Convergence of EMU Equity Portfolios

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Abstract

This paper demonstrates that, after integration, equity portfolios of countries that joined the European Monetary Union have converged at faster rate than those of NON EMU countries. This outcome can be interpreted as a combination of the convergence of inflation rates and the convergence of investment barriers. On the one hand, the common monetary policy might have driven a stronger comovement in inflation rates, leading to increasingly similar hedging strategies among member countries. On the other hand, exposure to the common currency might have homogenized bilateral investment barriers, thus inducing increasingly similar portfolio allocations among member countries. We find that the comovement of inflation rates has not significantly increased after EMU inception, pointing toward an exclusive role for convergence in investment barriers.

JEL classification: F21, F30, F36, G11, G15

Keywords: financial integration; EMU; inflation hedging; investment barriers

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1 Introduction

The European Monetary Union (EMU) represents the most far reaching attempt ever made toward international financial integration. There is a great deal of recent literature on alternative ways of measuring financial market integration, with particular focus on the EMU. The very definition of "integration" is quite ambiguous, as it depends critically on the financial market analyzed. In equity markets, the benchmark theoretical condition of full integration is the one in which all investors hold the same portfolio, the value-weighted portfolio. However, full integration does not necessarily imply the absence of investment barriers, such as transaction costs or information barriers; a sufficient condition is that all investors face the same barriers. Accordingly, financial integration in the euro area is captured in this paper through a measure evaluating the degree of convergence of member country international portfolios. If the birth of a common currency area such as the Eurozone had the effect of inducing member countries to invest more similarly, we should observe a convergence toward a euro area representative investor.

The peculiar elements that characterize the integration process are identified in two basic factors: the common currency and the common monetary policy (Fratzscher, 2002). Building on a variation of the Adler and Dumas (1983) model, the observed differences in portfolios may result from differing bilateral investment barriers or differing inflation hedging strategies. On the one hand, the impact of the common currency is reflected mainly in investment barriers, making homogeneous the exposure to foreign exchange risk and making potentially more symmetric any bilateral informational barriers. The common monetary policy, on the other hand, likely manifests in convergence of inflation rates, leading to increasingly similar hedging strategies. If EMU inception has actually given rise to a convergence process among EMU equity portfolios, this must be due to a combination of convergence in inflation rates and in bilateral investment barriers.

We find that dispersion among EMU portfolios (EMU *within* dispersion) has declined substantially since EMU integration if compared with dispersion between EMU and NON EMU portfolios (EMU-NON EMU *between* dispersion) and dispersion among NON EMU countries' portfolios (NON EMU *within* dispersion). We also uncover a convergence process among EMU members: countries more distant from one another before EMU integration seem to have converged with greater speed. The dispersion measure derived from our theoretical setting allows us to disentangle the role of convergence of inflation hedging from convergence of bilateral investment barriers in determining equity portfolio convergence. Examination of the determinants of this convergence process shows that the degree of comovement of inflation rates has remained almost unchanged since integration. Consequently, observed equity portfolio convergence must be ascribed to bilateral convergence of investment barriers thereby emphasizing the prevailing role of the common currency over common monetary policy. The negligible role of inflation convergence allows us not only to attribute the explanation of portfolio convergence to bilateral investment barriers but also, interestingly, to "quantify" their convergence. Bilateral investment barriers are indeed not directly observable and empirical analysis usually gets around this problem by means of - often questionable - proxies. Our results, however, allow us to quantify the reduction in "unobservable" investment barriers, since portfolio convergence coincides with investment barrier convergence.

This paper is structured as follows. The second section briefly reviews the empirical literature on financial integration in the euro area. In the third section, we build the theoretical framework. The fourth section describes the data. In the fifth section we describe the empirical analysis and derive results. The sixth section concludes.

2 Measures of integration on equity markets

Since EMU inception, a great deal of research has been devoted to investigating the degree of stock market integration. Adam et al. (2002) is the first systematic work that attempts trying to organize the different measures of integration in financial markets. This was followed, more recently, by Baele et al. (2004), which updated and integrated the previous work. In general, it is not possible to apply the same measures to quantify integration in different markets, due to the very nature of financial instruments. Focusing on equity markets, recent studies have analyzed the degree of EMU integration from various perspectives.

One strand of the literature examines whether expected returns are determined by global rather than local risk factors that rely on some specific asset pricing models (Bekaert and Harvey, 1995; Karolyi and Stulz, 2002; Hardouvelis et al., 1999). An important drawback of this methodology is that the results seem to depend heavily on the specification of the asset pricing model, and hence on correct identification of the relevant risk factors. A sub-group of this literature is the approach that focuses on the relative importance of country and industry effect in explaining returns: a decrease in the importance of country effects is often interpreted as an indicator of greater equity market integration. Baca et al. (2000), Cavaglia et al. (2000) and Flavin (2004) show that the importance of global industry factors has increased relative to country-specific factors. Adjouté and Danthine (2000) measure the relative importance of country and sector effects by simply calculating cross-sectional dispersion in country and sector returns, respectively: the higher the cross-sectional dispersion, the lower the correlations and the higher the diversification potential. These authors find that the potential of diversifying across sectors increased considerably at the end of the 1990s to levels even higher than those attainable through country diversification. European stock markets have therefore become more integrated over time, since returns in different European markets appear to be increasingly dominated by EU-wide factors rather than by country-specific ones.

The second methodology of analysis rests on equity return correlations. Fratzscher (2002) estimates a GARCH model with time-varying coefficients using data on daily returns from 1986 to 2000, finding an increase in correlation between stock returns within the euro area since the formal announcement of EMU inception in May 1998. Adjaouté and Danthine (2000) estimate the variance-covariance matrix of weekly returns from September 1990 to April 1999 and find a considerable increase in the correlation of stock returns. Fratzscher (2002) and Adjaouté and Danthine (2000) differ, however, in the economic interpretation of the same evidence. Adjaouté and Danthine (2000) interpret the increase in correlation simply as a decrease in diversification opportunities due to the convergence of economic structure and the homogenization of economic shocks, rather than to the disappearance of currency risk. This is because the increase in correlation results from both exchange risk-adjusted and unadjusted correlations. On the contrary, Fratzscher (2002) interprets the increased correlations as a symptom of greater integration. He asserts, in fact, that the elimination of exchange rate volatility and, to some extent, monetary policy convergence, has played a central role in explaining the increased financial integration.[1] More recently, Cappiello et al. (2009) confirm the increase in equity market comovement after integration, relying on an updated data set and on a regression quantile-based methodology.

A third strand of literature analyzes linkages across stock markets through cointegration analysis. Yang et al. (2003) study the impact of EMU on the long-run, short-run and contemporaneous structures of integration among 11 European stock markets. These authors find that the long-run linkages among these markets have generally been strengthened after the establishment of EMU.

Finally, some authors consider quantity based indicators. These measures may convey interesting information about the dynamics of euro area equity market integration. A number of authors have interpreted the recent decrease in equity home bias as evidence of further integration. Adam et al. (2002) report an increase in international portfolio diversification for European investment funds, pension funds and insurance companies after integration. They also conclude that, since the relative size of the local market is rather stable over time, the indicator of home bias is almost identical to the change in foreign assets, with the advantage that the latter does not rely on a benchmark that might be open to criticism. Recent evidence confirms that equity home bias has been reduced, at least within the euro area (Lane and Milesi-Ferretti, 2007).

In the present paper, we adopt the quantity-based approach in order to assess the degree of integration among EMU countries after EMU inception. Reduction in home bias would be an appropriate synthetic measure if the objective of the analysis were the level of *global* integration, whose standard benchmark is

[1] Croci (2004) finds an increase in return correlations across the euro equity markets since the mid-1990s. This increase in correlation seems to depend not only on the relaxation of restrictions to capital mobility, but also on higher informational market efficiency.

represented by the value-weighted portfolio. In this work, however, we are interested in capturing the degree of *local* integration within a subgroup of countries experiencing the same process of monetary integration regardless of the degree of integration with the rest of the world. To pursue this objective, we opt for a bilateral dispersion measure among EMU country portfolios. The theoretical framework we rely upon allows us to connect observed portfolio dispersion to the convergence of inflation hedging and investment barriers. The introduction of the common currency is a factor likely to affect investment barrier convergence. while the single monetary policy is expected to influence mainly inflation hedging strategies. Consequently, the relative explanatory power of investment barriers over inflation hedging allows us to highlight the relative impact of the single currency over the common monetary policy on stock market behavior.

3 Theoretical framework

3.1 The Model

In the Adler and Dumas (1983) model with stochastic inflation, the vector of portfolio weights in investor l's equity portfolio is made up of two components, the "logarithm portfolio", which is the portfolio driven by excess return and variance-covariance, and the "hedge portfolio", which is the portfolio hedging the investor's inflation risk.[2]

$$\mathbf{w}_l = \mathbf{\Omega}^{-1}\left\{\tfrac{1}{\lambda}([\boldsymbol{\mu} - r\mathbf{i}] + \left(1 - \tfrac{1}{\lambda}\right)[\boldsymbol{\varpi}_l]\right\} \tag{1}$$

where $\mathbf{w}_l$ is the vector of investor l's portfolio shares, $\boldsymbol{\mu} - r\mathbf{i}$ is the vector of stock excess returns, $\mathbf{\Omega}$ is the matrix of instantaneous variances-covariances of nominal rates of return, $\boldsymbol{\varpi}_l$ is a vector of covariances between nominal asset returns and country l's rate of inflation, and λ is the investor's relative risk aversion coefficient.

We integrate investment barriers as in Giofré (2009). The investment barriers -either direct such as transaction costs or indirect such as information asymmetries- are assumed to modify the variance-covariance matrix in such a way that each investor l has a perceived variance in the asset issued by country k that differs from an investor residing in any other country.

For each investor l, the vector of equity portfolio shares, $\mathbf{w}_l$, is

$$\mathbf{w}_l = \mathbf{C}_l^{-1}\mathbf{\Omega}^{-1}\left[\tfrac{1}{\lambda}(\boldsymbol{\mu} - r\mathbf{i}) + \left(1 - \tfrac{1}{\lambda}\right)\boldsymbol{\varpi}_l\right] \tag{2}$$

[2] See Appendix A for details on the model.

where $\mathbf{C}_l$ is a positive-definite matrix whose generic element $\mathbf{C}_l^j$ captures the bilateral investment barrier for investor l holding asset j.

The equilibrium condition on each stock market j commands a rate of return that equalizes the demand for asset j with the supply of asset j (market capitalization of asset j, MS_j).

After normalizing by world market capitalization we obtain the following equilibrium demand from country l's investor

$$\mathbf{w}_l = \mathbf{D}_l^{-1}\mathbf{MS} + \left(1 - \tfrac{1}{\lambda}\right)\mathbf{C}_l^{-1}\mathbf{b}_l \tag{3}$$

where $\mathbf{D}_l = \mathbf{C}_l\mathbf{\Phi}$, and $\mathbf{\Phi}$ is a diagonal matrix whose generic element ϕ_j is the inverse of the average of investment barriers faced when holding asset j. Consequently, $\mathbf{D}_l$ is a matrix capturing the *relative* (to average) bilateral investment barrier faced by investor l.

