estimated D_t, is then maximized to estimate α and β, which finally enables us to obtain the series of dynamic conditional correlation via the matrix Q_t.

Applying the DCC model to our analysis, we actually take into account the time-varying nature of the *variances* of the estimated underlying shocks, which cannot be considered in the moving-window approach. In addition, this model allows us to estimate the dynamic correlations without imposing any *ad hoc* length of window. However, what is more interesting about this application is that it enables us to compare its results with those obtained using the moving-window technique, which is useful in selecting and confirming the most appropriate time length of window for convergence process.

III. Data and Results

A. Data

Our data on industrial production, real effective exchange rates, and the consumer price index for France, Germany, and Italy are drawn from the International Financial Statistics released from the International Monetary Fund. The frequency of our data is monthly, and the sample period ranges from January 1992 to June 2012. Some basic statistics of variables are shown in Table A in the Appendix.

B. Recovered Series of Underlying Shocks

Our assessment of shock correlations starts by constructing a standard three-variable VAR model for each of the three countries examined. We first perform the ADF tests with up to 15 lags with each of the examined time series, which confirms that all variables included in our VAR models are $I(1)$. The AIC and BIC tests are also performed to select the optimal lag length for each of our VAR models (Table B in the Appendix). Thus, our initial VAR model comprises first log differences in industrial production, real effective exchange rates, and the consumer price index, with three lags. This standard VAR is then estimated by the usual OLS method. Based on this result and using the three long-run restrictions mentioned before, we finally recover the series of underlying shocks for each of the three countries examined. Table C in the Appendix reports basic statistics of the estimated underlying shock series and results of the ADF tests. As expected, each of the series is stationary with zero mean and unit variance.

C. Static Correlations of Shocks

For the purpose of a simple comparison between pre- and post-euro periods, Table 1 below reports static correlations of underlying shocks for the three bilateral relationships (France-Germany, France-Italy, Germany-Italy), estimated for the pre-euro period (July 1992 to December 1998) and post-euro period (January 2006 to June 2012), both with the same length of time, 78 months. One can easily notice that shock symmetry has

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been significantly increased for all types of shocks in all bilateral relationships.

Let us now compare the post-euro correlations with the pre-euro ones, across different types of shocks. We notice that there have been some significant increases in the supply-side convergence, even though they are smaller than those in the demand-side convergence. This observation provides our first confirmation of the endogeneity prediction: that the single currency seems to have enhanced the supply-side convergence in the euro group. It is especially the case for the Germany-Italy relationship: they diverged with a negative correlation (-3.57%) before, but now their convergence (32.85%) is even higher than that between France and Italy (27.98%). This means that the business cycle of Italy is today more closely synchronized with that of Germany than with France's, even though it had previously converged with France's. Meanwhile, the highest convergence in output is however recorded by the France-Germany pair (36.87%).

Table 1. Static Correlations of Underlying Shocks: Pre-Euro vs. Post-Euro

	Sample period	France-Germany	France-Italy	Germany-Italy
Supply shock	1992:07~1998:12	*19.99%*	*24.21%*	*-3.57%*
	2006:01~2012:06	*36.87%*	*27.98%*	*32.85%*
Demand shock	1992:07~1998:12	*56.29%*	*-8.74%*	*-33.62%*
	2006:01~2012:06	*89.91%*	*80.33%*	*75.68%*
Monetary shock	1992:07~1998:12	*21.64%*	*28.40%*	*9.90%*
	2006:01~2012:06	*50.15%*	*48.40%*	*44.21%*

We also note that the highest convergence was recorded by the France-Italy pair (24.21%) for the pre-euro period. These changes may in fact indicate a significant change in the 'leading' position within the core group: France led the supply-side convergence in Europe before,[14] but today it is Germany that leads.[15]

Table 1 also reports that the estimated endogeneity effect is much stronger for the

[14] Between France and Italy, two countries showing together the highest convergence level (24.21%) before the adoption of the euro, it was France that showed a higher convergence (19.99%) with the 3rd country (Germany) than Italy (-3.57%). France was then considered as the leader in supply-side convergence.

[15] Between France and Germany, two countries showing together the highest convergence level (36.87%) after the adoption of the euro, it is Germany that shows a higher convergence (32.85%) with the 3rd country (Italy) than France (27.98%). Germany is then considered as the leader in supply-side convergence.

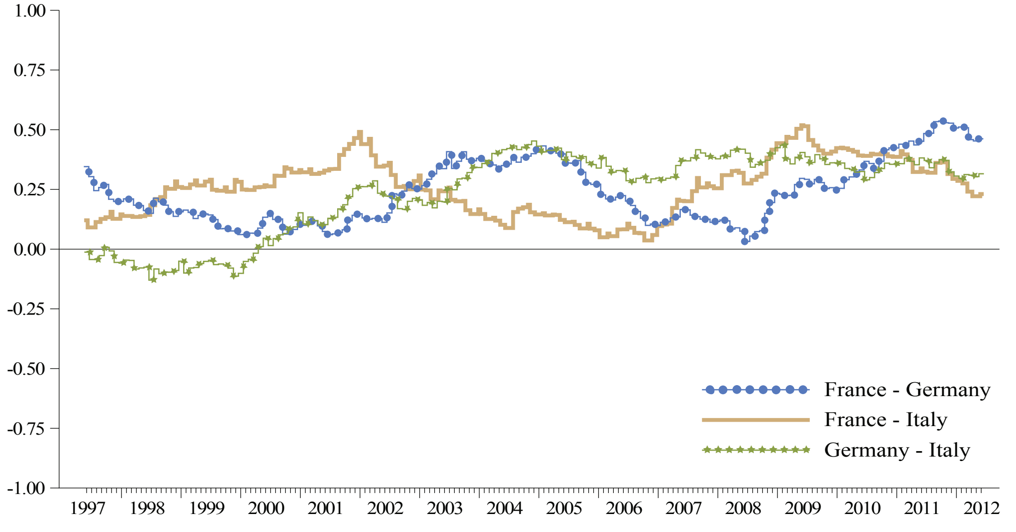
demand-side convergence than for the supply-side convergence. It is especially the case for real demand based convergence: before the adoption of the euro, the demand-side convergence was lower, much lower even than the supply-side convergence (except for the France-Germany pair), while the average demand-side convergence records high today at around 83%. However, it should be noted that, even though France and Germany show the strongest demand-side convergence (89.91%), the estimated endogeneity effect is greatest for Italy: before the adoption of the euro, this country literally diverged with Germany (-33.62%) and France (-8.74%), but today it converges very highly, at 80.33% with France and 75.68% with Germany. This finding is consistent with the fiscal convergence resulting from the Stability and Growth Pact. On the other hand, we note that France maintains its leading position in this real demand side convergence: with the two leading countries France and Germany (at 89.91%), the third country (Italy) converges more with France (80.33%) than Germany (75.68%).

Concerning the monetary convergence, it has also been increased significantly. The largest effect has occurred, again, in the Germany-Italy relationship (from 9.90% to 44.21%), while the France-Germany and France-Italy pairs maintain a higher convergence level (50.15% and 48.40%, respectively) than the Germany-Italy relationship. This result also suggests that France leads the monetary convergence: while the two more convergent countries are France and Germany, the third country (Italy) converges more with France than with Germany.

D. Dynamic Supply-Side Convergence

To consider the time-varying feature of convergence, we shall now discuss dynamic correlations of the recovered underlying shocks. Figure 1 depicts the evolution of the three bilateral correlations of supply shocks, using a month-by-month sliding five-year window. The examined period dates from the first sample period (July 1992 to June 1997) to the last sample period (July 2007 to June 2012).

Figure 1. Five-Year Window Correlations of Supply Shocks



Let us now look in detail at the evolution of these bilateral convergence processes in output. Concerning the France-Germany pair, the correlation was measured at 10% for the period January 1994~December 1998, while it was improved to 48% for the period January 2001~December 2005. After this record high, the convergence degree declined until the end of 2008, but since then, it has continuously improved to reach 50% in the last sample period. As for the France-Italy pair, the record high (around 51%) occurred during the period January 1998~December 2002. After a continuous decline until the end of 2006, the symmetry was intensified until the end of 2011, reaching around 50%. A declining trend has however prevailed in the most recent periods, and the last sample period (July 2007 to June 2012) shows a very limited symmetry of 25%.

In contrast, we observe a significant convergence between Germany and Italy: before the adoption of the euro, the two countries diverged, but they started to converge in 2000, roughly 18 months after the adoption of the euro. Their bilateral convergence then continuously increased to reach around 50% in 2005, and has stabilized at around 40%.

We find that the supply-side convergence process has in fact evolved very differently both across different country pairs and across different time periods. First, the country pair-specific contrast is very clear between the France-Germany pair and that of France-Italy: the former declines (increases), while the latter increases (declines) until 2008 (except for the period between 2004 and 2007). In parallel, the Germany-

Italy convergence began to be positive around 2002, and has continued to increase since then. This observation leads us to underline that the adoption of the euro enhanced all the German bilateral convergence processes in output, while it decreased that between France and Italy. The leading position in the supply-side convergence process has thus shifted from France to Germany.[16]

Second, we also notice that in mid-2008, all the three bilateral correlations started to show a multilaterally common trend: an upward trend until the end of 2011, and a downward trend from the beginning of 2012. This suggests that the supply-side convergence process was a bilateral one between 1999 and 2008, whereas it has become a multilateral one since 2009. This finding may imply that the real benefits from the single currency in terms of the multilateral convergence in output started to be generated recently. This finding is also consistent with the long-term nature of the supply side of the economy.

E. Dynamic Real Demand Convergence

Figure 2 presents the evolution of the three bilateral correlations of real demand shocks. One can easily observe that the real demand-side economies of the three member countries began to converge together very soon after the adoption of the euro, and their multilateral convergence continued to be very strong until the last sample period despite the recent crises. For example, it was measured at around 50% between France and Germany for the first sample period (July 1992~June 1997), while it increased to around 90% for the first period of the euro era (January 1999~December 2003) and to around 95% for the last sample period (July 2007~June 2012). A very similar result is found for the France-Italy and Germany-Italy pairs. In fact, we can notice that Italy diverged before, but once the single currency was adopted, its bilateral convergence processes were enhanced very quickly. Today, Italy's overall bilateral convergence level is comparable to that of France and Germany.

