The macroeconomic determinants of stock market synchronization

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Abstract

This paper focuses on the macroeconomic variables underlying comovements between stock market returns for fifteen industrialised countries over the period 1973 to 1997. Synchronization is measured by a correlation coefficient, possibly adjusted for changes in volatility following Forbes and Rigobon (2002). Explanatory variables include the intensity of trade relations, the degree of financial integration, and the nature of the exchange rate regime. Trade and financial integration contribute positively to synchronization, while a fixed exchange rate regime increases comovements, in particular when the institutional mechanism requires mutual interventions. Other factors such as the similarity of economic structure across countries, informational asymmetries and a common language also contribute to stock market synchronization.

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1 Introduction and motivation

The last thirty years have witnessed a tremendous increase in the strength of economic linkages across the economies of the world. The most recent synchronised slowdown of major world economies has refocused attention on understanding the connection between such enhanced cross-country linkages and business cycle synchronization. There are in fact two main reasons underlying the observation that national economies move together. On the one hand, these can exhibit synchronization because they face common shocks such as sharp movements in world interest rates, abrupt changes in oil prices or increasingly similar fiscal and monetary policies. On the other hand, national economies can move together because of the international transmission of country-specific shocks through economic linkages such as trade or finance.

Although the current state of the literature provides for an increased understanding of the impact of globalisation on output comovements, much less has been said about the determinants of stock market comovements. Indeed, in a study devoted to the evolution of stock market returns over time, Longin and Solnik (1995) conclude that "*future research should also focus on the fundamental determinants of international correlation across equity markets. This correlation is likely to be affected by the industry mix of each national market as well as the correlation of the countries' business cycles*"[1]. While the macroeconomic literature deals with the link between several fundamental variables and international business cycle linkages, the financial literature studies the relation between the comovement in some fundamental variable, usually output or dividends, and the comovement in stock market returns. Fama (1981, 1990) and Canova and De Nicolo (1995) show that there is a significant positive relationship between current and expected future output growth, and stock market returns. In turn, correlated business cycles should generate correlated returns. Indeed, Dumas, Harvey and Ruiz (2003) present statistical evidence that correlations in output growth rates and correlations in stock market returns exhibit a positive and significant relationship.

[1]Longin and Solnik (1995), p. 20.

In general, theoretical models generate ambiguous predictions about the impact of various types of linkages on synchronization. Consequently, such ambiguities can only be resolved empirically. The aim of this paper is to use the insights gained from the study of business cycle synchronization and to determine to what extent common shocks and enhanced economic linkages explain stock market synchronization. In other words, we depart from the macroeconomic literature in using its results to study stock market correlations. We also depart from the financial literature in going beyond simple measures of output comovements as an explanation for correlated asset returns.

Different methodologies have been used to study the interdependence across stock markets. Cointegration allows for the identification of a long-run relationship between equity markets. Kasa (1992) shows that international stock prices are cointegrated. Bessler and Yang (2003) find a long-run relationship across nine major stock market prices, and show that only the U.S. market has a significant and strong impact on other markets. Another strand of the literature aims at determining whether the variation in stock market returns is explained by country effects or by global industry effects. Early references such as Heston and Rouwenhorst (1994) and Griffin and Karolyi (1998) conclude that country sources are predominant in the determination of stock market returns. However, it is sometimes argued that industry-specific factors have become the most important source of variation at the turn of the century. Brooks and Del Negro (2004) downplay this new hypothesis and conclude that the recent increase in stock market comovements is largely due to a bubble phenomenon, thereby implying that the recent period was exceptional with respect to historical standards.

Cointegration studies examine whether a significant long-run relationship exists between national stock markets. However, such studies do not rely on structural models and they do not allow to identify what types of linkages lie behind market comovements. Moreover, studies which disentangle country-specific and industry-specific factors typically estimate regressions with dummy variables corresponding to country and industry affiliation. Therefore, these two strands of literature cannot provide for an explanation of the fundamental determinants of stock market synchronization. This paper studies the fundamental determinants of stock market correlations between fifteen developed economies over the period 1973 to 1997 and addresses both the cross-sectional and time-series dimensions of the data. We describe stock market synchronization by the correlation coefficient between stock market returns expressed in U.S. dollars. We provide some sensitivity analysis for this dependent variable using the adjustment procedure proposed by Forbes and Rigobon (2002) in so far as changes in the volatility of returns can lead to variation in the correlation coefficient without any corresponding modification of the degree of interdependence between stock markets. We also present some evidence using returns denominated in domestic currency. Our explanatory variables include the intensity of trade linkages, the degree of financial integration and the nature of the exchange rate regime. We also consider the explanatory contribution of the similarity of economic structure between national economies and other factors such as culture and informational asymmetries. Finally, we control for global disturbances such as changes in major interest rates, gold prices and oil prices in order to avoid concluding in favour of a transmission of country-specific shocks when countries are actually facing a common shock.