Vector $\mathbf{b}_l$ represents the inflation hedging coefficient of the regression of inflation deviation on stock returns (Cooper and Kaplanis, 1994)

$$\mathbf{\Omega}^{-1}\left(\varpi_l - \sum_{l=1}^{L} MS_l\varpi_l\right) = \mathbf{b}_l \tag{4}$$

If we define as p_l the inflation rate of country l then $\sum_{l=1}^{L} MS_l\varpi_l$ is the average world inflation rate and $\mathbf{b}_l$ is the vector of coefficients of the multiple regression of $(p_l - \sum_{l=1}^{L} MS_l p_l)$ on the vector of nominal returns. The regression coefficient $\mathbf{b}_l$ reflects, in fact, how far the returns can explain the deviation of investor l's inflation rate from average inflation. Variation of the inflation rate constitutes a risk factor that the investor seeks to hedge through optimal investment in risky assets. The higher the correlation of stock j's return with the deviation of country l's inflation from the average, the higher the share of country j's equity held by country l, since stock j is a good hedge against inflation risk.

This coefficient is obtained from the following regression

$$(p_l - \sum_{l=1}^{L} MS_l p_l)_t = b_l^0 + \sum_{j=1}^{N} b_l^j R_t^j + \varepsilon_{l,t}^j \tag{5}$$

Considering the portfolio share j held by country l's investor (where $\gamma = 1 - \frac{1}{\lambda}$)

$$w_l^j = \left(D_l^j\right)^{-1} MS^j + \gamma\left(C_l^j\right)^{-1} b_l^j \tag{6}$$

It is notable how the factor capturing investment barriers operates in a nonlinear way in our equation. How country j's market share determines the demand for asset j by investor l depends on the bilateral investment barriers of investor l relative to the average.[3] Investor l, for the fraction of her portfolio related to the "logarithm portfolio", will hold a share of assets greater (or smaller) than the market share proportional to $\frac{1}{D_l^j}$ (inverse of *relative* bilateral investment barrier). As far as the "hedge portfolio" is concerned, the country j's share in investor l's portfolio is determined by the inflation hedging properties of the considered stock, b_l^j, but proportional to $\frac{1}{C_l^j}$ (inverse of bilateral investment barrier).

3.2 Measures of dispersion

Let us consider two investing countries, l and y. We define by k_{ly}^j the *investment cost wedge,* that represents the difference in bilateral investment barriers between country l and j in asset j's investment.[4]

$$C_y^j = (1+k_{ly}^j)C_l^j \Longrightarrow \left(C_l^j\right)^{-1} = (1+k_{ly}^j)\left(C_y^j\right)^{-1}$$

$$\left(D_y^j\right)^{-1} = \frac{\left(C_y^j\right)^{-1}}{\phi^j} \Longrightarrow \left(D_l^j\right)^{-1} = \frac{\left(C_l^j\right)^{-1}}{\phi^j} = \frac{(1+k_{ly}^j)\left(C_y^j\right)^{-1}}{\phi^j} = (1+k_{ly}^j)\left(D_y^j\right)^{-1}$$

We define by Δ_{ly}^j the *asset j wedge* for the pair of countries l and y , that is the relative (to country y's portfolio share) distance between the portfolio shares invested in asset j by the two countries

$$\begin{aligned}
\frac{\left|w_l^j - w_y^j\right|}{w_y^j} &= \frac{\left|(1+k_{ly}^j)\frac{\left(C_y^j\right)^{-1}}{\phi^j}MS^j + \gamma b_l^j(1+k_{ly}^j)\left(C_y^j\right)^{-1} - \frac{\left(C_y^j\right)^{-1}}{\phi^j}MS^j - \gamma\left(C_y^j\right)^{-1}b_y^j\right|}{\frac{\left(C_y^j\right)^{-1}}{\phi^j}MS^j + \gamma\left(C_y^j\right)^{-1}b_y^j} \\
&= \frac{\left|(1+k_{ly}^j)\frac{MS^j}{\phi^j} + \gamma b_l^j(1+k_{ly}^j) - \frac{MS^j}{\phi^j} - \gamma b_y^j\right|}{\frac{MS^j}{\phi^j} + \gamma b_y^j} = \\
&= \left|\left(1+k_{ly}^j\right)\left(1+\gamma\frac{\left(b_l^j - b_y^j\right)}{\frac{MS^j}{\phi^j}+\gamma b_y^j}\right) - 1\right| \equiv \Delta_{ly}^j
\end{aligned} \tag{7}$$

Variable Δ_{ly}^jdepends on the *investment cost wedge* k_{ly}^j and on the difference between the inflation hedging coefficients of country l and y in asset j.[5]

[3] Our approach delivers an equilibrium condition in line with Obstfeld and Rogoff (2001). These authors show how the share of country j's equity held by country l is a decreasing (increasing) function of bilateral trading cost (efficiency) between l and j, relative to average trading costs between country j and all other countries.

[4] Note that we define $\mathbf{C}_l$ as a positive definite matrix such that the expressions below always hold.

[5] See Appendix B for derivation of Δ_{ly}^j under more restrictive assumptions of the model (alternatively, no investment barriers, symmetric investment barriers, no inflation hedging motive).

The final objective of our analysis is the growth rate of Δ^j_{ly}, that is its variation from the period before EMU integration to the period after integration, conjecturing a negative growth rate induced by the monetary union.

$$\frac{\left(\Delta^j_{ly}\right)_{post} - \left(\Delta^j_{ly}\right)_{pre}}{\left(\Delta^j_{ly}\right)_{pre}} = \frac{\left|\left[1+\left(k^j_{ly}\right)_{post}\right]\left(1+\gamma\frac{\left(b^j_l\right)_{post} - \left(b^j_y\right)_{post}}{\left(\frac{MS^j}{\phi^j}+\gamma b^j_y\right)_{post}}\right)-1\right|}{\left|\left[1+\left(k^j_{ly}\right)_{pre}\right]\left(1+\gamma\frac{\left(b^j_l\right)_{pre} - \left(b^j_y\right)_{pre}}{\left(\frac{MS^j}{\phi^j}+\gamma b^j_y\right)_{pre}}\right)-1\right|} - 1 \tag{8}$$

In general $b^j_l \neq b^j_y$ such that the growth rate of Δ^j_{ly} depends both on the variation in the distance of hedging coefficients and on the variation of the *investment cost wedge* k^j_{ly}. However, if $b^j_l = b^j_y$ both in the pre- and in the post-integration periods, the above expression reduces to

$$\frac{\left(\Delta^j_{ly}\right)_{post} - \left(\Delta^j_{ly}\right)_{pre}}{\left(\Delta^j_{ly}\right)_{pre}} = \frac{\left|\left(k^j_{ly}\right)_{post}\right| - \left|\left(k^j_{ly}\right)_{pre}\right|}{\left|\left(k^j_{ly}\right)_{pre}\right|} \tag{9}$$

that is, the growth rate of Δ^j_{ly} reduces to the growth rate of the *investment cost wedge* k^j_{ly}. This measure reflects the change in distance between the portfolio share invested in asset j by country l and y. If the distance has decreased after creation of the monetary union then the observed growth rate should be negative.

To obtain the wedge between overall portfolios rather than between individual assets we need to compute the *bilateral portfolio wedge* (bpw) between country l and y. This is obtained adding up the *asset j wedges* and attaching to each asset j a weight equal to MS^j, that is asset j's market share.

$$bpw_{ly} = \frac{\sum_j MS^j \Delta^j_{ly}}{\sum_j MS^j} \tag{10}$$

This measure quantifies the distance between the observed equity portfolios of country l and y.

To obtain a measure of dispersion of country l's portfolio from the group of EMU countries we compute the *aggregate portfolio wedge* (apw) of country l. This is a more synthetic measure that allows us to quantify the dispersion of country l's portfolio from a group Y of n countries. The apw of country l with respect to group Y is obtained by adding up the bpw with respect to each country y in the pool Y either attaching the same weight to each country y (unweighted apw)

$$apw_{l,Y} = \frac{1}{n} \sum_{y \in Y} bpw_{ly} \tag{11}$$

or weighting each country y by its market share (weighted apw) in the pool

$$apw_{l,Y} = \frac{\sum_{y \in Y} MS^y bpw_{ly}}{\sum_{y \in Y} MS^y} \tag{12}$$

Finally, substituting Δ_{ly}^{j}in (10) and in (11;12) with the growth rate of Δ_{ly}^{j} obtained as in (8) allows us to compute the growth rates in *bpw* and *apw*.

4 Data

Since 1997, the IMF has released surveys on bilateral foreign portfolio positions of many investing countries (Coordinated Portfolio Investment Survey, CPIS) and since 2001 this survey has been released annually. The CPIS dataset reports data on foreign portfolio holdings by residence of the issuer for many investing countries. Data are collected by gathering security-level data from the major custodians and large end-investors.[6] We consider in this work the 1997 edition as the benchmark for the pre-EMU integration period, and the 2004 edition as the benchmark for the post-EMU integration period. The 2001 edition - the first release after EMU integration - is also considered for a robustness check. Unlike other papers using the same dataset (e.g., Lane and Milesi-Ferretti, 2008), we opt to limit analysis to a subset of the countries participating in the survey. We selected them on the basis of their financial and, more broadly, economic importance.[7] We consider 12 countries: six EMU countries (Austria, Belgium, Finland, France, Italy, Netherlands) and six NON EMU countries (Canada, Denmark, Japan, United Kingdom, United States).[8] The destination countries are the same investing countries, representing more than 75% of world market capitalization and covering almost 85% of overall portfolio investment.[9]

The CPIS provides a unique perspective on cross-country bilateral equity positions, allowing the implementation of empirical analysis on international portfolio allocation for a large set of investing countries.

[6] The CPIS dataset and information on data collection are available at www.imf.org/external/np/sta/pi/datarsl.htm.

[7] Moreover, since our theoretical model predicts all nonzero portfolio weights, our sample of host countries has been restricted to destination stock markets with non zero liabilities. Alternatively, some authors prefer to include all investing and destination countries and to run a Tobit regression, thereby accounting for zero portfolio holdings (Lane and Milesi-Ferretti, 2008). In the present case, the very limited time span dictates a parsimonious number of stock return regressors to consistently derive the inflation hedging coefficients according to (5).

[8] Germany and Switzerland, although large and important countries, are excluded from this analysis, as they did not participate in the 1997 CPIS. Greece is excluded from the pool of EMU countries because it did not participate in the 1997 CPIS and entered EMU only in 2001. Luxembourg and Ireland are excluded, as often in the literature, because they are considered financial centers.

[9] The range of coverage in individual country portfolios is quite wide, ranging from 66% for Austria to 97% for Canada.