[16] Aguiar-Conraria and Soares (2011) confirm that France and Germany are the two core countries of the euro group but argue that France still leads business cycle synchronization in Europe.

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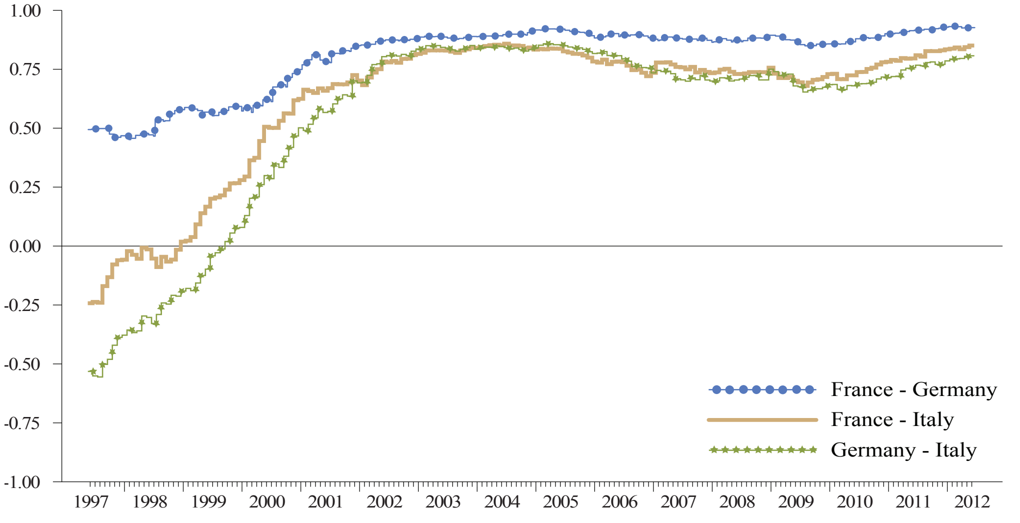
Figure 2. Five-Year Window Correlations of Demand Shocks



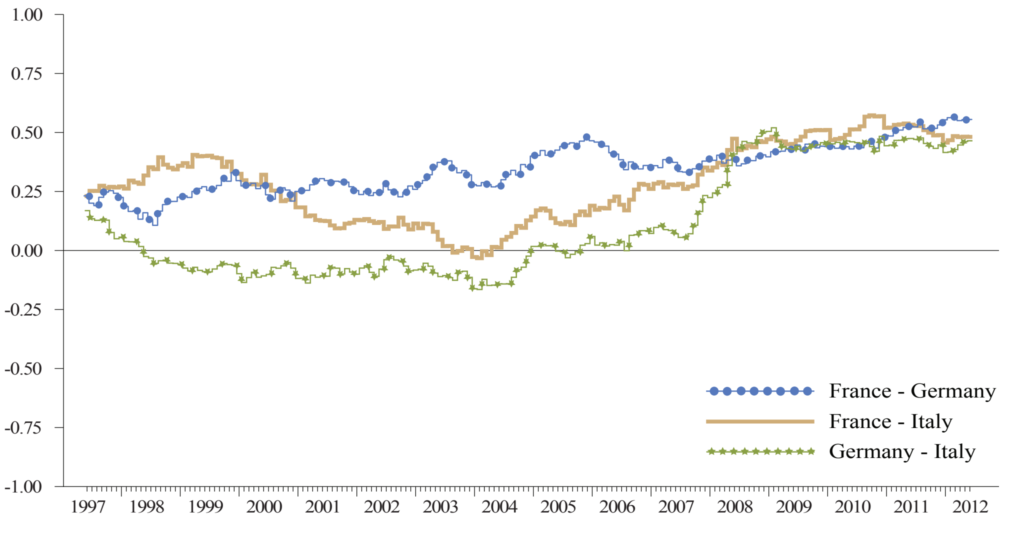
In contrast with the case of supply-side convergence, the adoption of the single currency seems to have induced a prompt multilateral convergence process on the real demand side of the euro group. Another point to notice is that, between the two leading countries (France and Germany), it is France to which the third country (Italy) converges more closely. It follows that it is not Germany but France that is likely to lead demand-side convergence in the euro group.

F. Dynamic Monetary Convergence

Figure 3 depicts the evolution of the three bilateral monetary convergence processes. The France-Germany pair shows a long-term upward trend with some non-significant disruptions, while the France-Italy pair reports a significant and continuous decrease until 2003 but a continuous upward trend since 2004. As for the Germany-Italy pair, there was no similarity in monetary aspects until 2007, but they began to converge together in 2008. Since then, their bilateral convergence has been enhanced in a prompt and continuous way. However, similar to the case of real demand convergence, Italy shows a higher monetary convergence with France than with Germany, which suggests that France is indeed in the leading position regarding demand-side convergence in the euro group.[17]

On the other hand, the dynamic of the monetary convergence process shows two heterogeneous periods: the pre-2009 and the post-2009 periods. During the former, each of the three bilateral relationships evolved in a country pair-specific way. Some difference in the transmission mechanism of monetary policy, due to country-specific structures (e.g., tax rates, credit system, and price levels), may explain this heterogeneity to some extent. However, this country-pair specificity disappeared at the end of 2008, and a multilaterally common upward trend appeared. Very similar to the case of supply-side convergence, this result suggests that the expected effects of the single currency on multilateral monetary convergence began to be effectively generated only recently (in 2009). Indeed, Cavallero (2011) has reported that some country-specific institutional structures could explain the limited monetary convergence in the euro group prior to 2007. Lopez and Papell (2012) has found that inflation rates in the euro zone began to converge together, especially after the crisis of 2007~2009. Our findings confirm this recent upward trend in the multilateral monetary convergence process in the euro group.[18]

Figure 3. Five-Year Window Correlations of Monetary Shocks



[17] Mylonidis and Kollias (2010) confirm the leading position of France and Germany within the euro group but highlight the dominant position of Germany in financial market convergence.

[18] However, it is important to note that monetary convergence in Europe has a much longer history, especially with the EMS within the EU. For example, Kocenda and Papell (1997) provided evidence that the ERM helped to accelerate the convergence.

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G. Summary of our Empirical Results

Empirical analysis confirms that the expected endogeneity effects have been generated in the core euro group. Our findings can be summarized as follows. First, the strongest effect occurred in real demand convergence. Second, the Germany-Italy convergence was the first beneficiary from the adoption of the euro. Third, it is confirmed that France and Germany are at the core of the European convergence. Fourth, the leading position in supply-side convergence shifted from France to Germany, while France continues to lead demand-side convergence. Fifth, the single currency seems to have recently modified the nature of the European convergence process, from a *bilateral* to a *multilateral* one. According to our results, multilateral convergence first occurred on the demand side, then on the supply side. To some extent, this finding is consistent with both the short-term nature of the demand side and the long-term nature of the supply side.

IV. Sensitivity Analysis

As mentioned before, we perform a twofold sensitivity analysis using both different time lengths of the sliding window (two-, three-, five-, seven- and ten-year) and the DCC approaches.

A. Different Time Lengths of the Window

Table D and Figures A and B in the Appendix summarize the results based on different time lengths of the window.[19] Table D shows some selected correlations for the purpose of comparison between pre- and post-euro periods, while different time-varying evolutions (depending on the time length of the window) are depicted in Figure A (two- and three-year) and B (seven- and ten-year). The results confirm first the idea that a shorter (longer) window would correspond to a more (less) volatile evolution of correlation. It is also found that real demand convergence is much less sensitive to the

[19] More detailed estimation results are available from the authors on request.

time length of the window than supply-side convergence and monetary convergence. These different sensitivities may have some interesting implications. First, lower sensitivity confirms the strong endogeneity effect in terms of real demand convergence, described in the previous section. Second, higher sensitivity may indicate a more complex nature of the endogeneity effects on the convergence process in output and monetary aspects.

Concerning supply-side convergence, Figure A and Figure B show that there is no clear-cut improvement in business cycle synchronization exclusively attributable to the adoption of the euro. It is especially the case for the France-Germany relationship: the adoption of the single currency cannot be distinguished from other events that seem to have influenced supply shock symmetry. Furthermore, short-term convergence records a much lower level in recent periods than before. For example, Table D reports that Italy's convergence is abruptly reduced by more than half (with Germany, from 45.65% for 2008/1~2009/12 to 16.96% for 2009/1~2010/12; and with France, from 47.39% for 2008/1~2009/12 to 15.65% for 2009/1~2010/12), which seems to have triggered an important decrease in the France-Germany convergence in the following periods (from 54.35% for 2009/1~2010/12 to 12.35% for 2010/7~2012/6). However, this short-term volatility disappears when looking at longer-term evolution (Figure B). Moreover, this figure shows that there has been a significant and continuous increase, attributable to the adoption of the euro, in all the three bilateral relationships. Further, the most important and continuous increases are found in the bilateral relationships of Italy (especially with Germany).

As for monetary convergence, our results show a similar sensitivity to that of supply-side convergence. First, a greater (lesser) volatility is observed in the shorter (longer) run. Second, although there is no evidence that the adoption of the euro has increased short-term convergence, the endogeneity effects have been generated in long-term monetary convergence. For example, we notice that, in the short run (Table D and Figure A), Italy has moved away from Germany and France in recent periods (from 72.17% for 2007/1~2008/12 to 33.74% for 2009/1~2010/12 with Germany, and from 67.57% for 2009/1~2010/12 to 32.09% for 2010/7~2012/6 with France). A similar short-term deviation of Italy from the core group was observed in supply-side convergence, while this Italian monetary deviation does not seem to have weakened the short-term monetary convergence between France and Germany (as was the case for supply-side convergence in the short run). However, short-term volatility disappears, again, when observing the evolution of long-term monetary convergence, which shows

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a continuous upward trend, at least since 2008, in all the three bilateral relationships (including the Germany-Italy pair).