In contrast with the ambiguous predictions of theoretical models, our empirical estimations provide clear-cut results. We find that a greater intensity of trade relations increases stock market comovements. The level of financial openness also induces more correlated stock market returns, whereas a process of financial liberalization has no significant immediate effect. The evidence for the nature of the exchange rate regime is interesting. On the one hand, a strongly institutionalized regime such as the Exchange Rate Mechanism (ERM) increases stock market synchronization beyond the effects of trade and financial integration. On the other hand, having a fixed exchange rate regime without requiring that this mechanism be mutual increases comovements only by a small amount. The similarity of economic structure between two countries also increases stock market synchronization. Finally, informational asymmetries lead to less correlated stock markets whereas cultural factors such as a common language induce stronger comovements, other things being equal.

Section 2 revisits the literature on business cycle synchronization and stock market comovements both theoretically and empirically. Theoretical predictions are usually ambiguous and assessing the role of economic linkages for synchronization remains an empirical question. Section 3 deals with the econometric specification and discusses the measurement of the different variables which are used in our regressions. Section 4 presents the results from our estimations and provides some further interpretation. Section 5 deals with some robustness checks and further extensions. Section 6 contains concluding remarks.

2 Channels of transmission and synchronization

Synchronization is the result of two different effects. On the one hand, many countries can be affected by a common disturbance, thereby bringing about stronger comovements in output growth rates and stock market returns. The literature notably emphasizes significant movements in the level of world interest rates, sharp changes in the volatility and the level of the price of oil, greater political uncertainty which is of concern for many nations, or common institutional characteristics such as similar strategies for economic policymaking. On the other hand, comovements can also be the consequence of the transmission of country-specific shocks through various economic linkages such as trade in goods and financial assets. This paper focuses on the second set of determinants of synchronization, yet controlling for global disturbances. The theoretical predictions about the impact of various macroeconomic linkages on business cycle and stock market synchronization are often ambiguous and therefore, assessing the net contribution of economic linkages to comovements remains ultimately an empirical question.

2.1 Trade linkages

Although the contribution of international trade in goods is usually recognized as increasing the extent of business cycle synchronization, its overall effects remain theoretically and empirically ambiguous. On the demand side, higher aggregate demand in one country will partially fall on imported goods, thereby raising output and income in trading partners' economies and inducing output comovements across countries. On the supply side, however, there are two opposite effects which relate to two different approaches to modeling international trade. Intra-industry models of trade emphasize economies with similar production structures and factor endowments. To the extent that trade occurs mostly within industries, an expansion in some industries will raise output comovements across countries. However, trade integration may also lead economies to specialize in the production of goods for which they have a comparative advantage, hence reducing comovements. The net impact of international trade on comovements is therefore ambiguous.

Frankel and Rose (1998) find strong evidence that closer trade linkages lead to an increase in the correlation of business cycles. Calderon, Chong and Stein (2002) find similar evidence for developing countries, for which we could expect that specialization along the lines of comparative advantage is more important. Otto, Voss and Willard (2001) and Bordo and Helbling (2003) conclude that international trade affects output comovements in a positive and significant way, although it does not explain very much. Therefore, other factors should also be included. Kose, Prasad and Terrones (2003) find limited support in favour of the hypothesis that trade has a positive effect. Imbs (2004) refines the analysis of the impact of international trade by estimating the respective contributions of both types of trade effects and concludes that a sizable part of the impact of trade on bilateral correlations works through intra-industry trade, although there are some smaller but significant inter-industry effects.