However, the above dataset contains information on foreign holdings only and does not include domestic positions. In order to derive the actual share of foreign assets, we draw from *International Financial Statistics* (*IFS*), outstanding foreign equity portfolio investments and corresponding liabilities. Then, we derive the "foreign share", FS

$$FS_{i,t} = \frac{(FA)_{i,t}}{(MCAP_{i,t} + FA_{i,t} - FL_{i,t})} \tag{13}$$

where FA stands for "foreign equity assets", FL for "foreign equity liabilities" and $MCAP$ for "stock market capitalization". After obtaining the foreign share, FS, it is then possible to calculate the share of each foreign holding in the overall portfolio.[10]

Stock returns and stock market capitalization are derived from *Datastream-Thomson Financials* and the inflation rates from *International Financial Statistics* (*IFS*).

5 Empirical analysis

5.1 Portfolio dispersion: evidence

There is some controversy over the date to be considered as the starting year of EMU integration. EMU was formally created in 1999 but 1998 was the pivotal year and the effects of the union could be anticipated in the markets. In March 1998, the European Commission and the European Monetary Institute published their convergence reports, recommending the eleven countries to be admitted into the EMU. At the beginning of May 1998, the decision was formally announced in a meeting of the Heads of States in Brussels, during which the bilateral irrevocable conversion rates were set among the member currencies. This was followed on 1 June 1998 by the official creation of the European Central Bank. It is commonly agreed that in 1997 the creation of the EMU was still in doubt. This is the year we designate as the "pre-EMU" period, plausibly not incurring in any dating problem. We choose the 2004 year as representative of the "post-EMU" period, since we require a sufficient number of observations after 1999 to estimate consistently the hedging coefficients in the post-EMU period.[11]

[10] Fidora et al. (2007) and Sorensen et al. (2007) follow the same procedure with respect to the CPIS dataset.

[11] However, as shown below, we also derive results using the year 2001 - the year of the first CPIS release after EMU integration - as the benchmark "post-EMU" year. Results under the two alternative specifications are consistent.

5.1.1 Portfolio wedge

We adopt a measure of bilateral dispersion to capture the degree of integration of equity markets among EMU member countries. In standard international asset pricing models, the value weighted portfolio represents the benchmark for *global* integration since it represents the optimal portfolio held by all investors if they faced identical barriers and sources of risks. Analogously, when the focus of the analysis shifts to the degree of *local* integration within a subgroup of countries, such as the EMU group, the benchmark becomes the euro area representative investor. We may therefore observe full convergence within a sub-group even though there is divergence of the group from the rest of the world, and consequently an absence of global integration. A direct implication of this reasoning is that the reduction in *home bias*, often indicated as a plausible measure of EMU integration, might be misleading: rather, the *home bias* measure addresses the issue of global integration, since the benchmark is the value weighted portfolio and nothing is said about internal EMU integration. Lane and Milesi-Ferretti (2007), in a recent empirical contribution to the literature, have also demonstrated a trend toward a "euro area bias", that is a bias of EMU countries toward equities issued by member countries. This important finding points to the reduction of investment barriers among EMU countries, but it does not necessarily entail a higher degree of *local* financial integration as defined in this paper. In fact, as stressed above, what must be tested is the *homogenization* of investment barriers, rather than the *reduction* of investment barriers.[12] It might in fact be the case that the representative investors of the various EMU countries, though increasing their portfolio shares invested in euro assets, do follow diverging investment patterns, and in so doing, depart from the euro area representative investor.

An alternative to our measure of bilateral dispersion could be a measure of dispersion of EMU country portfolios around an EMU benchmark. However, this would give rise to the problem of choosing the appropriate benchmark against which to compare the observed portfolios. Furthermore, our choice of bilateral dispersion rests on two key foundations. The first is the capture of the convergence speed of each pair of EMU countries. The second is the derivation, directly from our theoretical setting, of testable implications and interpretations of the determinants of portfolio dispersion.

Table 1 reports the growth of the *bilateral portfolio wedge* (*bpw*) from 1997 to 2004. This measure quantifies the extent to which two countries' portfolios have approached (negative growth) or diverged (positive growth).[13] The reported measure is obtained by computing, for any asset in the opportunity set, the growth in *asset j wedge*, Δ_{ly}^{j} for the country pair (l, y) and weighting each growth in Δ_{ly}^{j} by j's market share. For

[12] The two concepts are not at all equivalent, except in the limit case in which a reduction in investment barriers leads to their elimination.

[13] Note that our definition of portfolio wedge depends on country y taken as a benchmark and against which other countries are compared. In fact, each *asset j wedge* between country l and country y can be computed relative to country y's or to country l's portfolio, leading generally to different results. For simplicity, we report in the table the average growth rate of *bpw* for each couple (l, y), obtained by averaging the two - l-based and y-based - measures of *bpw*.

instance, we compute the distance of the investment in Japanese stocks for Austria and Belgium, and weight it by Japanese stock market capitalization. We repeat the same procedure for all other assets in the portfolio and add them up weighting each asset by its respective market share, thereby obtaining the growth of *bpw*. A glance at Table 1 reveals an obvious process of global integration. In fact, the growth of *bpw* is generally negative, pointing to a decrease in portfolio dispersion from 1997 to 2004 for all countries in our sample. However the integration process does not seem to be equally effective for EMU and NON EMU countries. The growth in bilateral portfolio wedge *within* EMU countries seems to be much larger (in absolute terms) than within NON EMU countries. The higher negative growth rates, i.e. the countries approaching faster, are among EMU countries: nine country pairs out of 15 display a drop in portfolio dispersion larger than 50%. Only two country pairs out of 36 show a reduction in bilateral portfolio wedge larger than 50% when matching one EMU country with a NON EMU country and no such a decrease is recorded within the NON EMU country group. Finland and Italy appear to be the two countries most strongly reducing their dispersion with respect to the other countries, especially with respect to EMU countries. This impression is confirmed when computing the growth of aggregate portfolio wedge (*apw*), a measure that captures the growth in dispersion of a given country's portfolio from a pool Y of countries. We report in Table 2 the growth rates of *apw* for all countries considered, EMU and NON EMU. The "weighted" growth in *apw* is obtained by weighting the growth of *bpw* by the relative market share of the corresponding country in the pool Y , while in the "unweighted" growth all countries are equally weighted. For example, the "weighted" change in dispersion of Italy from the group of EMU countries is obtained by adding up the growth in dispersion of Italy from any EMU country, weighting each addend by the weight of the country in the EMU group. The impression of higher global integration is also confirmed by this aggregated measure: EMU and NON EMU countries have reduced their portfolio distance from 1997 to 2004. EMU countries, however, show a *within* reduction in portfolio wedge larger than 50%, twice as large as the *within* reduction of NON EMU countries. Finland and Italy are confirmed to be the two countries with the strongest reduction in dispersion with respect to EMU and NON EMU countries. The Netherlands shows a comparable degree of reduction toward EMU and NON EMU countries while Austria, Belgium and France are shown to converge twice as fast to EMU countries than to NON EMU countries. For NON EMU investing countries, the growth in *apw* is always significantly below 50%, except for Japan which shows a stronger drop in dispersion relative to other NON EMU countries; however, this is below the average EMU reduction.

5.1.2 Portfolio convergence

The evidence above suggests a deeper integration of EMU equity portfolios after creation of the monetary union. However. it is not sufficient to simply assess the convergence of EMU portfolios. These results might be driven by countries starting closer to each other before integration and getting closer at a higher speed, while countries starting further apart might approach each other more slowly or even depart one another after integration. In order to determine whether an actual convergence pattern has taken place among EMU countries, we must investigate how *growth* in portfolio dispersion is related to the initial (pre-EMU) *level* of portfolio dispersion. Panel A of Table 3 reports the *level* of aggregate portfolio wedge (*apw*) for 1997 and 2004 for all investing countries with respect to the EMU and NON EMU groups. The reported "weighted" *apw* level is obtained according to expression (12). For instance, in order to compute the portfolio wedge of France with respect to Italy we sum the corresponding individual *asset j wedges* (7) with respect to all destination assets (Austria, Belgium, Canada, etc.) weighted by their market share.[14] We repeat this procedure for France with respect to all other EMU countries, obtaining the portfolio wedge of France with respect to all EMU countries. Finally, these measures are weighted by each EMU country's relative market share in order to obtain the aggregate portfolio wedge (12), that is the portfolio dispersion of France with respect to the EMU group.[15] Let us first examine the average *apw* level and then delve deeper, analyzing individual countries. It is immediately evident how the average level of aggregate portfolio wedge has decreased for all countries from 1997, thus evidencing stronger global integration.[16] For NON EMU countries, the *within* NON EMU and the NON EMU-EMU *between apw* were very similar to one another before EMU inception and remain very similar after EMU integration, although at a lower level. Conversely, for EMU countries, there was a large difference between the EMU *within* and the EMU-NON EMU *between apw* before EMU integration and this persists afterwards. The *within* EMU *apw* was indeed one third of the *between* EMU-NON EMU *apw* before integration and it drops to one-fourth after integration. Examining the *apw* of individual investing countries, we notice that for all countries, we detect a generalized decrease in *apw* with respect to both NON EMU and EMU countries. Among NON EMU investing countries, we note how the decrease is quite modest for all countries and no systematic difference can be found between the two reference groups, EMU and NON EMU. The only exception is Japan, almost halving its *apw* with respect to EMU countries and remarkably reducing the distance with respect to NON EMU countries. Among EMU countries, Austria, Belgium, France and the Netherlands, all reduce their distance with respect to EMU countries and to a lesser extent to NON EMU countries.[17] Finland and Italy emerge among EMU countries because of their high *apw* level before integration: the *between* EMU-NON EMU *apw* was almost three times larger than the EMU average for

[14] Note that in the dispersion measures adopted *all* destination assets, either EMU or NON EMU, are included. The EMU/NON EMU distinction refers uniquely to the investing side.

[15] The reported "ALL weighted average" is obtained by weighting the aggregate portfolio wedges of each country by its relative market share (similarly, for the "EMU weighted average" and the "NON EMU weighted average").

[16] Results obtained for the *unweighted* average case, not reported here, are slightly higher in the 1997 period (14.7, 6.4 and 23.0 with respect to ALL, EMU and NON EMU, respectively) while almost identical to the weighted average case in 2004.

[17] This is the mirror result of the decrease in dispersion of NON EMU versus EMU countries; however, as already noted above, they are not quantitatively identical since the wedges are computed relative to the investing country's portfolio share.