Finally, the contrast between the short-term and long-term convergence measures, resulting from the high sensitivity of supply-side and monetary convergence, suggests that the convergence process may have been disturbed by the recent crises (the global crisis of 2007~2009 and the recent euro crisis), while the long-term convergence process has not been compromised. In particular, if business cycle synchronization is the most important criterion of economic convergence within the euro group and if this criterion is considered as a long-term process, this result provides clear support to the endogeneity theory: the adoption of the euro has enhanced economic convergence. Furthermore, our results, especially with the high convergence between Germany and Italy *in the long run*, do not support the idea of cleavage between the 'South' and the 'North', according to which Italy belongs to the former and Germany the latter, with France being 'in between'.

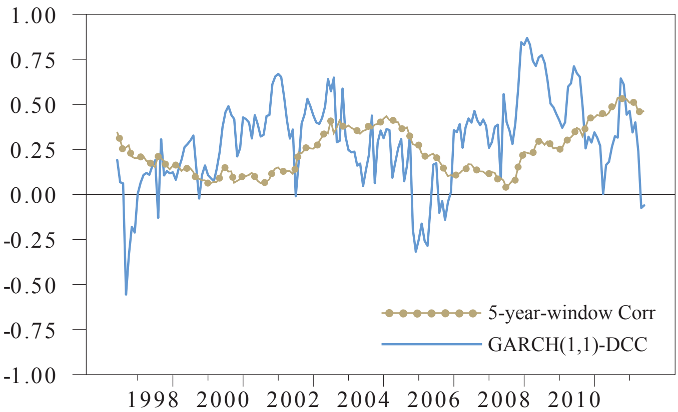
B. Dynamic Conditional Correlation Model

Before selecting the final specification for each of the nine bilateral relationships examined here, we have tested a number of possible GARCH(p,q) specifications for our Dynamic Conditional Correlation(DCC) analysis. Table E in the Appendix reports the best performing specification for each relationship, while Figure 4 below contrasts the estimated dynamic conditional correlations[20] with those obtained using the five-year sliding window. We find that the two types of correlation show generally very similar dynamics and trends, especially in the long run, except for the France-Germany supply-shock correlation.

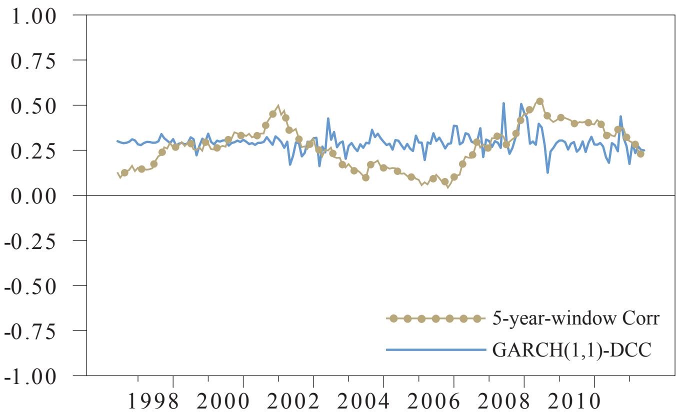
[20] When performing our DCC estimation, we allowed for asymmetric effects. More details on our estimation methods and results are available from the authors on request.

Figure 4. Five-Year Sliding Window Correlation vs. GARCH-DCC
(1997/6~2012/6)

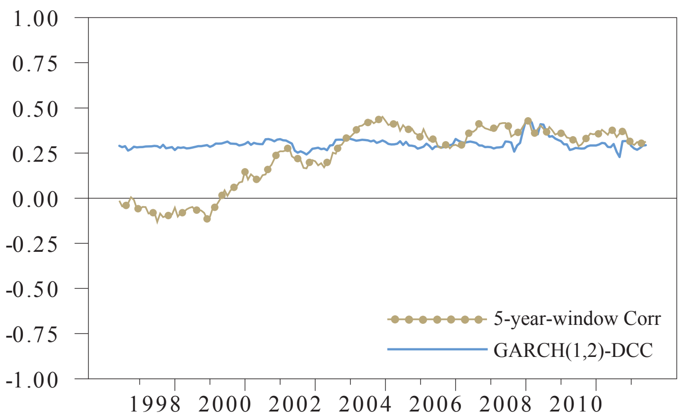
Supply



France-Germany



France-Italy



Germany-Italy

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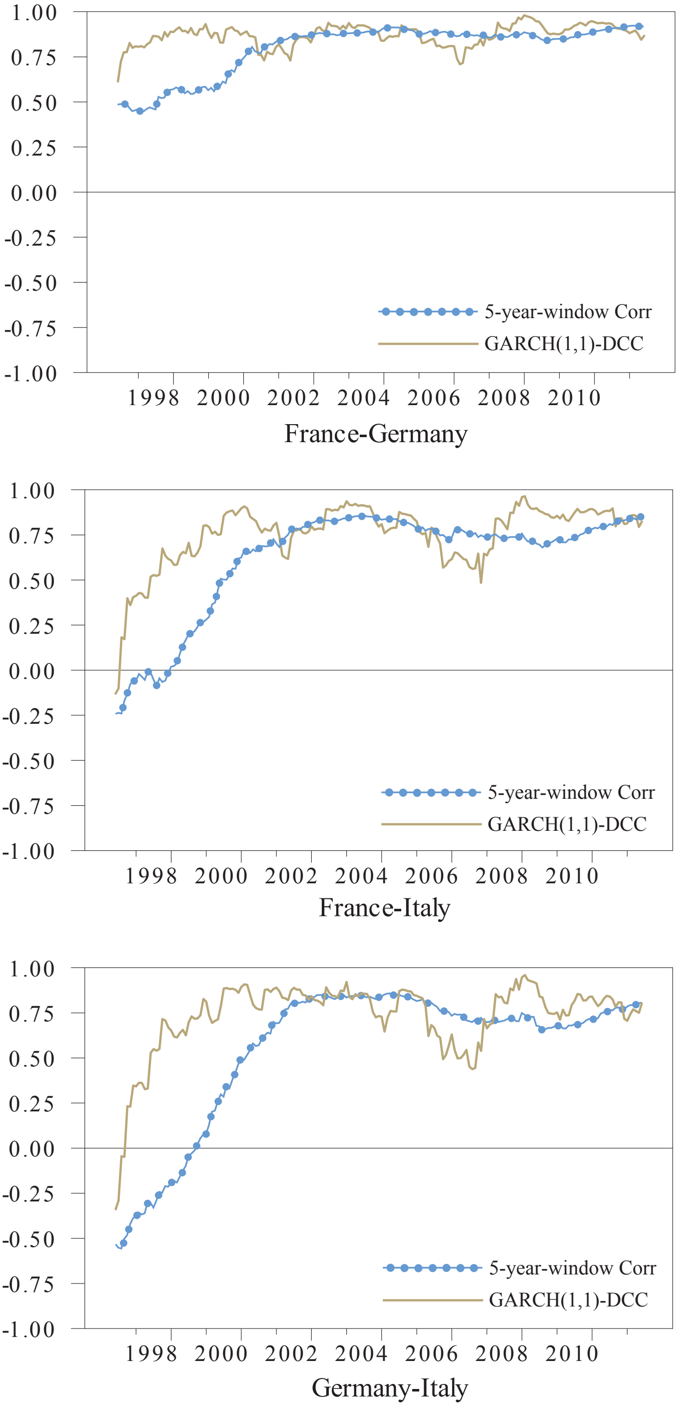
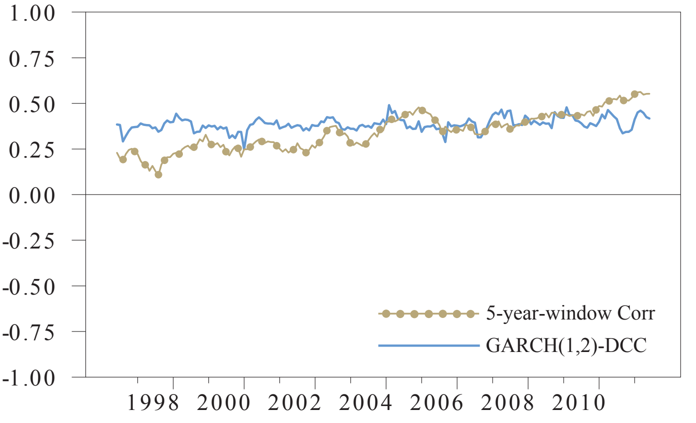
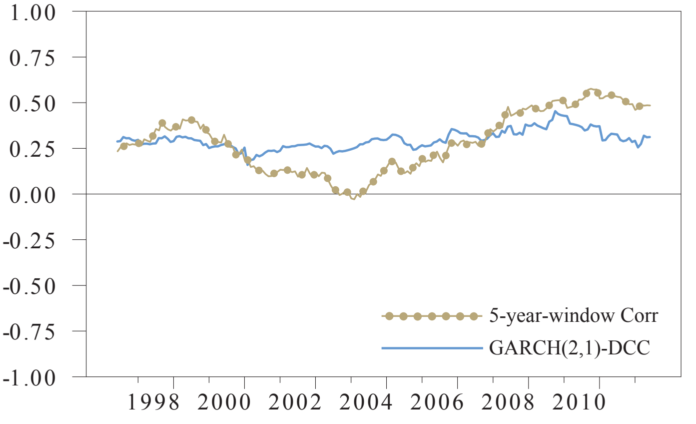
Demand



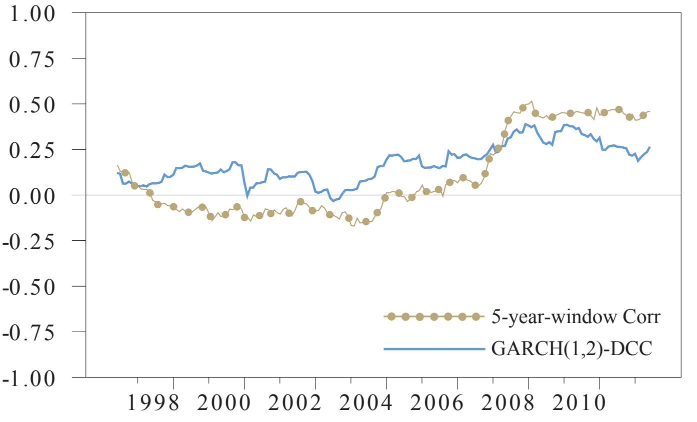
Monetary



France-Germany



France-Italy



Germany-Italy

The similarity is even more striking when looking at the demand-shock correlations in Figure C (in the Appendix) where the DCCs are compared to the two-year sliding-window correlations. Furthermore, the same similarity in the monetary-shock correlations can be observed in Figure D in the Appendix, where the DCCs are contrasted with the long-run correlations (ten-year window). These results confirm that demand-side convergence is a dynamic process in the short run, while monetary convergence is an ongoing process in the long run.