The contagion literature in international finance examines the channels of transmission through which currency and financial crises are propagated. Eichengreen, Rose and Wyplosz (1996) and Glick and Rose (1999) find that the apparent regional pattern of contagious crises is the consequence of more intense trade linkages at the regional level. The importance of trade linkages in this literature and the evidence that stock markets exhibit larger comovements at times of high market turbulence suggests that trade is an important factor in explaining not only business cycle but also stock market synchronization. Chinn and Forbes (2004) examine the role of direct trade flows, competition in third markets, bank lending and foreign direct investment. The authors conclude that despite the significant increase in international capital flows, direct trade linkages remain the predominant determinant of the effect of large markets on other markets. In general, trade linkages are an important determinant of business cycle and stock market synchronization, although other variables are likely to be significant.

2.2 Financial linkages

At a theoretical level financial integration carries an ambiguous impact on business cycle synchronization. On the one hand, to the extent that equities of a given country are widely held internationally, a fall in that country's stock market will trigger a negative wealth effect for asset holders in the world, thereby affecting consumer demand and in turn, output comovements. On the other hand, international diversification of portfolios allows to smooth consumption patterns without having to diversify production, thereby leading to the possibility of greater specialization. The former effect would increase business cycle synchronization, whereas the latter effect would tend to reduce comovements.

Financial openness leads to increased international capital flows (Bekaert and Harvey, 2003) and provides a channel for large capital flow reversals, such as those which occurred in the midst of the 1997/98 south-east Asian crisis. Losses in one market may induce investors to rebalance their portfolios and sell in other markets too. Herding effects lead investors to sell assets in many markets within a single region (Calvo and Mendoza, 2000). Overall, greater financial integration is expected to lead to increased stock market comovements at times of market turbulence.

Empirical evidence on the role of financial linkages for business cycle synchronization is somewhat mixed. Bordo and Helbling (2003) conclude that financial integration does not affect business cycle synchronization. Imbs (2004) and Kose, Prasad and Terrones (2003) show that financial integration impacts positively on business cycle comovements. However, Kalemli-Ozcan, Sorensen and Yosha (2001) show that capital market integration also leads to greater specialisation in production structures, thereby inducing a lower degree of output comovements. In general, financial integration carries different and opposite effects on synchronisation.

2.3 The exchange rate regime

The nature of the exchange rate regime is likely to have implications for the degree of covariation between national economies. The standard argument in favour of floating exchange rates is that they act as a shock absorber for foreign real disturbances. A greater flexibility of the exchange rate should therefore reduce the effects stemming from the transmission of country-specific real shocks, thereby delivering lower output comovements across countries. Similarly, provided that capital mobility is high, maintaining a fixed exchange rate requires a high degree of coordination of monetary policies, thereby inducing greater comovements in economic conditions. In the extreme case of a currency union, the stance of monetary policy would in fact be identical for all participating countries.

Building upon this theoretical insight, Bordo and Helbling (2003) find that although a fixed exchange rate induces higher output correlations, this result is not robust to the inclusion of other control variables such as trade linkages or a European Union dummy variable. The authors thus conclude that fixing by itself does not make any difference for the degree of synchronization of business cycles. It is only when a stable exchange rate fosters international trade that it induces greater output comovements across countries. Rose and Engel (2002) find that currency unions bring about higher business cycle synchronisation, even after controlling for other factors including trade relations. Kouparitsas (2003) broadens the analysis by considering the entire postwar period and concludes that there is no consistent relationship between output comovements and the exchange rate regime. Bodart and Reding (1999) distinguish between ERM and non-ERM countries and make use of a GARCH specification for bond and stock market returns. They find evidence that bond and stock markets correlations depend negatively on exchange rate variability. In general, it seems that strong forms of exchange rate arrangements will affect synchronisation, whereas limited exchange rate flexibility will have no impact.

3 Econometric specification and data

This paper focuses on the fundamental determinants of stock market synchronization between fifteen industrial countries over the period 1973 until 1997[2]. Synchronization is the result of common disturbances which affect many countries in a similar but not identical way, and of cross-market linkages which propagate country-specific shocks internationally. Therefore, our general specification can be written as

$$\rho_{i,j,t} = \beta_0 + \beta_1 trade_{i,j,t} + \beta_2 finance_{i,j,t} + \beta_3 regime_{i,j,t} + \beta_4 common_t + \eta_t \qquad (1)$$

where $\rho_{i,j,t}$ is a measure of synchronization between the stock markets of two countries i and j during period t. This section discusses the measurement of the explanatory variables in equation (1).