Finland and more than two times larger for Italy, while the *within* EMU *apw* was almost twice as large for both investing countries. However, in 2004, the values of *within* and *between apw* for Finland and Italy drop dramatically and become almost in line with the EMU average. As noted in the previous subsection, Finland and Italy were the EMU countries with the sharpest drop in dispersion with respect to other EMU member countries. Now, if the countries with the higher pre-EMU *apw* level, i.e. the countries which were furthest apart from other countries before integration, are also the ones approaching other countries fastest after integration, this means that EMU integration might have put in motion a convergence process. In panel B of Table 3 we report the relation of the growth rate of *apw* from 1997 to 2004 with respect to its initial level in 1997. For all countries in our sample, we find a negative correlation between the growth rate and the initial level: countries starting with a higher dispersion level are those experiencing the stronger reduction, and the convergence among EMU countries appears much stronger. Since these correlations are based on only few aggregate-level observations, we can derive no sound conclusions. In order to find support for the convergence hypothesis, we must step back and disaggregate the *apw* into its bilateral components, the *bpw,* and derive the relation between its growth rate and its initial level. In other words, we analyze the *bilateral* convergence process by considering the level and change in dispersion between portfolios.

We plot the growth rate of *bpw* against its initial level in Figures 1-6. A first glance at the six graphs suggests that our conjecture on convergence is reliable, since the observations are approximated by a negatively sloped fitting line. In Figure 1 we report the scattered plot of the growth in *bpw*, as reported in Table 1, against its initial level in 1997 for all investing countries. We then draw a least squares line fitting the data (thick line) which results negatively sloped, with a coefficient equal to -0.014 and adjusted R^2 - capturing the degree to which the line fits the data - equal to 0.13. However, the growth rate reported on the vertical axis is naturally lower-bounded by -1. Accordingly, a straight line does not appear to be an optimal fitting curve, as it is by definition unbounded. We therefore choose to adopt a functional form that better accomplishes the objective of capturing data behavior, that is a logarithmic function (thin curve).[18] At the bottom of the graph, we also report the coefficient of the straight line fitting the growth rate of *bpw* to the log(*bpw*), that is -0.142, with the adjusted R^2 equal to 0.14.[19] In Figure 2 and 3 we plot the same graph but restrict the analysis to the *within* EMU subsample and to the *within* NON EMU subsample, respectively. The most interesting finding is that, for both the linear and logarithmic specifications, the slope of the fitting

[18] Note that we draw the logarithmic curve better fitting *bpw* while the reported linear coefficient relative to the logarithmic function considers log(*bpw*) as indipendent variable.

[19] Since there are 12 investing countries, we should have 132 pair-observations (each country compared to all others except itself). However, we exclude four outliers (referring to between EMU/NON EMU observations), yielding 128 observations. To remove any doubt on the potential importance of the outliers, we also compute the fitting lines with all observations. The outliers, by definition, alter the size of coefficients, but in our case they do not bias the coefficient size in any systematic direction. In fact, the corresponding slope of the least squares straight line is lower (-0.004), statistically significant at 1% and with adj-R^2 equal to 0.06. In the logarithmic specification the slope is, instead, higher (-0.153), statistically significant at 1% and with adj-R^2 0.15.

line of the *within* EMU subsample is twice as large as the corresponding coefficient of the *within* NON EMU sub-sample. The adjusted R^2 is also much larger in the *within* EMU case than in the *within* NON EMU case, being 0.32 against 0.19 in the linear specification case and 0.48 against 0.15 in the logarithmic specification.[20] In Figure 4, we illustrate the convergence between EMU and NON EMU with a slope close to the average one represented in Figure 1. Figure 5 and 6 display, respectively, the convergence of EMU investing countries and NON EMU investing countries with respect to all countries. The slope is, unsurprisingly, very similar since the two graphs reflect the same convergence process by two mirror perspectives.[21]

Finally, EMU inception appears to have homogenized portfolio allocation strategies, boosting a convergence process among member countries.

To provide support to our hypothesis, we consider the growth rate between 1997 and 2001, which is the first available post EMU year in our dataset. We plot in Figure 7 the growth rates (1997-2001) of *within* EMU *bpw*, *within* NON EMU *bpw* and *between* EMU-NON EMU *bpw* .[22] The flatter fitting line corresponds to the *within* NON EMU convergence while the steeper line corresponds to *within* EMU convergence. Interestingly, in this shorter time span, there is no significant convergence among NON EMU countries and the convergence between EMU and NON EMU countries is almost identical to that recorded in the longer period. We find that this pattern is very similar to the one found for the 1997-2004 period: the *within* EMU convergence is still sizeable with a coefficient twice as large as the *between* EMU/NON EMU coefficient and three times larger than the (non-statistically significant) *within* NON EMU slope. As expected, since the time span is shorter, the degree of convergence in the *within* EMU case is lower than in the 1997-2004 period, stressing that the convergence process was already in effect in 2001 and continued to speed up thereafter.[23]

5.2 Portfolio dispersion: determinants

If the EMU inception had an effect on equity portfolio convergence, it may be attributable to several factors. We focus on two main channels through which the financial integration among member countries could have arisen: the common monetary policy and the single currency (Fratzscher, 2002). A common monetary policy should tend to synchronize member country inflation rates thereby inducing investors to choose increasingly similar strategies to hedge inflation risk. At the same time, the presence of the single currency could induce

[20] For both the *within* EMU and the *within* NON EMU subsamples, there are no outliers so we maintain all 30 observations for each group.

[21] This result stresses how the peculiar, stronger convergence of *within* EMU countries is not driven at all by the nature of the bilateral dispersion measure, that is defined relative to a particular investing country. If this were the case and the higher convergence were uniquely due to some characteristics of EMU countries as investors, then we should observe a different convergence of EMU portfolios also with respect to NON EMU countries and so a different convergence slope in Figure 5 and 6.

[22] For the sake of clarity, we report only the linear least square case (the logarithmic case shows a qualitatively similar pattern).

[23] We exclude one outlier for the *within* EMU *bpw* and two outliers for the *between* EMU-NON EMU *bpw*. Including the outliers the regression coefficient for the *within* EMU *bpw* would have been even larger (-0.031*), while the coefficient for the *between* EMU-NON EMU *bpw* (-0.004***) would have been even lower, further supporting our hypothesis.

member country investors to hold increasingly similar international equity positions as investment barriers (direct, such as transaction costs and indirect such as informational barriers) might have become more similar.[24] The next section describes how these two forces might have determined the strong convergence of EMU equity portfolios described above.

5.2.1 Inflation hedging

Some literature on the convergence in inflation rates considers the correlation measure or the dispersion in inflation rates. In Figure 8 we report the standard deviation of inflation rates among EMU countries in the period 1993-2004 (solid line). For comparison, we report the standard deviation of inflation rates for the NON EMU countries included in our analysis (dotted line). It seems quite evident that the average standard deviation among NON EMU countries has remained fairly stable over the period considered while the standard deviation of EMU countries has decreased since the beginning of 1997, pointing to a homogenization of inflation rates among member countries. However, the evidence of a lower dispersion across member countries is not sufficient to conclude a stronger role for a common inflation hedging motive as, according to our theoretical framework, what matters in shaping optimal portfolios is the *comovement* of inflation rates across countries and therefore their covariance more than their standard deviation.[25] We report in Table 3 descriptive statistics on inflation rates for EMU and NON EMU countries, distinguishing between the pre-EMU period and the post-EMU period. It is immediately evident how, for the sample of countries analyzed, there is no much variation in the covariance, so we do not expect *a priori* a great impact on portfolios.[26] In order to size the impact of the inflation hedging motive, we run regression (5). We instrument return R_t^j by its lagged value R_{t-1}^j, where the orthogonality condition $E(R_{t-1}^j \varepsilon_{lt}^j) = 0$ holds. A GMM regression is therefore implemented returning - for each investing country - consistent estimates of the 12 b_l^j coefficients - one for each destination country. In order to estimate the above expression, we use monthly data for the six years preceding each portfolio holding date. For 1997 stock holdings, we use monthly returns for the period January 1993-December 1997, while for portfolio positions in 2004 we refer to the January 1999-December 2004 period. The number of observations, identical for the pre- and post-EMU periods, is dictated by the relatively short post-EMU period. In Table 4, we report the results of the Wald test on the difference in the

[24] The recent literature has emphasized the stronger informational linkages among EMU countries after monetary integration (Lane and Milesi-Ferretti, 2007; Croci, 2004).

[25] Note that our results are not driven by the fact that we consider 1993-1998 as the pre-EMU period, while our pre-EMU portfolios refer to December 1997. We also compute the covariances and standard deviations of inflation rates when the pre-EMU period is assumed to end in December 1997; we find that their relative size with respect to the post-EMU period remains quite similar to what is reported here. Further, considering May 1998, the month of the formal announcement of EMU inception, as the cutoff point does not alter our conclusions.

[26] When all EMU countries are included, the mean and standard deviation are only marginally affected while the average correlation slightly decreases from 0.58 to 0.54 and the average covariance ($1*10^3$) is almost halved, moving from 0.56 to 0.30. This reflects the evidence of inflation divergence recorded by Honohan and Lane (2003, 2005). It also stresses that the divergent pattern is mainly due to smaller EMU countries such as Ireland.

estimated b_l^j hedging coefficients. For each pair of EMU countries, we test twelve coefficients, corresponding to the number of destination assets. An equal, or not statistically different, hedging coefficient of Austria and Belgium with respect to Japanese assets implies that the two countries should have the same position in Japanese stocks in order to hedge inflation.[27] Our results support, in general, the hypothesis of no substantial difference in hedging strategies induced by EMU integration. Inflation comovement was in fact already strong in the pre-EMU period and has not remarkably increased after integration. The Wald test does not reject the null hypothesis of equal hedging coefficients at the 1% confidence level for 96 percent of cases prior to EMU integration and for 100 percent of cases for the post-EMU period.[28] The table reports for each EMU country-pair the number of different coefficients out of 12 and, in parentheses, the destination assets, displaying different hedging properties with the confidence level indicated. The upper diagonal elements report the number of statistically different coefficients in the pre-EMU period, while the lower diagonal elements refer to the post-EMU period. The maximum number of different hedging coefficients is 12 for each country-pair. We may note how hedging portfolios for Austria and France, for instance, demand different portfolio shares in Japan, UK and the US in order to hedge inflation before EMU integration, while the absence of different coefficients after EMU integration implies that their hedge portfolio has become identical.[29] The hedging coefficients result statistically different only in very few cases, suggesting a very limited role for the inflation hedging motive in explaining EMU portfolio convergence. There has been some convergence in inflation comovement after the integration, evidenced by the lower number of different coefficients. However, this change is modest as a high comovement was already present in the pre-EMU period. In order to check the relevance of inflation convergence in driving our results, we compute the portfolio dispersion and portfolio convergence, excluding for the relevant pair of countries, those destination assets showing different hedging properties. For instance, in the computation of growth in bilateral portfolio dispersion between Austria and Finland, we exclude UK and US assets for which the Wald test rejects the null hypothesis of equal hedging coefficients. We find that our results are unchanged. The negligible fraction of significantly different hedging coefficients and the small size of the distances allow us to attribute the observed dispersion in portfolios to investment barriers. In other words, the observed reduction in portfolio dispersion is reasonably approximated by reduction in dispersion of bilateral investment barriers and, consequently, the observed convergence in EMU portfolios can be imputed to convergence in the investment barriers of EMU countries.