Meanwhile, the long-term nature of supply-side convergence is not confirmed: the similarity between the two types of correlation is found in the *short* run for the France-Germany pair (see Figure C), while the similarity observed in the long run is not clear-cut for the France-Italy pair. (see Figure D).

On the other hand, if we focus on the estimated degree of convergence and its evolution in the long run (especially from 1999 to 2012), we find that the DCC-based results are clearly in line with those obtained using the sliding-window technique. That is, even though volatility in the economy seems to have disturbed the convergence process in the short run, overall convergence has been considerably enhanced in the long run.

V. Conclusion

To determine whether the expected endogeneity effects have been generated in the euro zone, this paper has examined the degree of convergence using the correlation of underlying shocks to the three core member countries: France, Germany, and Italy. We have adopted a comprehensive definition of convergence by considering both the supply and demand sides of the economy. This has led us to decompose underlying shocks into three types: supply, demand, and monetary. These series of shocks have been first recovered using a SVAR model. Then, we used a month-by-month sliding window technique to estimate the dynamic correlations of shocks for each of the examined country-pairs. Moreover, in an effort to define the appropriate time length corresponding to each type of convergence, several time lengths of the sliding window and the dynamic conditional correlation model have been applied for sensitivity analysis.

In general, we have found that overall convergence has been significantly enhanced since the adoption of the euro, which confirms the prediction of the endogeneity theory. Especially, endogeneity effects have been most pronounced for demand-side convergence and in the bilateral relationships of Italy. As for supply-side convergence, our results have also provided clear-cut evidence in favor of the endogeneity theory, in particular, in the most recent periods. This finding is also consistent with the long-run feature of the convergence in output: a positive and multilateral effect of the single currency on business cycle synchronization appears clearly only in the long run (ten years after the launch of the single currency). We have obtained a similar conclusion for monetary aspects – the single currency took almost ten years to show its positive multilateral impact on price convergence. This multilateral endogeneity effect, observed in the core euro countries, is in line with some evidence provided in the literature on the convergence process of new EU/Euro member countries (Kocenda, Kuta and Yigit, 2006), which leads us to have a positive perspective regarding the convergence process in Europe.

We have also found that Italy was the principal beneficiary: it diverged before 1999 (especially with Germany), but its overall convergence level is now comparable with that of France and Germany. In addition, its convergence in output with Germany is even greater than that between Germany and France. This finding may usefully contribute to the debate on the so-called cleavage of the euro zone into the 'North', led by Germany, and the 'South', in which Italy is often placed: there is no such cleavage, and the associated euro-skepticism is not corroborated. We also confirm the enhanced convergence between Germany and France and their status as the two core euro countries, with Germany leading supply-side convergence, and France leading demand-side convergence.

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Appendices

Table A. Basic Statistics of Initial Variables

	Industrial production			*REER*			*Consumer price index*		
	FR	BD	IT	FR	BD	IT	FR	BD	IT
Mean	*107.05*	*107.82*	*109.12*	*98.33*	*101.51*	*85.96*	*120.45*	*123.38*	*134.75*
S.D.	*6.86*	*12.71*	*8.04*	*3.95*	*5.91*	*5.08*	*11.46*	*11.45*	*19.27*
Max.	*118.81*	*134.69*	*123.30*	*106.43*	*116.91*	*105.21*	*142.32*	*144.91*	*169.31*
Med.	*107.96*	*105.86*	*112.04*	*98.52*	*100.67*	*86.49*	*118.93*	*123.01*	*134.97*
Min.	*93.74*	*87.25*	*90.96*	*88.74*	*91.04*	*69.98*	*101.52*	*100.74*	*97.99*
J-B.	*20.25*	*17.52*	*20.34*	*4.72*	*13.84*	*125.34*	*16.34*	*10.02*	*11.64*

(Note) Monthly data from 1992/01 to 2012/06 (base 1992=100; Obs.=246). FR : France; BD : Germany; IT : Italy; REER : Real effective exchange rates. Data source: IMF-IFS.

Table B. AIC/BIC Tests for our Standard 3-variable VAR Models

	France		*Germany*		*Italy*	
Lags	AIC	BIC	AIC	BIC	AIC	BIC
0	*-5217.2*	***-5206.8***	*-4898.0*	***-4887.6***	*-5008.1*	***-4997.7***
1	*-5237.7*	*-5196.5*	*-4914.8*	*-4873.6*	*-5037.3*	*-4996.1*
2	*-5234.6*	*-5163.1*	*-4911.7*	*-4840.2*	*-5054.1*	*-4982.6*
3	*-5230.1*	*-5128.8*	***-4916.8***	*-4815.6*	***-5071.9***	*-4970.6*
4	*-5222.9*	*-5092.3*	*-4904.6*	*-4774.0*	*-5068.6*	*-4938.0*
5	*-5230.0*	*-5070.7*	*-4891.7*	*-4732.3*	*-5056.1*	*-4896.7*
6	*-5245.1*	*-5057.6*	*-4882.1*	*-4694.6*	*-5054.7*	*-4867.2*
7	***-5249.9***	*-5034.8*	*-4866.3*	*-4651.2*	*-5045.7*	*-4830.5*
8	*-5237.1*	*-4995.0*	*-4855.5*	*-4613.3*	*-5041.1*	*-4798.9*

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Table C. Basic Statistics and ADF test of Underlying Shock Series

	Supply shock			***Demand shock***			***Monetary shock***		
	France	Germany	Italy	France	Germany	Italy	France	Germany	Italy
Mean	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
S.D.	*1.002*	*1.002*	*1.002*	*1.002*	*1.002*	*1.002*	*1.002*	*1.002*	*1.002*
Max.	*2.865*	*2.968*	*3.287*	*3.421*	*3.519*	*3.564*	*2.784*	*5.148*	*3.345*
Med.	*-0.023*	*0.048*	*0.069*	*-0.026*	*-0.003*	*-0.014*	*-0.031*	*-0.052*	*0.056*
Min.	*-4.206*	*-4.940*	*-3.246*	*-3.328*	*-2.955*	*-5.983*	*-2.944*	*-2.403*	*-4.077*
Skewness	*-0.641*	*-0.643*	*-0.016*	*0.125*	*0.328*	*-1.372*	*-0.092*	*0.749*	*-0.322*
Kurtosis	*2.087*	*2.822*	*1.034*	*0.433*	*0.695*	*8.920*	*0.133*	*2.455*	*1.272*
J-B	*59.988*	*96.196*	*10.695*	*2.501*	*9.133*	*870.89*	*0.518*	*82.671*	*20.345*
T-statistic (ADF test)	*-6.776*	*-7.198*	*-6.176*	*-6.296*	*-6.465*	*-6.654*	*-8.471*	*-6.675*	*-7.593*
	Critical values (significance): -3.4594 (1%) ; -2.8738 (5%); -2.5731 (10%)								

Table D. Correlation of Shocks in Different Time Horizons

Time period		*Two-year correlations (%)*								
		Supply-side Convergence			Real demand Convergence			Monetary Convergence		
Start	End	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT
97:01	98:12	-16.00	61.22	-9.57	88.61	53.91	56.70	23.91	17.48	-26.26
99:01	00:12	3.04	16.87	16.87	70.17	76.61	75.30	1.39	5.30	1.48
07:01	08:12	51.22	55.39	40.96	87.57	81.39	73.74	56.78	47.13	72.17
08:01	09:12	56.61	47.39	45.65	86.61	78.96	71.57	54.44	60.09	54.61
09:01	10:12	54.35	15.65	16.96	90.87	82.96	71.91	50.09	67.57	33.74
10:07	12:06	12.35	-11.39	20.78	88.78	88.87	82.96	52.09	32.09	30.00

Time period		*Three-year correlations (%)*								
		Supply-side Convergence			Real demand Convergence			Monetary Convergence		
Start	End	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT
96:01	98:12	13.49	38.87	-6.23	64.12	37.68	16.63	35.91	34.85	-13.10
99:01	01:12	38.25	43.89	41.65	73.26	79.92	76.58	26.26	6.64	-1.65
07:01	09:12	51.25	51.35	39.13	84.43	74.52	65.33	56.47	57.17	58.61
08:01	10:12	59.25	35.57	39.10	93.39	85.02	80.10	55.01	59.72	48.42
09:07	12:06	32.28	-15.78	9.06	88.49	88.26	78.10	58.84	47.23	41.03

Time period		*Five-year correlations (%)*								
		Supply-side Convergence			Real demand Convergence			Monetary Convergence		
Start	End	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT
94:01	98:12	13.55	28.98	-9.09	56.66	-1.55	-21.22	20.55	34.35	-5.44
99:01	03:12	36.79	15.31	34.15	88.07	84.09	85.11	31.82	0.69	-11.34
06:01	10:12	42.17	39.52	35.34	88.30	77.96	71.75	47.01	56.91	48.40
07:07	12:06	46.01	23.69	31.38	91.83	85.06	80.74	55.27	48.14	46.51

Time period		*Seven-year correlations (%)*								
		Supply-side Convergence			Real demand Convergence			Monetary Convergence		
Start	End	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT
92:07	99:06	18.40	23.69	-2.87	58.75	-4.03	-29.43	25.62	30.65	12.15
99:01	05:12	25.37	16.68	33.46	88.80	83.25	82.93	34.46	12.81	1.90
04:01	10:12	28.93	35.49	34.44	88.78	78.01	72.30	44.39	51.62	44.68
05:07	12:06	29.00	26.16	30.39	89.55	79.81	75.93	45.95	45.83	42.32