3.1 Measuring synchronization

Common practice measures stock market synchronization by the correlation coefficient between two series of stock returns during a given time period. We use monthly data on MSCI stock market indices and transform these into stock market returns through log-differentiation. Stock market indices are retrieved from Datastream and expressed in U.S. dollars, thereby taking the perspective of an international investor. Some sensitivity analysis deals with returns denominated in domestic currency. The correlation coefficient is calculated for each year based on the monthly observations contained in this year.

Forbes and Rigobon (2002) have noted that correlation coefficients may change without any modification in the degree of fundamental comovement. More precisely, the computed correlation coefficient is an increasing function of the variance of the underlying asset return. Writing the stock market return of some country as $s_{i,t}$ and that of another country as $s_{j,t}$, where i and j are country indices, and adding an idiosyncratic shock for country i, we have

[2]These countries are the United States, the United Kingdom, Austria, Denmark, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, Canada, Japan, Spain and Australia.

$$s_{i,t} = \beta_0 + \beta_1 s_{j,t} + \varepsilon_t \tag{2}$$

where the error term has zero mean, finite variance, and $E(s_{j,t}\varepsilon_t) = 0$. Using the fact that $\rho_{i,j} = \frac{\sigma_{ij}}{\sigma_i \sigma_j}$ and $\beta_1 = \frac{\sigma_{ij}}{\sigma_j^2}$, we obtain

$$\rho_{i,j} = \beta_1 \sqrt{\frac{\sigma_j^2}{\sigma_i^2}} \tag{3}$$

Using the fact that $\sigma_i^2 = \beta_1^2 \sigma_j^2 + \sigma_\varepsilon^2$, we get

$$\rho_{i,j} = \beta_1 \sqrt{\frac{\sigma_j^2}{\beta_1^2 \sigma_j^2 + \sigma_\varepsilon^2}}$$

Differentiating with respect to σ_j^2, we get

$$\frac{\partial \rho_{i,j}}{\partial \sigma_j^2} = \frac{1}{2} \beta_1 \frac{\sigma_\varepsilon^2}{\sigma_j \left(\beta_1^2 \sigma_j^2 + \sigma_\varepsilon^2\right)^{\frac{3}{2}}} > 0 \tag{4}$$

The coefficient β_1 in equation (2) measures the degree of interdependence between two stock markets. However, the correlation coefficient in equation (3) consists of more parameters, namely the variance of country j's stock market return and the variance of its idiosyncratic shock. Suppose that the volatility of country j's return has been decreasing over time and that the correlation coefficient remains constant, other things being equal. In this case, the degree of economic interdependence as measured by the coefficient β_1 must have increased. In so far as correlation coefficients may provide a misleading measure of interdependence, Forbes and Rigobon (2002) propose to adjust the correlation coefficient $\rho_{i,j}$ as follows:

$$\rho_{i,j,t}^c = \frac{\rho_{i,j,t}}{\sqrt{1 + \delta_j \left(1 - \rho_{i,j,t}^2\right)}} \tag{5}$$

where $\delta_j = \frac{\sigma_j^2(h)}{\sigma_j^2(l)} - 1$ is the increase in the variance in the period of high volatility (h) relative to the low volatility period (l), minus one. However, the validity of this adjustment remains questionable because it relies on the assumption that $s_{j,t}$ in equation

(2) is exogenous. This is unlikely to be satisfied in reality since interdependence would imply two-way causality. In other words, we should rather specify equation (2) as a system of two simultaneous equations. Bearing in mind the weakness of the exogeneity assumption, we define the exogenous country on the basis of country size as measured by gross domestic product. Then, we split the sample of stock market returns of this country into two sub-samples. Our criterion is that the high-volatility sub-sample contains observations whose absolute value is greater than the mean plus 2 standard deviations, the remaining observations forming the low-volatility sub-sample. We compute the variances of returns in both sub-samples, thereby obtaining estimates for $\sigma_j^2(h)$ and $\sigma_j^2(l)$. These values are used to compute the corrected correlation coefficient $\rho_{i,j,t}^c$.