[27] However, an equal hedge portfolio does not command an equal portfolio share, since investing countries are allowed to differ in terms of bilateral investment barriers.

[28] When the confidence interval is widened to 10%, the percentage of not statistically different coefficients decreases to 90 percent and to 98 percent for the pre- and post-EMU period, respectively. Note that the weak correlation between stock returns and inflation rates makes the coefficient estimates quite unprecise so further reducing the percentage of rejected tests.

[29] We perform 180 tests (6 countries, therefore 15 pairs, investing in 12 countries). We consider as statistically significant those differences for which the Wald test rejected the null hypothesis, provided at least one of the two hedging coefficients was different from zero. There are 3% and 10% of tests, for the pre-EMU and post-EMU period, respectively, rejecting the null hypothesis with *both* coefficients being statistically not significant. In other words, these are simply two different "zeros" and are considered to play no role in determining portfolio dispersion.

5.2.2 Investment barriers

After ruling out the role of inflation hedging, the explanatory burden falls entirely on bilateral investment barriers. The expression for variation of portfolio dispersion over time reduces, accordingly, to (9) and the only force driving the growth in *asset j wedge* between country l and y (Δ^j_{ly}) is the *investment cost wedge* k^j_{ly}. This crucial finding allows us to reinterpret the results from an alternative point of view. The negative growth in *bpw* among EMU countries reported in Table 1 can be seen as a reduction in dispersion of bilateral investment barriers. The fastest drop in distance is between Finland and Italy, whose *investment cost wedge* drops by 83% and, in general, the stronger drops are related to Finland and Italy moving closer to other EMU countries. The Netherlands, even though it on average reduces its dispersion with respect to EMU countries, shows some anomalous features with an increase *investment cost wedge* of 41% with respect to Austria and of 11% with respect to France. Table 2 conveys a more general picture of the investment wedge of different EMU countries with respect to the two reference groups, EMU and NON EMU. The drop in *investment cost wedge* among EMU countries is above 50%, meaning that the distance between bilateral investment barriers is halved in the period 1997-2004. Finland and Italy are the countries showing on average the strongest reduction in distance from other EMU country portfolios; this can be read as a reduction in distance between their bilateral investment barriers and other EMU countries' barriers. Analogously, Table 3 can be read in terms of *investment cost wedges*: in 1997 the *within* aggregate investment wedge of EMU countries was lower than the *between* EMU aggregate investment wedge, and it continued to decline with respect to both EMU and NON EMU countries. The level of k^j_{ly} is not very informative *per se* since, as stressed above, symmetrical investment barriers command symmetrical portfolios. However, the *distance* of k^j_{ly} from the overall mean reveals which countries start from a less integrated position, and the *growth rate* of k^j_{ly} points out those countries converging more rapidly. Finland and Italy, the countries which displayed the highest drop in dispersion, were also the countries having the highest pre-EMU *investment cost wedge*, suggesting a convergence process in investment barriers. The convergence process in bilateral investment barriers is finally represented in Figure 2. The common currency union had the effect of making bilateral investment barriers - direct barriers such as transaction costs or indirect barriers such as information costs - increasingly similar among member countries. Since the convergence process is driven by convergence of investment barriers rather than inflation convergence, we stress the prevailing role of the common currency over common monetary policy (Fratzscher, 2002) in determining convergence in equity portfolios.

6 Conclusions

We uncover strong convergence among EMU countries' international equity portfolios after the creation of the monetary union. We investigate whether this evidence is due to inflation hedging or to investment barriers. We test the difference in inflation hedging coefficients in order to detect how far the common monetary policy, determining a higher comovement in inflation rates, might have induced similar hedging strategies, thus driving the convergence in portfolio allocations. We find no support for the inflation hedging explanation since a remarkable comovement in inflation rates was already present before EMU integration. Convergence in bilateral investment barriers induced by the single currency is therefore recognized as the sole responsible factor in portfolio convergence. An interesting implication of this clear-cut finding is the possibility of quantifying convergence in investment barriers: in the period considered (1997-2004), the dispersion in investment barriers among EMU countries is halved and the speed of convergence is twice as large as NON EMU countries, suggesting a strong convergence process fostered by creation of the EMU.

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Appendix A: Model with inflation hedging and investment barriers

Inflation hedging

We model the inflation risk in the investor's problem following Adler and Dumas (1983). We consider L investors investing in N stocks and one risk-free asset. Lacking data on the specific securities exchanged between individuals, we assume that investors are restricted to hold national market indexes. Consequently, considering one investor and one asset per country, we deal with L source countries and N host countries. Hence, the vector of weights will have dimension $(N+1)x1$ while the portfolio variance-covariance matrix will be of dimension NxN since the $(N+1)th$ asset is riskless. All variables are expressed in a common currency chosen as numeraire.[30]

The investor's constrained optimization problem is the following

$$\underset{w^j}{Max}\ E\int_t^T V(C,P,s)ds \tag{14}$$

$$sub \quad dW = \left[\sum_{j=1}^{N} w^j(\mu^j - r) + r\right] Wdt - Cdt + \sum_{j=1}^{N} w^j\sigma^j dz^j \tag{15}$$

where W is the nominal wealth, r is the riskless instantaneous nominal interest rate, μ^j is the asset j's instantaneous expected rate of return, σ^j is the instantaneous standard deviation, C is the nominal rate of consumption, P is the price level index, V - expressing the instantaneous rate of indirect utility - is a function homogeneous of degree zero in (C,P) and w is the vector of investor's portfolio shares.

The instantaneous total rate of return on the market portfolio of country j is

$$dY^j/Y^j = \mu^j dt + \sigma^j dz^j$$

where z^j is a Wiener process and dz^j is a standard Gauss Wiener process with zero mean.

The price index of an investor l in the measurement currency follows the Brownian process

$$dP_l/P_l = \pi_l dt + \sigma_{l,\pi} dz_{l,\pi}$$

where π_l is the expected value of the instantaneous rate of inflation and $\sigma_{l,\pi}$ is the standard deviation of the instantaneous rate of inflation.

Denoting by $J(W,P,t)$ the maximum value of (14) subject to (15), we define by λ the investor's relative risk aversion coefficient

$$\lambda = -\frac{J_{WW}}{J_W}W$$

where J_W and J_{WW} are, respectively, the first and second partial derivative of $J(.)$ with respect to W.

This yields the optimal expected rate of return

$$\mu^j = r + (1-\lambda)\sigma^{j,\pi} + \lambda\textstyle\sum_{k=1}^{N} w_k\sigma^{j,k}$$

and the optimal portfolio allocation

$$\tilde{\mathbf{w}}_l = \tfrac{1}{\lambda}\begin{pmatrix} \boldsymbol{\Omega}^{-1}(\boldsymbol{\mu} - r\mathbf{i}) \\ 1 - \mathbf{i}'\boldsymbol{\Omega}^{-1}(\boldsymbol{\mu} - r\mathbf{i}) \end{pmatrix} + (1 - \tfrac{1}{\lambda})\begin{pmatrix} \boldsymbol{\Omega}^{-1}\boldsymbol{\varpi}_l \\ 1 - \mathbf{i}'\boldsymbol{\Omega}^{-1}\boldsymbol{\varpi}_l \end{pmatrix} \tag{16}$$

where $\mathbf{i}$ denotes a $Nx1$ vector of ones, $\boldsymbol{\Omega}$ is a NxN matrix of instantaneous variances-covariances of nominal rates of returns and $\boldsymbol{\varpi}_l$ is a $Nx1$ vector of covariances between nominal asset returns and country l's rate of inflation. The last element in each vector refers to the riskless asset. The first term in parentheses of the above equilibrium condition is often called "logarithm portfolio"[31], that is the portfolio driven by excess

[30] As shown by Solnik (1974) and Sercu (1980), the portfolio composition is independent from the numeraire considered.

[31] It is the portfolio held by the investor characterized by a unitary coefficient of risk aversion, i.e. a logarithmic utility function.

return and variance-covariance considerations, while the second is the "hedge portfolio", that is the portfolio hedging the investor's inflation risk.

The vector of weights in the investor l's equity portfolio is then

$$\mathbf{w}_l = \mathbf{\Omega}^{-1}\left\{\tfrac{1}{\lambda}([\boldsymbol{\mu} - r\mathbf{i}] + \left(1 - \tfrac{1}{\lambda}\right)[\boldsymbol{\varpi}_l]\right\} \tag{17}$$

Information asymmetries

We integrate investment barriers following Giofré (2009). The informational barriers are assumed to modify the variance-covariance matrix according to Gehrig (1993) approach[32]: investor l has a different perceived variability of the asset issued by country k from an investor residing in another country.[33]

For each investor l the vector of equity portfolio shares, $\mathbf{w}_l$, will be therefore

$$\mathbf{w}_l = \mathbf{C}_l^{-1}\mathbf{\Omega}^{-1}\left[\tfrac{1}{\lambda}(\boldsymbol{\mu} - r\mathbf{i}) + \left(1 - \tfrac{1}{\lambda}\right)\boldsymbol{\varpi}_l\right] \tag{18}$$

where $\mathbf{C}_l$ is a diagonal NxN positive definite matrix whose generic element C_l^j is the bilateral cost of holding country j's stock by country l's investor. Its reciprocal, $\dfrac{1}{C_l^j}$, stands for a variable capturing the investment "advantage" of country l investing in country j.

The equilibrium condition equates stock demand and stock supply: the vector of market shares of stock indexes (supply side) must be set equal to the right hand side that is the (weighted) sum of stock indexes' demands (demand side).

$$\sum_{l=1}^{L}\nu_l\mathbf{w}_l = \mathbf{MS} \tag{19}$$

where ν_l represents country l's fraction of world wealth.[34]

Let us consider $\mathbf{\Phi}$, a diagonal NxN positive definite matrix whose generic element, ϕ_j, is the *average* investment "advantage" in holding asset j.

$$\phi_j = \sum_{l=1}^{L} MS_l \frac{1}{C_l^j}$$

Let us define $\mathbf{D}_l = \mathbf{\Phi}\mathbf{C}_l$, where $\mathbf{D}_l$ is again a diagonal NxN positive definite matrix. We can rewrite the above expression (18) as

$$\mathbf{w}_l = \mathbf{D}_l^{-1}\mathbf{\Phi}\mathbf{\Omega}^{-1}\left[\tfrac{1}{\lambda}(\boldsymbol{\mu} - r\mathbf{i}) + \left(1 - \tfrac{1}{\lambda}\right)\boldsymbol{\varpi}_l\right] \tag{20}$$

where $D_l^j = \phi_j C_l^j$ and $\dfrac{1}{D_l^j} = \dfrac{\frac{1}{C_l^j}}{\sum_{l=1}^{L} MS_l \frac{1}{C_l^j}}$

and using the equilibrium condition (19) equating stock supply ($\mathbf{MS}$) to stock demands we get the following result

[32] Cooper and Kaplanis (1994) use the return reduction approach in modelling direct transaction costs. We chose this alternative solution since it allows to derive a more clear-cut and easily interpretable expression for bilateral portfolio dispersion.