Time period		*Ten-year correlations (%)*								
		Supply-side Convergence			Real demand Convergence			Monetary Convergence		
Start	End	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT	FR-BD	FR-IT	BD-IT
92:07	02:06	23.09	25.42	10.39	66.84	20.28	2.81	23.42	21.64	7.04
99:01	08:12	27.54	29.80	37.78	89.25	81.14	80.43	37.04	27.11	20.14
01:01	10:12	35.65	27.02	35.59	88.24	78.87	76.94	46.97	39.37	27.36
02:07	12:06	31.39	21.81	33.78	90.34	82.10	77.06	47.33	40.56	31.20

(Note) FR : France, BD : Germany, IT : Italy

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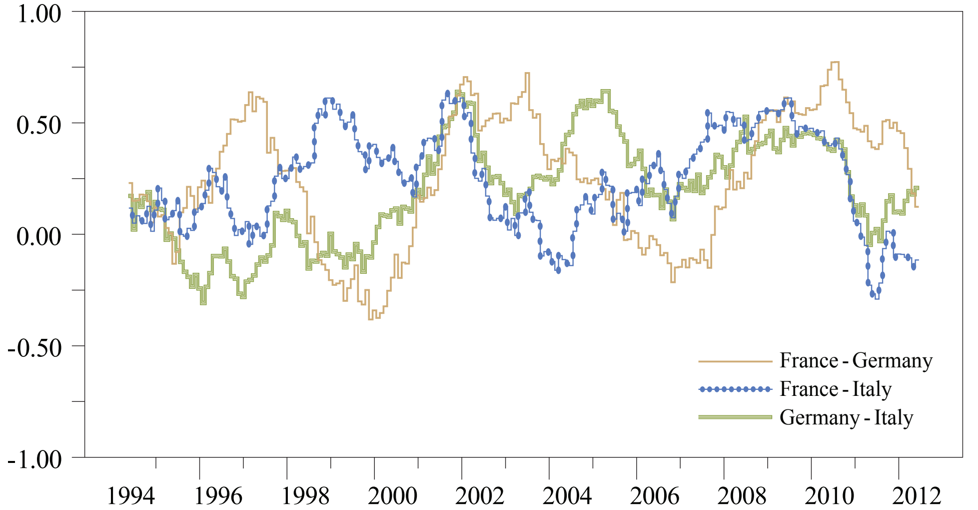
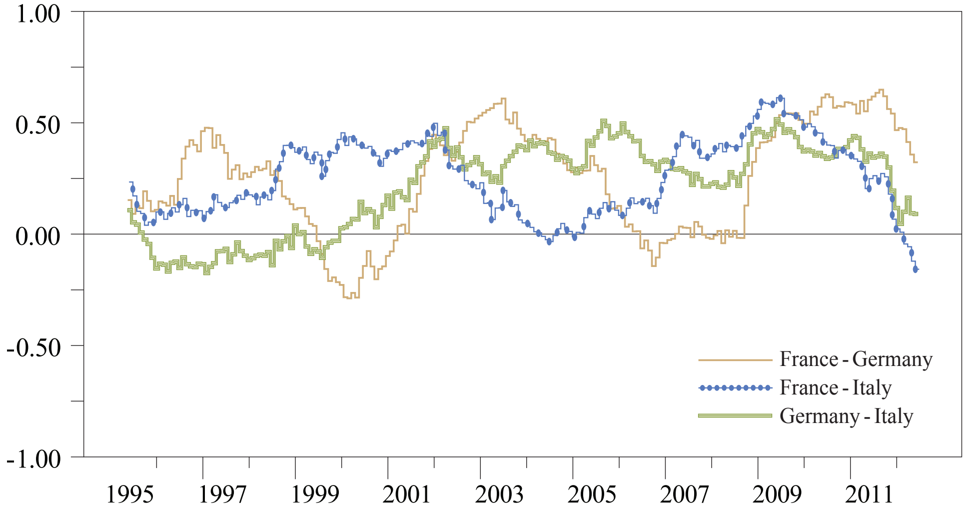
http://dx.doi.org/10.11130/jei.2014.29.1.20