Clearly, a correlation coefficient is not normally distributed. Nevertheless, a significant number of studies make use of raw correlation coefficients as the dependent variable. This paper follows Otto, Voss and Willard (2001) and adopts the following transformation:

$$\begin{aligned} w_{i,j,t} &= \ln \frac{1+\rho_{i,j,t}}{1-\rho_{i,j,t}} \\ w_{i,j,t}^c &= \ln \frac{1+\rho_{i,j,t}^c}{1-\rho_{i,j,t}^c} \end{aligned}$$

3.2 Measuring trade linkages

Frankel and Rose (1998) and Bordo and Helbling (2003) measure bilateral trade intensity as the sum of exports and imports between countries i and j during year t, scaled by either total exports and imports of each country, or by the sum of respective gross domestic products. Bilateral trade data are obtained from the IMF's *Direction of Trade Statistics*. There is, however, an important problem with the use of trade intensity variables. Frankel and Rose (1998) argue that countries will tend to link their currencies with their most important trading partners. To the extent that monetary autonomy is lost, a common currency will generate business cycle comovements and therefore, a stable exchange rate delivers both high trade and synchronised output movements. To focus exclusively on the contribution of international bilateral trade on stock market synchronization, we must find some exogenous determinants of bilateral trade. In line with the literature on gravity equations in international trade, and following Frankel and Rose (1998), we select four instruments: the natural logarithm of the distance between the main business centers of each country, the logarithm of the product of country sizes as measured by gross domestic product, a dummy variable for a common border, and a dummy variable for common language.

3.3 Measuring financial integration

Increasing the degree to which both domestic and foreign residents are allowed to acquire domestic and foreign assets is only a necessary but not a sufficient condition for international capital flows to increase. Other factors such as investment opportunities, institutional characteristics and political stability are also important. Moreover, Bekaert and Harvey (2003) have noted that the announcement of financial liberalization may not coincide with the completion of its implementation, so that international capital flows will start rising only after a certain period following the *de jure* liberalization. Consequently, we will focus on a *de jure* concept of financial integration as opposed to a *de facto* measure[3].

A further dimension of financial integration relates to the nature of the measure itself. The IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* provides a binary indicator of restrictions based on official statements by national authorities. The well-known shortcoming of this indicator is that it does not reflect the evolution of financial openness over time. However, recent research by Quinn (1997) and Chinn and Ito (2002) develops continuous measures of financial regulation. Quinn (1997) codes the laws regulating international financial transactions into a 0-14 index. Such laws are those which deal with inward and outward capital account transactions, inward and outward current account transactions, and international legal agreements that constrain a country's ability to restrict exchange and capital flows. Chinn and Ito (2002) use principal component analysis to create an index of financial openness. Importantly, financial openness should not only be measured by restrictions on capital account transactions. A country with an open

[3]See Adam et al. (2001) for a complete discussion of the measurement of financial integration.

capital account could still limit inward and outward flows of capital by introducing restrictions on current account transactions and multiple exchange rates. Conversely, closing the capital account but liberalizing the current account would potentially enable controls on capital account transactions to be circumvented.

We make use of both the measures proposed by Quinn (1997) and Chinn and Ito (2002)[4]. We construct measures of the degree of financial integration as the logarithm of the product of two countries' Quinn (1997) measures, and as the sum of two countries' Chinn and Ito (2002) measures. Quinn (1997) also suggests that his measure of regulation can be used in first differences to examine the role of financial liberalization, defined as a change in the degree of financial openness. Taking the difference implies that the new explanatory variable for financial liberalization is given as the difference in the logarithm of the product of the two Quinn indices. This measure will be different from zero whenever any of the two countries liberalizes.

3.4 Defining exchange rate regimes

The conventional *de jure* classification of the exchange rate regime of a country has often relied on the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions*. National governments declare what type of exchange rate arrangements they are running. However, governments do not always do what they say; in practice, many floaters intervene regularly and to a significant extent in the foreign exchange market to stabilize the exchange rate, a phenomenon called "fear of floating" by Calvo and Reinhart (2002). Moreover, although some countries announce a central parity for the nominal exchange rate, frequent realignments may make the regime more alike a dirty float than a pure fixed exchange rate regime.

The apparent difference between official announcements and the actual exchange rate regime has led to the construction of *de facto* classifications of exchange rate regimes. The central problem is to map the continuous behaviour of observed macroeconomic time series

[4]I am very grateful to Dennis Quinn for providing data on his index of financial regulation in electronic format. The dataset constructed by Chinn and Ito (2002) is available from Menzie Chinn's web site at http://people.ucsc.edu/∼chinn.

into a discrete number of categories of exchange rate regimes. Shambaugh (2004) constructs a binary classification (fixed and floating) on the basis of the behaviour of the nominal exchange rate, while Levy-Yeyati and Sturzenegger (2005) also include the behaviour of international reserves. Reinhart and Rogoff (2004) observe that these two studies do not take account of the fact that many countries had dual or multiple exchange rates, and parallel markets. *De facto* classifications should rely on market-determined exchange rates rather than official ones: the presence of dual markets would allow a government to declare a fixed exchange rate parity when the arrangement would be better described as a crawling peg or even an actual float. Reinhart and Rogoff (2004) offer a *de facto* classification in which countries' regimes are classified into fourteen categories. We build a dummy variable for a fixed exchange rate which is equal to unity whenever the type of regime is not described as managed floating, free floating, or freely falling.