[33] In a standard setting with asymmetric information (Grossman and Stiglitz, 1980), an informed investor has a lower perceived variance due to her private signal but, at the same time, her perceived expected return is generally also different from the uninformed investor's. It implies that it should be sometimes observed a "foreign-bias" when the domestic investor observes bad signals. Our perspective on information asymmetry is, instead, closer to the concept of "model uncertainty" or "Knightian uncertainty" (Epstein and Miao, 2003; Uppal and Wang, 2003). Roughly speaking, we assume that investor k's perceived uncertainty is different from investor l's, though both face the same perceived return.

[34] As in Cooper and Kaplanis (1994) we proxy country l's fraction of wealth (ν_l) with country l's market share MS_l.

$$\mathbf{w}_l = \mathbf{D}_l^{-1}\mathbf{MS} + \left(1 - \tfrac{1}{\lambda}\right)\mathbf{C}_l^{-1}\mathbf{\Omega}^{-1}\left(\varpi_l - \sum_{l=1}^{L} MS_l \varpi_l\right) \tag{21}$$

$\dfrac{1}{D_l^j}$ represents the *relative* (with respect to world average) "advantage" of country l investing in asset j. In other words, the investor l will demand a share of assets greater than the market share in proportion to $\dfrac{1}{D_l^j}$ (inverse of relative investment barrier).[35]

We can now notice how the covariance vector in parentheses pre-multiplied by the inverse of the variance-covariance matrix of returns is a vector of regression coefficients (Cooper and Kaplanis, 1994).

$$\mathbf{\Omega}^{-1}\left(\varpi_l - \sum_{l=1}^{L} MS_l \varpi_l\right) = \mathbf{b}_l \equiv \begin{pmatrix} b_l^1 \\ \vdots \\ b_l^j \\ \vdots \\ b_l^N \end{pmatrix} \tag{22}$$

If we define by p_l the inflation rate of country l then $\sum_{l=1}^{L} MS_l \varpi_l$ is the average world inflation rate and $\mathbf{b}_l$ is the vector of coefficients of the multiple regression of $(p_l - \sum_{l=1}^{L} MS_l p_l)$ on the vector of nominal returns.

Appendix B: Restricted model

We derive here the *asset j wedge* under restricted versions of the model: no investment barriers, symmetrical investment barriers, no inflation hedging.

No investment barriers

If there are no investment barriers then

$$C_l^j = 1 \ \forall l, j \Longrightarrow D_l^j = 1 \ \forall l, j$$

and (21) reduces to the following standard Adler and Dumas (1983) equilibrium model

$$w_l^j = MS^j + \gamma b_l^j$$

The the *asset j wedge* (Δ_{ly}^j) in expression (7) in the text reduces therefore to

$$\begin{aligned} \frac{\left|w_l^j - w_y^j\right|}{w_y^j} &= \frac{\left|MS^j + \gamma b_l^j - MS^j - \gamma b_y^j\right|}{MS^j + \gamma b_y^j} = \\ &= \gamma \frac{\left|b_l^j - b_y^j\right|}{MS^j + \gamma b_y^j} \end{aligned}$$

If comovement of inflation rates between country l and y is such that the hedging coefficients are not statistically different ($b_l^j = b_y^j$) we should, consequently, observe identical portfolio allocations across EMU countries. However, even though the Wald test does not reject in almost all cases the null hypothesis

[35] Note that the average world covariance ($\sum_{l=1}^{L} MS_l \varpi_l$) is computed weighting each country by its market share MS_l. This is a proxy for country l's share of total wealth (ν_l) corrected by its "relative" (to world average) investment advantage.

$b_l^j = b_y^j$, differences in portfolios are still remarkable. Investment barriers are therefore necessary to give an interpretation the observed portfolio dispersions.

Symmetric investment barriers

In this specification we allow for the presence of investment barriers but we assume they are symmetrical for all countries. Since $\left(D^j\right)^{-1} = \frac{\left(C^j\right)^{-1}}{\phi^j}$

$$w_l^j = \left(D^j\right)^{-1} MS^j + \gamma \left(C^j\right)^{-1} b_l^j$$

The the *asset j wedge* (Δ_{ly}^j) in expression (7) in the text reduces therefore to

$$\frac{\left|w_l^j - w_y^j\right|}{w_y^j} = \frac{\left|\frac{\left(C^j\right)^{-1}}{\phi^j} MS^j + \gamma \left(C^j\right)^{-1} b_l^j - \frac{\left(C^j\right)^{-1}}{\phi^j} MS^j - \gamma \left(C^j\right)^{-1} b_y^j\right|}{\frac{\left(C^j\right)^{-1}}{\phi^j} MS^j + \gamma \left(C^j\right)^{-1} b_y^j} =$$

$$= \frac{\left|\frac{MS^j}{\phi^j} + \gamma b_l^j - \frac{MS^j}{\phi^j} - \gamma b_y^j\right|}{\frac{MS^j}{\phi^j} + \gamma b_y^j} = \gamma \frac{\left|b_l^j - b_y^j\right|}{\frac{MS^j}{\phi^j} + \gamma b_y^j}$$

Again, the differences in portfolio weights are entirely due to inflation hedging contradicting the empirical evidence of heterogeneity in portfolio allocations under equality of hedging coefficients. As pointed out above, the mere existence of investment barriers does not imply heterogeneity in portfolio positions.

Heterogeneous investment barriers without inflation hedging

Finally, we consider the case with heterogeneity in investment barriers but absence of stochastic inflation, that is we assume no role for stocks in hedging inflation. The equilibrium condition will be, therefore

$$w_l^j = \left(D_l^j\right)^{-1} MS^j$$

From the text

$$C_y^j = (1 + k_{ly}^j) C_l^j \Longrightarrow \left(D_l^j\right)^{-1} = \frac{\left(C_l^j\right)^{-1}}{\phi^j} = \frac{(1 + k_{ly}^j) \left(C_y^j\right)^{-1}}{\phi^j} = (1 + k_{ly}^j) \left(D_y^j\right)^{-1}$$

The the *asset j wedge* (Δ_{ly}^j) in expression (7) in the text reduces therefore to

$$\frac{\left|w_l^j - w_y^j\right|}{w_y^j} = \frac{\left|(1 + k_{ly}^j) \frac{\left(C_y^j\right)^{-1}}{\phi^j} MS^j - \frac{\left(C_y^j\right)^{-1}}{\phi^j} MS^j\right|}{\frac{\left(C_y^j\right)^{-1}}{\phi^j} MS^j} =$$

$$= 1 + \left|k_{ly}^j\right| - 1 = \left|k_{ly}^j\right|$$

The case of inflation hedging coefficients not statistically different among EMU countries emerging from our analysis is observationally equivalent to the case of null inflation hedging. In both cases, in fact, portfolio dispersion is exclusively due to heterogeneity in investment barriers.

Table 1. Growth in *bilateral portfolio wedge*

The table reports the variation over time of the *bilateral portfolio wedge* (*bpw*), that is the portfolio wedge of each investing country *l* with respect to any other investing partner considered, EMU and NON EMU. We report here values for the weighted bilateral portfolio wedge that is the portfolio wedges computed weighting each destination asset by its market share (expression (9) in the text). The change is computed between year 1997 (pre-EMU) and year 2004 (post-EMU).

	oe	bel	fin	fr	it	nl	can	dk	jp	swe	uk	us
oe	-	**-6%**	**-72%**	**-30%**	**-40%**	**41%**	42%	50%	-38%	4%	-22%	-11%
bel		-	**-29%**	**-52%**	**-73%**	**-58%**	70%	-46%	-2%	-18%	-16%	-24%
fin			-	**-78%**	**-83%**	**-60%**	-66%	-35%	-32%	-37%	-42%	-38%
fr				-	**-65%**	**11%**	60%	-16%	-18%	2%	-27%	1%
it					-	**-58%**	-62%	-11%	-25%	-34%	-39%	-34%
nl						-	-25%	-7%	-17%	-17%	-25%	-32%
can							-	-8%	-43%	-14%	-40%	-11%
dk								-	-27%	-20%	-29%	-23%
jp									-	-36%	-41%	-38%
swe										-	-40%	-4%
uk											-	-41%
us												-

Table 2. Growth in *aggregate portfolio wedge*

The table reports the variation over time of the *portfolio wedge* for each investing country *l*. The *aggregate portfolio wedge* measures the distance of country *l*'s portfolio from the reference group (ALL/EMU/NON EMU). By row we report the investing country and by column the reference group, that is the group against which we measure the degree of integration. The variation in portfolio wedge is obtained as the growth rate of the unweighted and weighted *apw* which are reported in expression (10) and (11), respectively, in the text. The change is computed between year 1997 (pre-EMU) and year 2004 (post-EMU).

	ALL		**EMU**		**NON EMU**	
	unweighted	weighted	unweighted	weighted	unweighted	weighted
Austria	-32%	-20%	-49%	-28%	-15%	-19%
Belgium	-38%	-25%	-54%	-38%	-21%	-23%
Finland	-72%	-75%	-73%	-76%	-71%	-75%
France	-29%	-9%	-65%	-34%	7%	-6%
Italy	-61%	-64%	-66%	-50%	-56%	-65%
Netherlands	-47%	-52%	-56%	-35%	-37%	-55%
Canada	-12%	-12%	-18%	2%	-4%	-11%
Denmark	-19%	-34%	-13%	19%	-27%	-15%
Japan	-51%	-38%	-54%	-34%	-47%	-12%
Sweden	-39%	-38%	-43%	-23%	-33%	-18%
United Kingdom	-44%	-35%	-40%	-5%	-49%	-10%
United States	-23%	-23%	-31%	-3%	-12%	-32%
EMU	-55%	-39%	-68%	-52%	-42%	-35%
NON EMU	-31%	-27%	-33%	-9%	-29%	-24%

Table 3. **Convergence of portfolios**

The table reports in panel A the level of (weighted) aggregate portfolio wedge (*apw*) before EMU (1997) and after EMU integration (2004). It is computed following expression (10) in the text. By row we report the investing countries and by column the reference group (ALL/EMU/NON EMU) against which we consider the degree of integration. The higher the *apw* with respect to a reference group the lower the degree of integration with respect to it. The last row of panel A reports the average *apw* for all investing countries relative to the different reference groups. Panel B reports the correlation of the growth of portfolio wedge *apw* with the initial level of *apw* (before EMU integration). Correlations - relative to the different reference groups- are reported for all investing countries, for NON EMU countries and for EMU countries.