Figure A. Sliding-Window Correlation of Shocks: 2-and 3-Year Windows

Supply

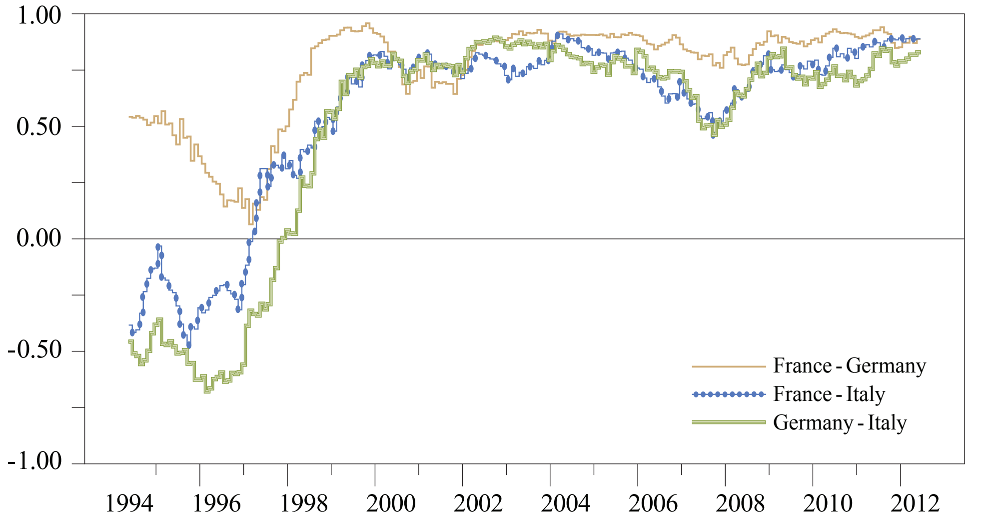


2-year window

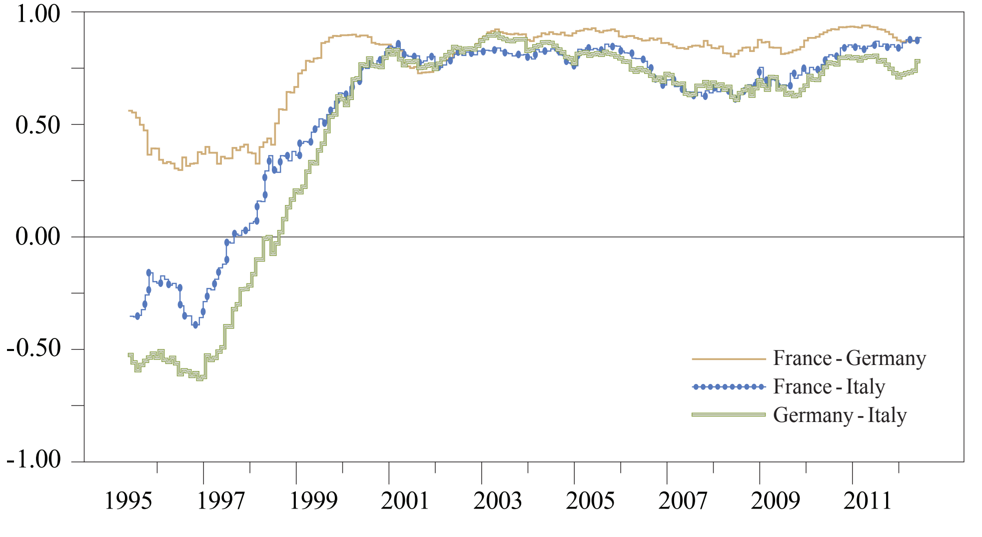


3-year window

Demand

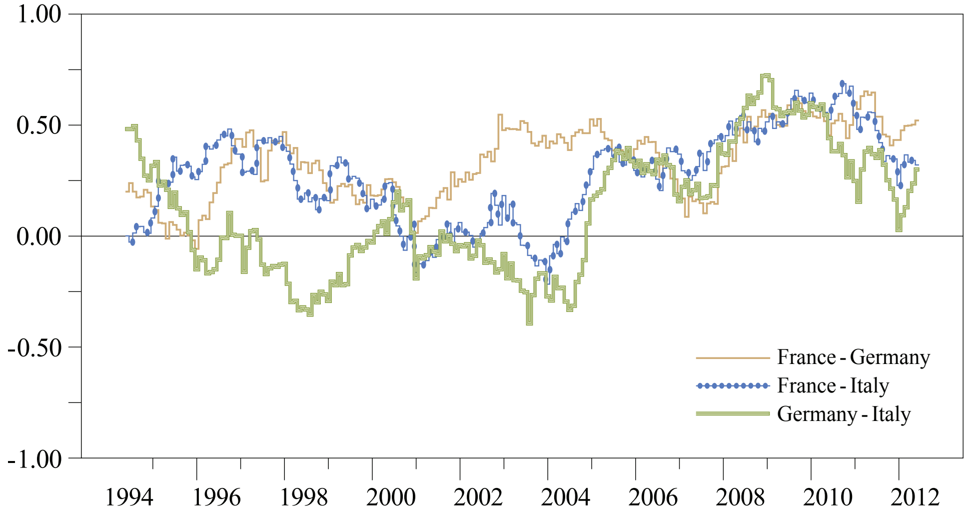


2-year window

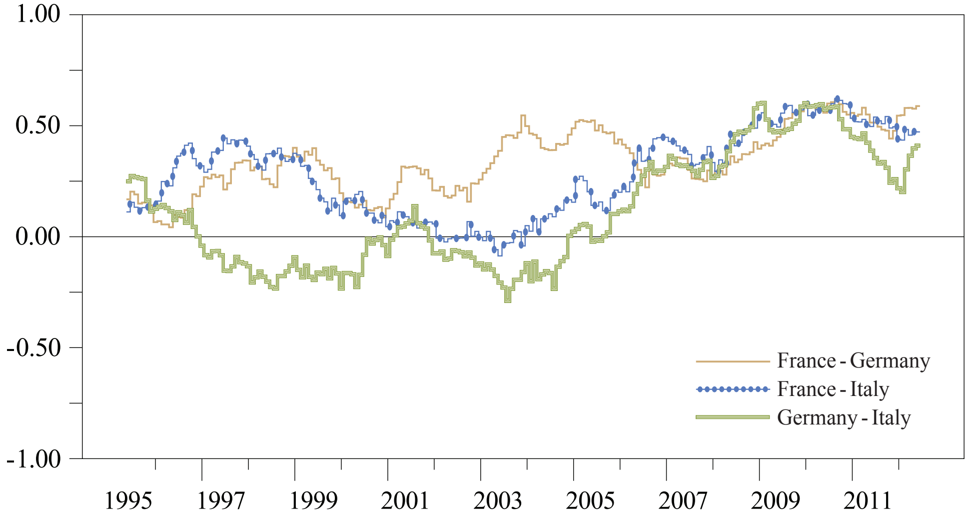


3-year window

Monetary



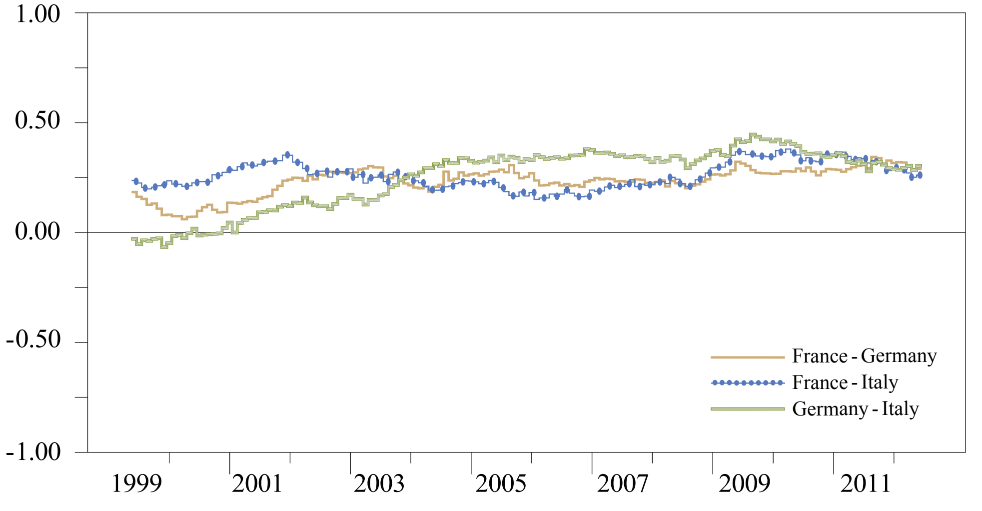
2-year window



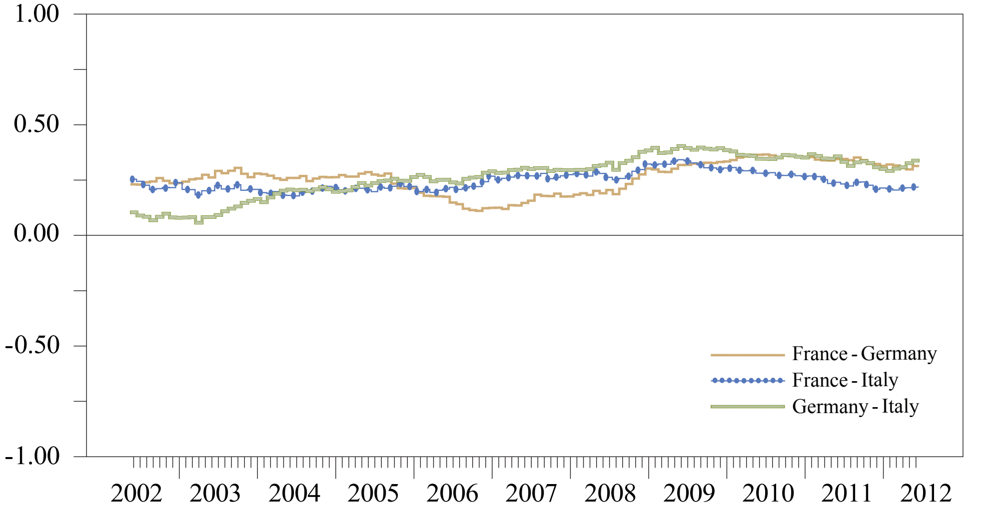
3-year window

Figure B. Sliding-Window Correlation of Shocks: 7 - and 10 - Year Windows

Supply

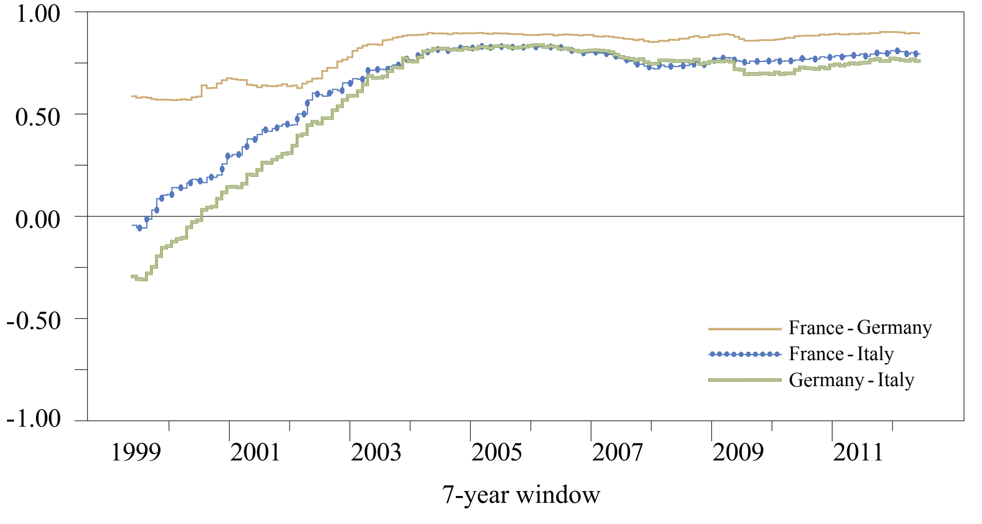


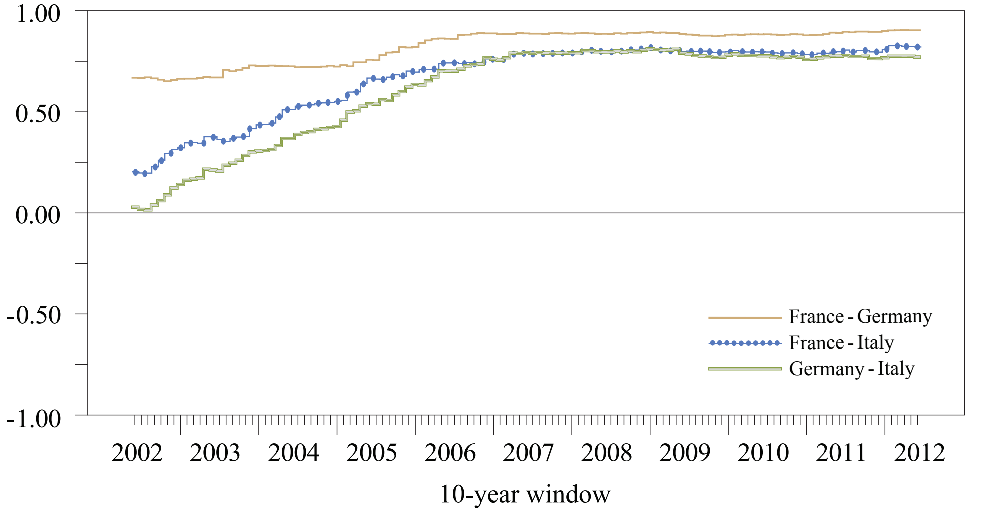
7-year window



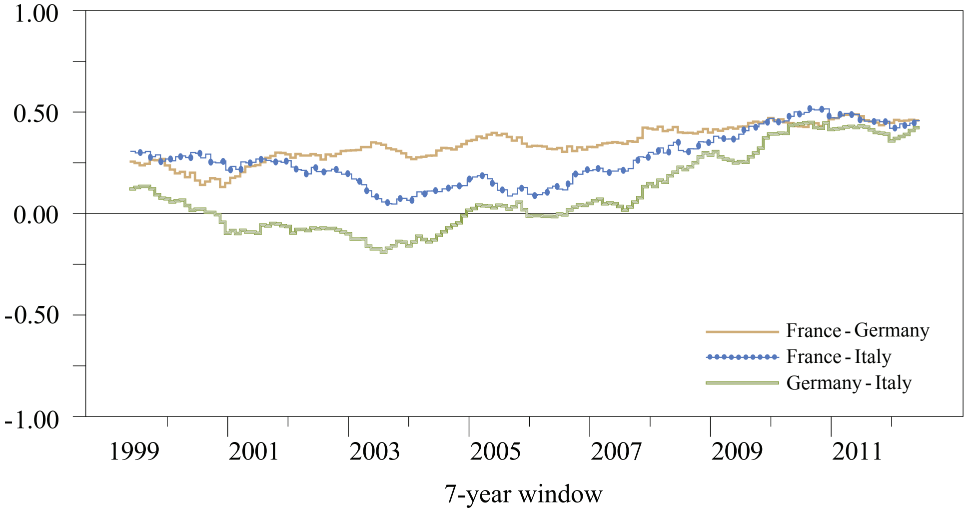
10-year window

Demand


1.00
0.50
0.00
-0.50
-1.00
1999
2001
2003
2005
2007
2009
2011
7-year window
France - Germany
France - Italy
Germany - Italy


1.00
0.50
0.00
-0.50
-1.00
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
10-year window
France - Germany
France - Italy
Germany - Italy