Then, we construct various measures of bilateral regime variables. We consider three possibilities. Firstly, we can add up the respective dummies for two countries and construct a 0-1-2 index, 0 when both float, 1 when one floats and the other fixes, and 2 when both fix. Secondly, we define another dummy variable that takes a value of 1 if the two countries share a *mutually* fixed exchange rate. This second definition basically amounts to an ERM dummy. Thirdly, we can build two new dummy variables, one taking a value of unity when both countries fix, without the requirement that this mechanism be mutual, and another taking a unit value when one country fixes and the other floats. This avoids imposing the constraint of a unique coefficient for different types of situations, where either the two countries fix or only one does so.

3.5 Measuring common shocks

Any study of the impact of economic linkages on synchronization should control for global variables. Otherwise, we may conclude that country-specific events are transmitted across countries when these are actually affected by a common disturbance. Chinn and Forbes (2004) include four global variables, namely global interest rates, oil prices, gold prices and commodity prices. Kose, Otrok and Whiteman (2003) also select oil prices along with terms of trade, government spending (fiscal policy) and interest rates (monetary policy). Hamilton (2003) shows that the relation between growth and oil prices is nonlinear. In so far as price increases do not reflect recoveries after large price decreases, such increases affect growth negatively whereas price decreases are much less important.

We control for global interest rates, oil prices, and gold prices. The evolution of gold prices should reflect changes in the degree of global risk aversion. It is a well-known fact that stock market comovements are reinforced at times of greater uncertainty. Chinn and Forbes (2004) compute the global interest rate as the first principal component of short-term interest rates of the United States, the United Kingdom and Japan. This approach should allow us to deal with the potential collinearity among interest rates. However, to the extent that our regressions do not exhibit such a problem, we introduce first-differences of interest rates of the United States, Germany and Japan directly.

4 Empirical results

This section presents the key results for the macroeconomic determinants of stock market synchronization. In order to solve the problem of endogeneity of international trade we start with the estimation of gravity equations. Both measures of trade intensity are relatively similar, except for the fact that the measure which uses total trade flows as a normalization appears to exhibit higher variability. In effect, trade flows are usually more volatile over time than gross domestic products.

Table 1 provides the results for the two gravity equations, respectively using the sum of total trade flows (1), and the sum of gross domestic products (2), as a normalization[5]. The explanatory variables are the logarithm of the distance between the main business centers of the respective countries, the logarithm of the product of gross domestic products, a dummy variable for a common language and a dummy variable for a common border. The dependent variables are also expressed in logarithms.

[5]Since we are focusing on fifteen countries over twenty-five years, we obtain $\frac{15*(15-1)}{2} * 25 = 2625$ observations.

TABLE 1 HERE

All the coefficients on the explanatory variables have the expected sign and are statistically significant at the 1% level[6]. Distance has a negative effect on bilateral trade flows, whereas a greater size, a common language and a common border contribute positively to the intensity of trade relations. Together these four variables explain about two thirds of the variability of both measures of trade intensity. We retrieve the predicted values of both regressions and use these new variables, instead of the original measures of trade intensity, as determinants of stock market synchronization.

We can then turn to the estimation of our main econometric specification (1). We have argued that using a correlation coefficient as the dependent variable is not appropriate since it will not be normally distributed. Indeed, a Jarque-Bera test rejects the null hypothesis that the correlation coefficient is normally distributed. The same null hypothesis cannot be rejected once that we make use of the transformed variable, thereby confirming the need for a transformation of the dependent variable for the purpose of statistical inference. Our baseline econometric specification includes a constant term, three major interest rates, gold prices, oil prices, a measure of trade intensity, financial integration, and an ERM dummy variable. Interest rates are taken in first differences, whereas we use percentage changes in gold and oil prices. Table 2 presents the estimated coefficients and their degree of statistical significance[7].