A. level of *aggregate portfolio wedge (apw)*

	1997			2004		
	ALL	EMU	NON EMU	ALL	EMU	NON EMU
Austria	5.0	4.2	5.8	3.6	2.2	5.1
Belgium	11.9	5.0	18.9	9.9	3.1	16.6
Finland	32.7	10.2	55.1	6.7	3.0	10.4
France	5.8	3.3	8.3	5.7	2.0	9.5
Italy	29.1	12.9	45.3	10.1	4.1	16.1
Netherlands	3.9	3.0	4.7	2.3	1.8	2.7
EMU weighted average	*12.5*	*5.9*	*19.1*	*6.4*	*2.6*	*10.3*
Canada	8.5	8.5	8.5	8.2	8.9	7.2
Denmark	4.6	2.5	7.6	3.3	2.6	4.2
Japan	18.7	20.5	16.0	10.3	10.6	9.8
Sweden	5.5	4.3	7.1	3.5	3.1	4.1
United Kingdom	3.5	3.0	3.6	2.6	2.4	2.4
United States	4.7	4.5	5.0	4.1	4.2	3.9
NON EMU weighted average	*7.4*	*7.6*	*7.1*	*5.2*	*5.4*	*5.0*
ALL weighted average	*8.1*	*7.3*	*8.7*	*5.4*	*5.0*	*5.7*

B. correlation (growth rate of *apw* - initial level of *apw*)

	ALL	EMU	NON EMU
NON EMU	*-0.45*	*-0.65*	*-0.22*
EMU	*-0.84*	*-0.92*	*-0.81*

Table 4. Inflation rate: descriptive statistics

The table reports descriptive statistics relative to inflation rate. Data are reported for EMU countries and NON EMU countries considered in the analysis. The first column reports the mean, the second column reports the average standard deviation, the third column reports the correlation and the fourth column reports the covariance. The pre-EMU period ranges from Jan 1993 to Dec 1998 while the period post-EMU ranges from Jan 1999 to Dec 2004.

	mean	average standard deviation	average correlation	average covariance ($1*10^3$)
pre-EMU (1993-1998)				
all countries	0.020	0.011	0.134	0.016
-EMU countries	0.021	0.010	0.445	0.027
-NON EMU countries	0.018	0.012	-0.027	-0.002
post-EMU (1999-2004)				
all countries	0.019	0.011	0.260	0.017
-EMU countries	0.020	0.007	0.485	0.028
-NON EMU countries	0.017	0.013	0.150	0.010

Table 5. Inflation hedging coefficients: significant differences

The table reports, for each pair of EMU countries (l,y), the number and (abbreviated) nationality of stock markets (j) in which the difference of the hedging coefficients is statistically significant. The null hypothesis $b^j_l = b^j_y$ is tested (Wald test) for all pairs of EMU countries and for all destination assets (180 tests: 15 country-pairs times 12 destination assets). The inflation hedging coefficients are computed over the period 1993:01-1998:12 for the pre-EMU period and over the period 1999:01-2004:12 for the post-EMU period. The upper-diagonal elements refer to the number of statistically significant coefficients in the pre-EMU period while the lower-diagonal figures refer to the post-EMU period. *** , ** , * indicate significance at the 1, 5 and 10% levels, respectively.

	Austria	Belgium	Finland	France	Italy	Netherlands
Austria	-	**1**(uk***)	**2**(uk**,us***)	**3**(jp***,uk***,us***)	**2**(jp**,us**)	**2**(us**,uk***)
Belgium	**0**	-	**0**	**2**(jp*,us***)	**2**(jp**,us***)	**1**(us*)
Finland	**0**	**0**	-	**0**	**0**	**0**
France	**0**	**0**	**0**	-	**2**(oe*,uk**)	**1**(it**)
Italy	**0**	**1**(dk**)	**0**	**1**(fin*)	-	**1**(uk*)
Netherlands	**2**(uk*,us*)	**0**	**2**(oe*,nl**)	**0**	**0**	-

Figure 1. Convergence of portfolios: all countries

The following figure plots the growth rate (from 1997 to 2004) of the bilateral portfolio wedge, *bpw*, on the initial level of *bpw* (in 1997) for all countries included in our sample. The thick line and the thin curve represent, respectively, the least squares line and the least squares logarithmic function fitting the data. The slope reported below the graph represents the standard OLS regression coefficient for the Linear Least Squares. For the Logarithmic Least Squares, the slope represents the OLS coefficient obtained regressing the growth rate of *bpw* on *log*(level of *bpw*). Adjusted R^2 for each fitting curve adopted is also reported.

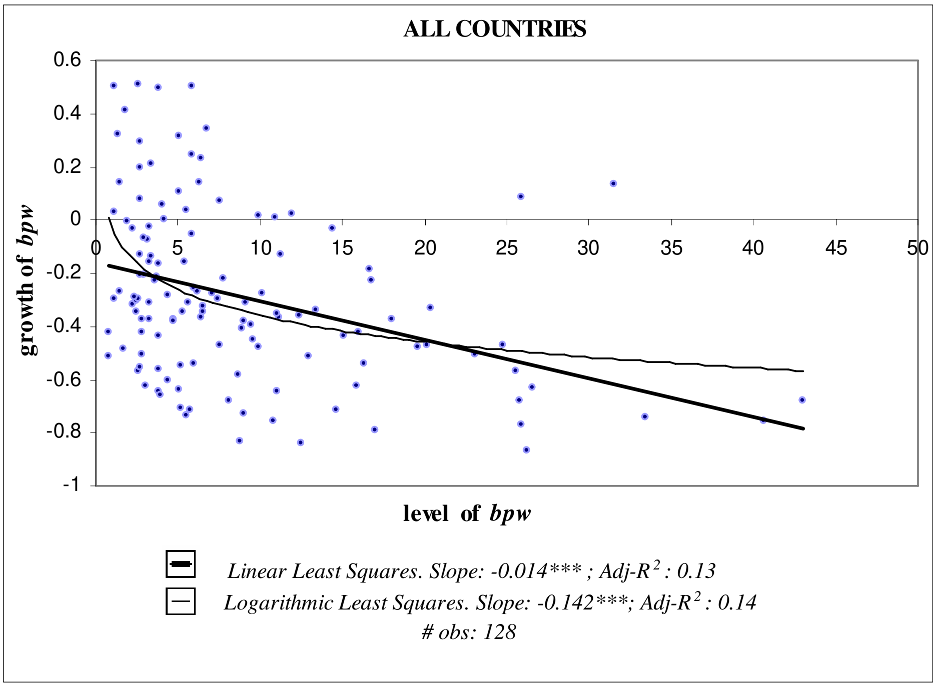

Figure 2. Convergence of portfolios: EMU/EMU

The following figure plots the growth rate (from 1997 to 2004) of the bilateral portfolio wedge, *bpw*, on the initial level of *bpw* (in 1997) for the EMU countries included in our sample (Austria, Belgium, Finland, France, Italy, Netherlands). Otherwise the figure is the same as figure 1.

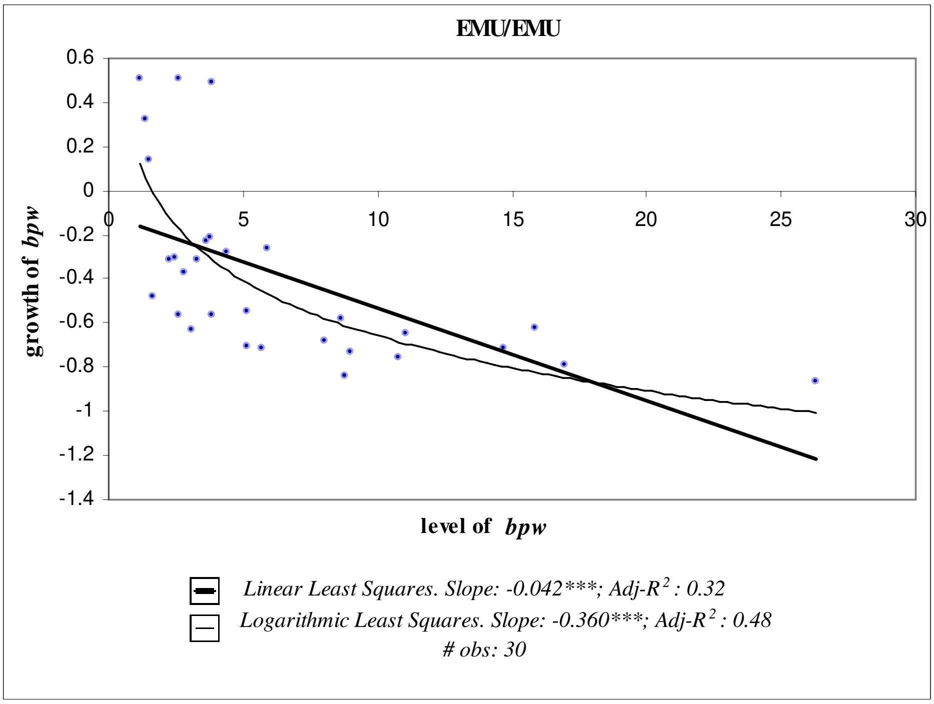

Figure 3. Convergence of portfolios: NON EMU/ NON EMU

The following figure plots the growth rate (from 1997 to 2004) of the bilateral portfolio wedge, *bpw*, on the initial level of *bpw* (in 1997) for NON EMU countries included in our sample (Canada, Denmark, Japan, Sweden, United Kingdom, United States). Otherwise the figure is the same as figure 1.

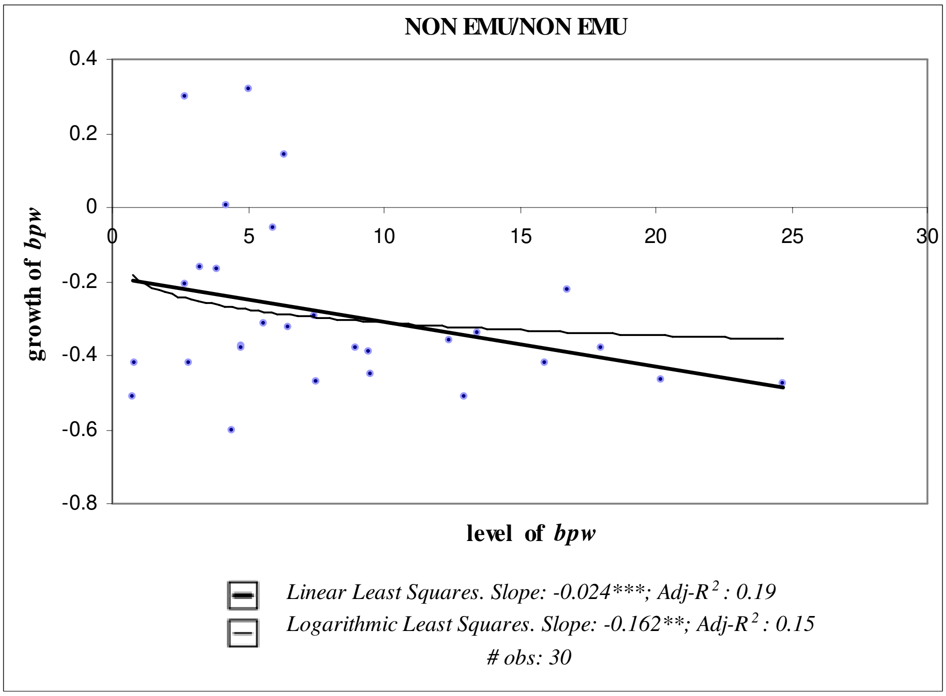

Figure 4. Convergence of portfolios: EMU/NON EMU

The following figure plots the growth rate (from 1997 to 2004) of the bilateral portfolio wedge, *bpw*, on the initial level of *bpw* (in 1997) for EMU countries versus NON EMU countries. Otherwise the figure is the same as figure 1.