Monetary



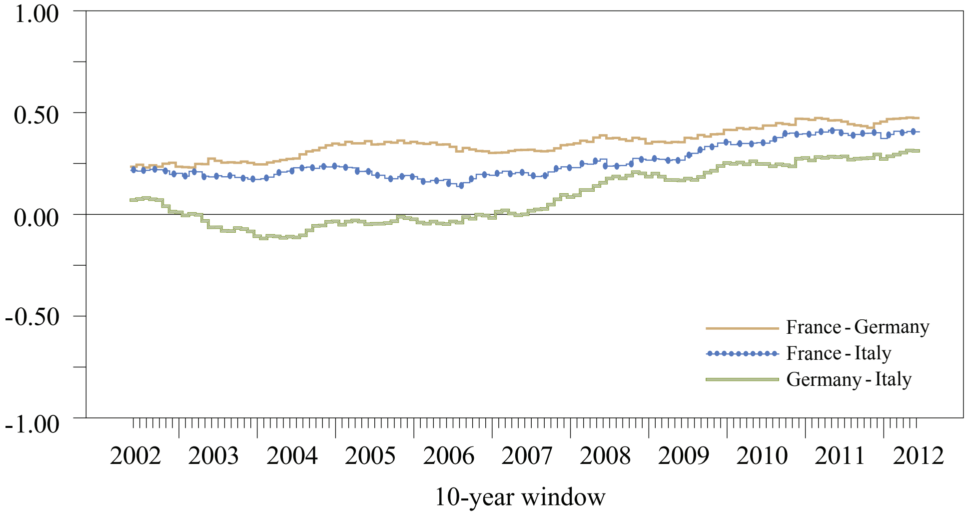
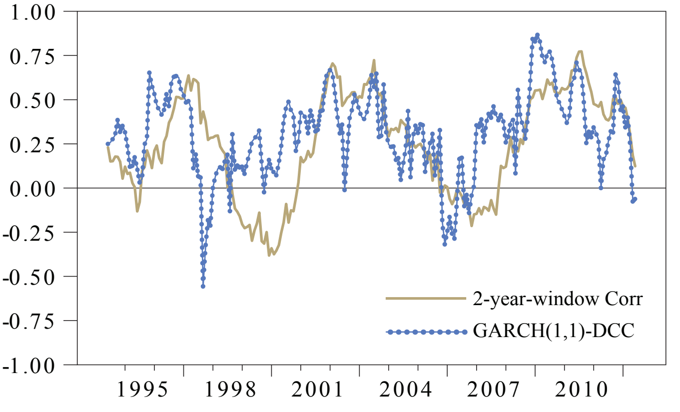


Table E. Selected GARCH Specification

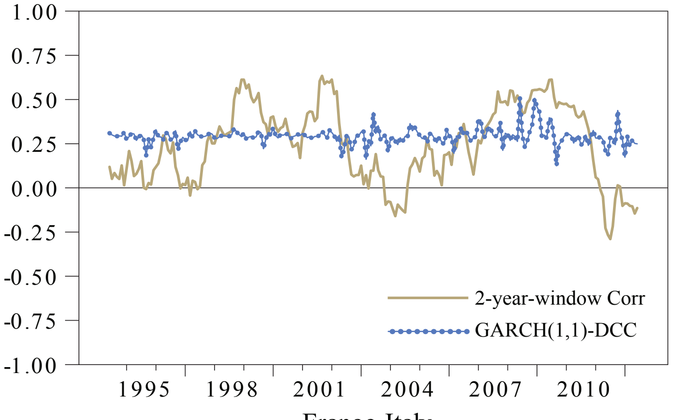
	France-Germany	France-Italy	Germany-Italy
Supply	GARCH(1,1)	GARCH(1,1)	GARCH(1,2)
Demand	GARCH(1,1)	GARCH(1,1)	GARCH(1,1)
Monetary	GARCH(1,2)	GARCH(2,1)	GARCH(1,2)

Figure C. Two-Year-Sliding Window Correlation vs. GARCH-DCC
(1994:6~2012:6)

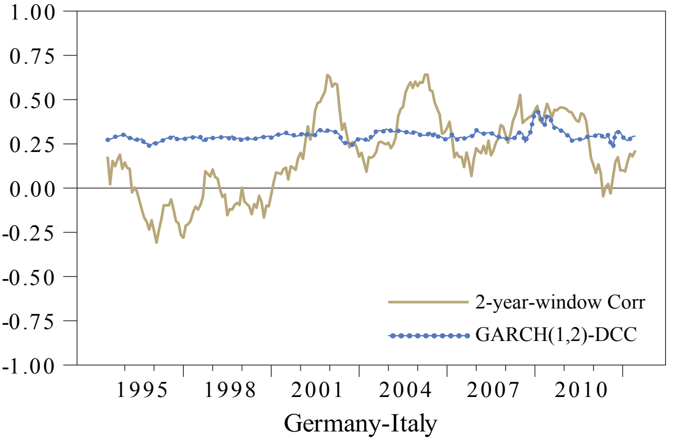
Supply



France-Germany

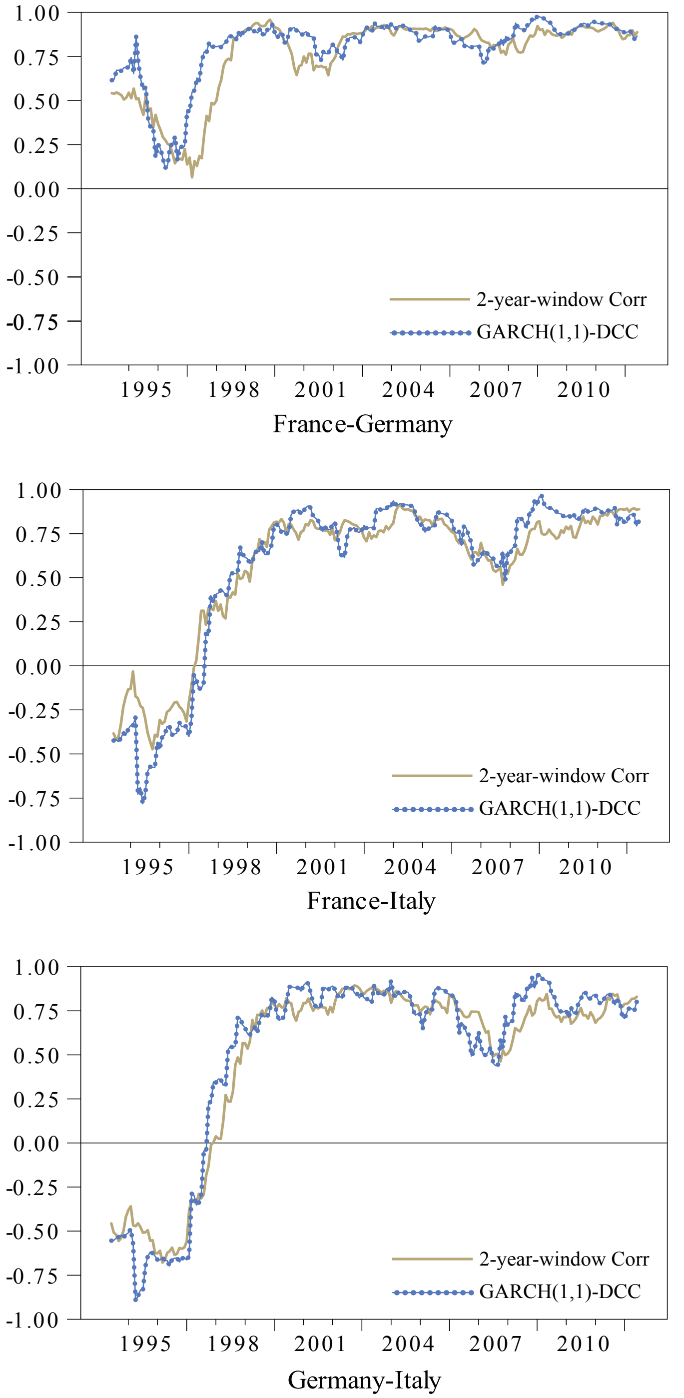


France-Italy



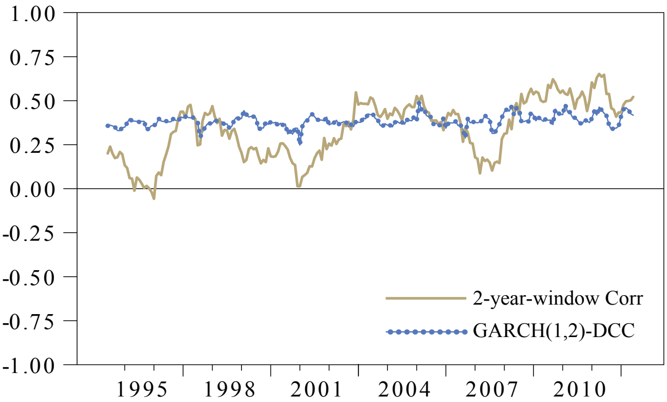
Germany-Italy

Demand

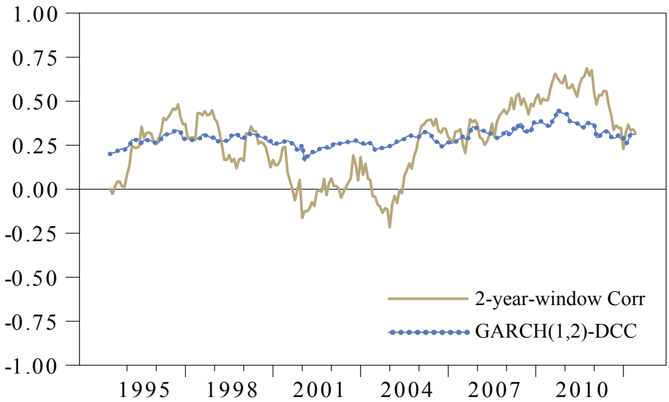

1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
2-year-window Corr
GARCH(1,1)-DCC
1995
1998
2001
2004
2007
2010
France-Germany
France-Italy
Germany-Italy