TABLE 2 HERE

For the benchmark specification (I) all coefficients are statistically significant with the expected sign, except for changes in oil prices. To the extent that interest rates are procyclical, thereby rising during economic expansions and decreasing during recessions, and since business cycles are more correlated during recessions, we would expect a negative

[6]Due to the presence of serial correlation we use the Newey-West estimator to correct the standard errors. One, two and three stars denote, respectively, statistical significance at the 10%, 5% and 1% level.

[7]In all our empirical estimations we use the White estimator to correct standard errors because of the presence of heteroscedasticity. As for the gravity equations, one, two and three stars denote, respectively, statistical significance at the 10%, 5% and 1% level.

sign on major interest rates. Higher interest rates in the United States and in Germany tend to reduce the degree of comovement among stock markets, whereas a higher Japanese interest rate coincides with more synchronization. Hence, only two out of three major interest rates behave as expected.

Increased global risk aversion tends to foster greater synchronization as reflected by the positive sign on gold prices. Oil prices exhibit a surprising negative sign. Periods of higher oil prices are usually associated with recessions and we know that business cycles are more synchronized during such periods. Therefore, we would have expected a positive sign. Although our goal is to assess to what extent cross-country linkages contribute to stock market comovements, yet controlling for common disturbances, we investigate the role of oil prices further. Firstly, the period from 1973 to 1979 was characterized by two large oil shocks which had lasting consequences on industrial economies. We hypothesize that there could be something different about the seventies in terms of the effects of changes in oil prices and run a new regression where the sample size ranges from 1980 until 1997. Specification (II) shows that the sign on oil prices switches. Therefore, changes in oil prices tend to reinforce stock market synchronization over the period from 1980 until 1997, whereas they induce contrasting effects on industrial countries during the seventies, thereby leading to less correlated stock markets.

Secondly, Hamilton (2003) shows that changes in oil prices have asymmetric effects on the economy as increases affect the economy to a significant extent while decreases do not. To the extent that changes in oil prices are a common shock to industrial countries, and since business cycles are more synchronized during economic downturns, we should therefore observe stronger stock market comovements when oil prices increase, and little effect when such prices decrease. We test this hypothesis by constructing a dummy variable which takes a unit value when changes in oil prices are positive, and interacting this variable with the original variable capturing changes in oil prices[8]. Specification (III) shows that

[8]We build a new variable D_t which equals 1 when changes in oil prices are positive. Then we estimate

$$\rho_{i,j,t} = \beta_0 + ... + \beta_{k-1}(D_t \Delta OIL) + \beta_k(1 - D_t)(\Delta OIL) + \eta_t$$

although oil price increases exhibit a statistically significant coefficient, it remains that they induce less correlated stock markets. Conversely, oil price decreases raise synchronization. Taken together, these two results contradict our hypothesis[9].

Turning to cross-market linkages, *trade intensity* variables, using as a normalization either total trade flows (specification (I)) or gross domestic products (specification (IV)), enter significantly and with a positive sign. The magnitude of the regression coefficient is identical for the two measures and remains very stable across various specifications. Therefore, countries with more intense trade relations will tend to exhibit greater stock market synchronization. This result is not surprising since studies on business cycle comovements conclude that enhanced trade linkages bring about more correlated business cycles. These results confirm that the effects of intra-industry trade are stronger than effects related to the specialization of production along the lines of comparative advantage.

A greater degree of *financial integration* also induces more correlated stock markets. This effect comes over and above that of bilateral trade intensity. The measure proposed by Quinn (1997) (specification (I)) performs better than that by Chinn and Ito (2002) (specification (V)). When using the latter variable, the coefficient on oil prices becomes insignificant, the otherwise very stable coefficient on gold prices decreases, and the adjusted R^2 statistic falls although trade linkages and the ERM dummy remain significant. We also find that *financial liberalization*, defined as a change in the degree of financial integration, does not affect synchronization (specification (VI)). Including both the Quinn index and its first difference (specification (VII)) does not alter these results. Therefore, financial integration and financial liberalization have independent effects on synchronization.

In general, a more rigid *exchange rate regime* increases stock market synchronization. Specification (I) shows that the ERM dummy is highly significant. However, not all of the other coefficients are statistically significant. The 0-1-2 index does not enter significantly (specification (VIII)). When we separate the cases where either two countries fix or only one fixes by including two separate dummy variables (specification (IX)), we find that synchronization is greater when the two countries have a fixed exchange rate. The

[9] We can reject the null hypothesis that the two coefficients β_{k-1} and β_k are equal.

corresponding coefficient is, however, significant only at the 10% level.