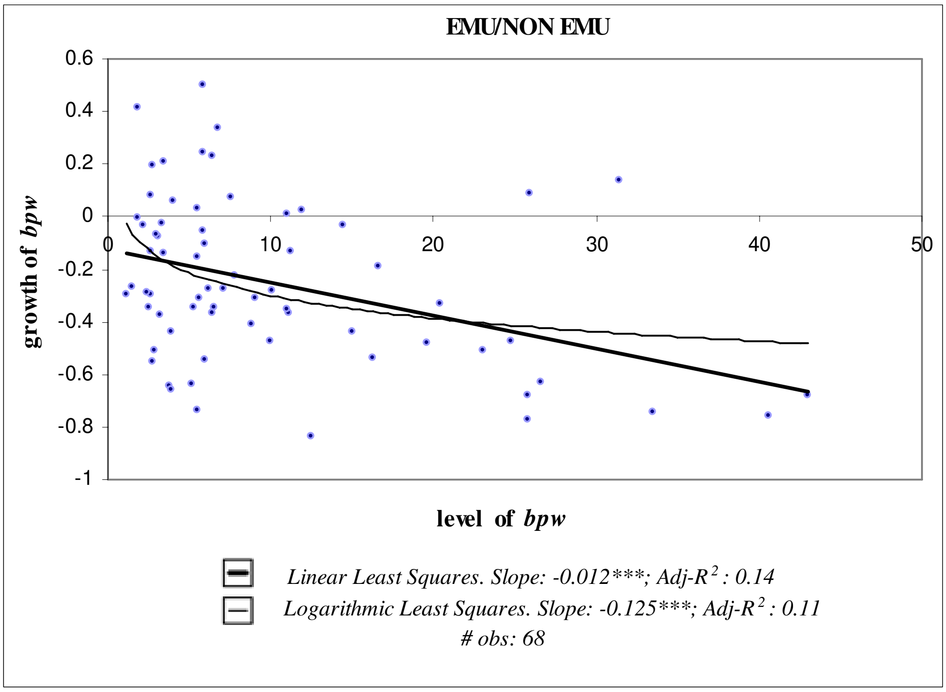

Figure 5. Convergence of portfolios: EMU/ALL

The following figure plots the growth rate (from 1997 to 2004) of the bilateral portfolio wedge, *bpw*, on the initial level of *bpw* (in 1997) for EMU countries compared to all countries included in our sample. Otherwise the figure is the same as figure 1.

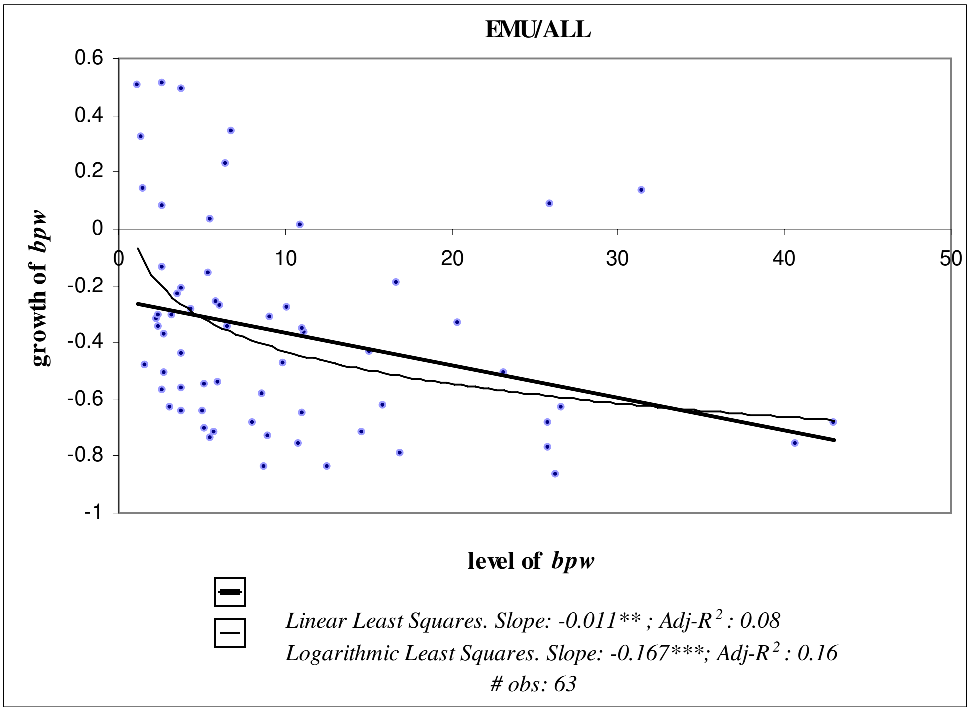

Figure 6. Convergence of portfolios: NON EMU/ALL

The following figure plots the growth rate (from 1997 to 2004) of the bilateral portfolio wedge, *bpw*, on the initial level of *bpw* (in 1997) for NON EMU countries compared to all countries included in our sample. Otherwise the figure is the same as figure 1.

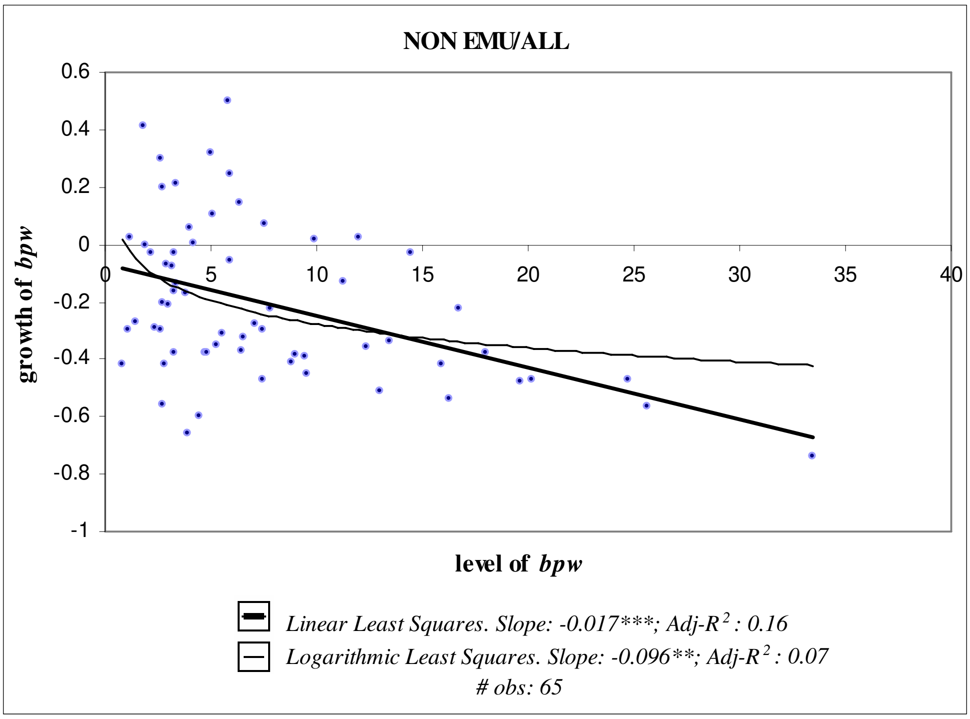

Figure 7. Convergence of portfolios: 1997-2001

The following figure plots the growth rate (from 1997 to 2001) of the bilateral portfolio wedge, *bpw*, on the initial level of *bpw* (in 1997) for EMU/EMU, NON EMU/NON EMU and EMU/NON EMU. The thick line represents the least squares line fitting the EMU/EMU data while the thin line and the dotted line represent the least square lines fitting, respectively, the NON EMU/NON EMU and the EMU/NON EMU data. The slope reported below the graph represents the standard OLS regression coefficient for the Linear Least Squares. Adjusted R^2 for each fitting line adopted is also reported.

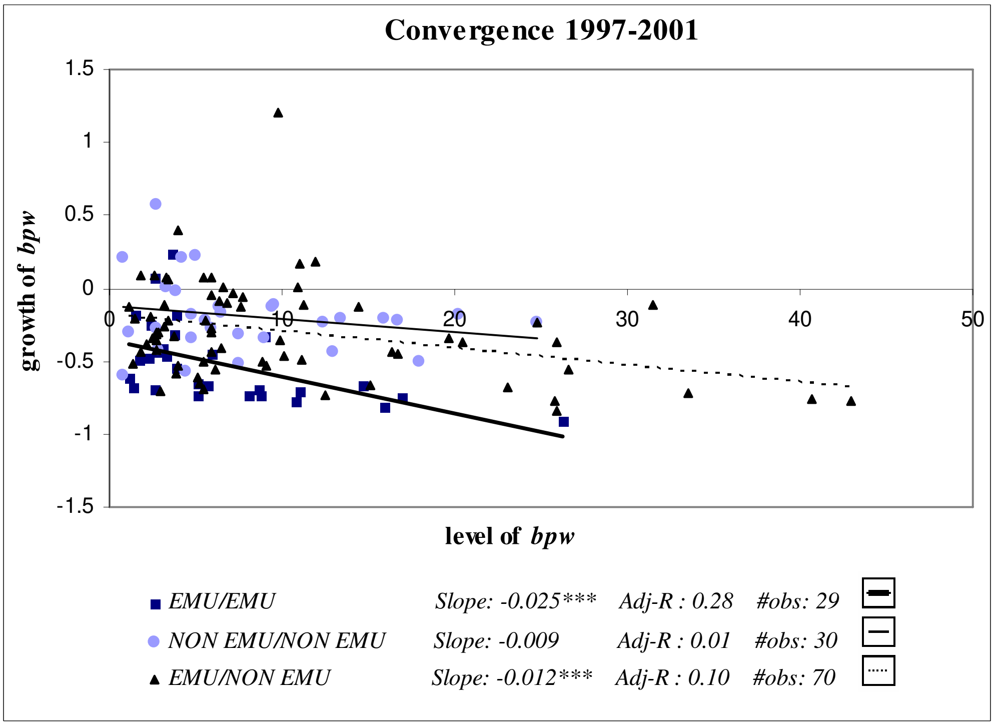

Figure 8. Standard deviation of inflation rates

The figure reports the standard deviation of monthly inflation rates of EMU countries (Austria, Belgium, Finland, France, Italy, Netherlands) and NON EMU countries (Canada, Denmark, Japan, Sweden, United Kingdom and United States). The time span is 1993:01-2004:12.