http://dx.doi.org/10.11130/jei.2014.29.1.20

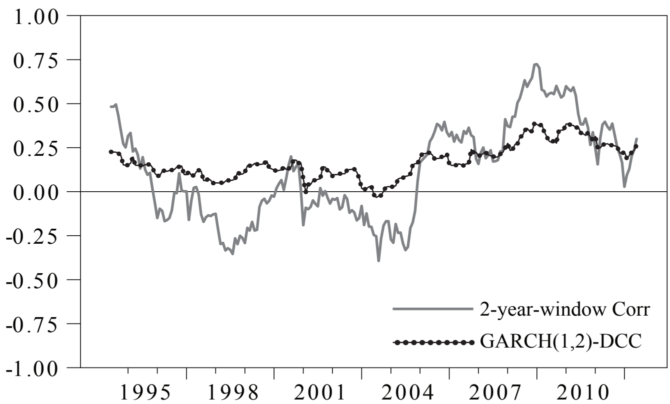
Monetary



France-Germany



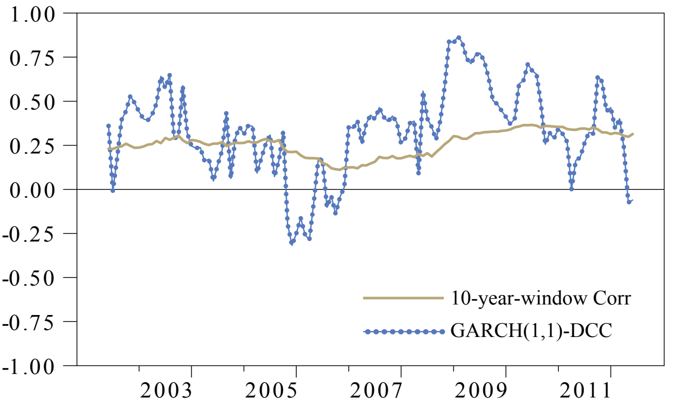
France-Italy



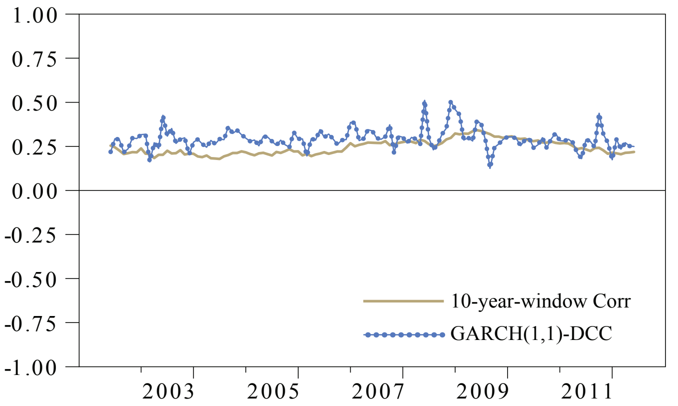
Germany-Italy

Figure D. Ten-Year-Sliding Window Correlation vs. GARCH-DCC
(2002:6~2012:6)

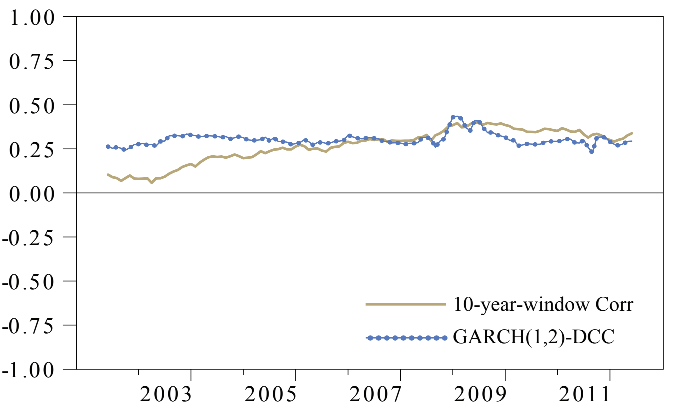
Supply



France-Germany

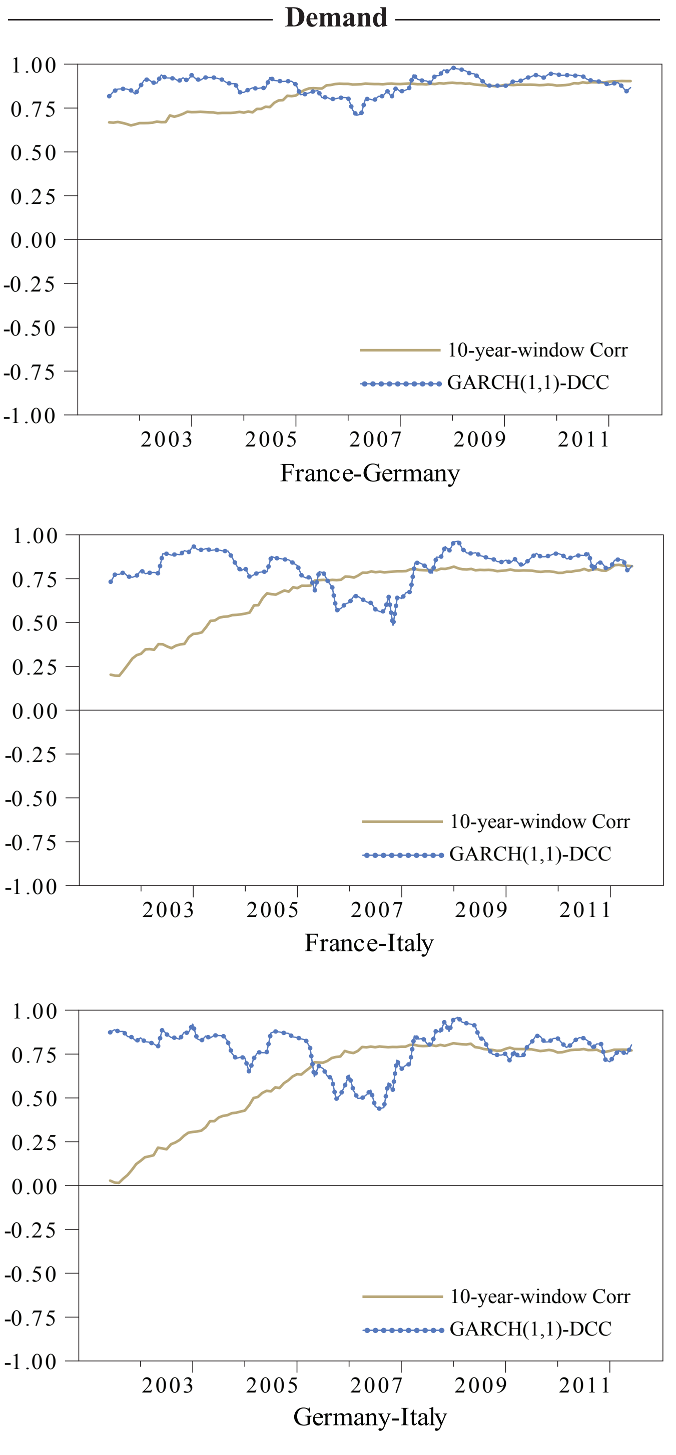


France-Italy

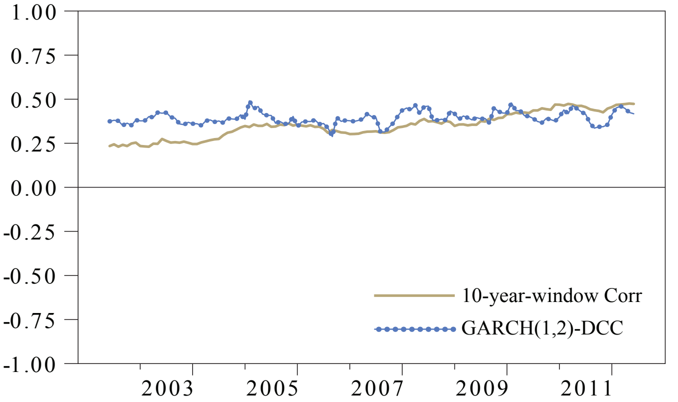


Germany-Italy

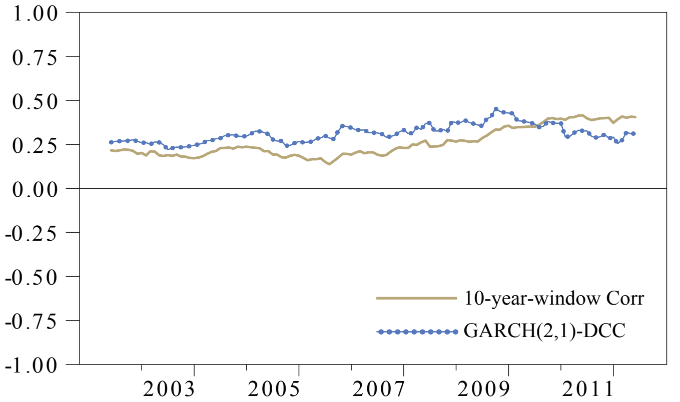
http://dx.doi.org/10.11130/jei.2014.29.1.20



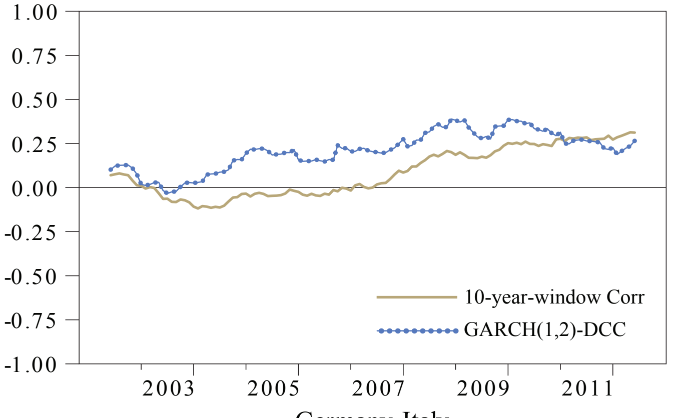
Monetary



France-Germany



France-Italy



Germany-Italy