The result that the ERM dummy variable is highly significant while other measures are weakly or not significant, could indicate that the institutional characteristics of the exchange rate regime are important in explaining the degree of stock market comovement. A system where countries are mutually responsible for maintaining a given parity seems to induce more correlated stock markets. To the extent that the values of the coefficients on the other explanatory variables remain stable across specifications, we are confident that the positive and significant coefficient on the ERM dummy really reflects the importance of the exchange rate regime and not trade or financial integration.

5 Robustness analysis and extensions

We examine the robustness of our results along two dimensions. We make use of stock market returns expressed in local currency, and of adjusted correlation coefficients on the basis of Forbes and Rigobon (2002). We also provide extensions of the results by including other variables such as the similarity of economic structure across countries, and informational asymmetries as well as cultural factors.

TABLE 3 HERE

Table 3 presents estimation results for the robustness analysis. Specification (X) uses local currency returns and specification (XI) focuses on adjusted correlation coefficients. Despite the fact that the magnitudes of the coefficients change, the qualitative results do not seem to depend significantly on the currency denomination of stock market returns, or on the fact that correlation coefficients are adjusted[10]. Gold prices and oil prices enter with a positive and a negative sign, respectively. A greater degree of trade intensity, of financial integration, and being part of a strong exchange rate regime such as the Exchange Rate Mechanism, contribute to more correlated stock markets. The adjusted R^2 statistics are very similar to those found using returns expressed in U.S. dollars.

[10]We note that the mean of the corrected correlation coefficient is much lower (0.158) than that of the raw correlation coefficient (0.412). Therefore, it seems that having different regimes of volatility brings about changing correlations between stock markets to an extent that is not warranted by interdependence.

Turning to extensions, there is a large number of empirical studies which examine the respective contributions of country-specific and industry-specific factors in explaining stock market returns. In a world of segmented markets it is likely that returns will be largely determined by national factors. However, sector-specific factors should play a major role in integrated markets. The consensus view in this literature is that although sectoral factors have become more important recently, returns are still widely driven by country-specific factors (Heston and Rouwenhorst, 1994; Griffin and Karolyi, 1998).

To the extent that sectoral factors are significant determinants of stock market returns, two countries which are characterized by a similar economic structure should exhibit greater stock market comovements. We follow Otto, Voss and Willard (2001) and Krugman (1991) to construct an index capturing the similarity of economic structure given by

$$s_{i,j,t} = \sum_{k=1}^{M} |l_{ik,t} - l_{jk,t}| \tag{6}$$

where $l_{ik,t}$ denotes employment in sector k in country i as a share of total employment in country i. The lower is our index $s_{i,j,t}$, the higher is the similarity of economic structure. At the limit where both countries i and j are characterized by an identical structure, the index is equal to zero. We use data on sectoral employment from the OECD's *Labour Force Statistics* for the period 1978 until 1997.

TABLE 4 HERE

Table 4 shows that the coefficient on the index of similarity of economic structure is negative and statistically significant. The lower is the index, the more similar two national economies are. The negative sign indicates that countries with more similar economic structures exhibit more correlated stock markets. Other variables capturing cross-country linkages remain significant and their coefficients are almost identical to those obtained in previous specifications. Therefore, sectoral factors are not only important in determining stock market returns as such, but also matter for comovements across national stock markets.

Interestingly, the coefficient on oil prices is not significant anymore. We cannot offer a tentative explanation for this result. On the one hand, the correlation between changes in oil prices and the similarity of the economic structure is very low (-0.06), so that at first sight a problem of multicollinearity could be ruled out. On the other hand, an auxiliary regression of changes in oil prices on a constant and structural similarity exhibits a negative coefficient which is statistically significant at the 5% level. The R^2 statistic of this regression remains very low (0.002).

Finally, Otto, Voss and Willard (2001) and Stock and Watson (2003) have reported the emergence of an English-speaking group of countries among which business cycle synchronization is more pronounced. Therefore, there may be a cultural explanation for the extent to which business cycles move together. Also, Portes and Rey (2005) use distance as a proxy for informational asymmetries. The simple argument is that an investor in some country is likely to hold more information about neighbouring economies than about countries at the other end of the world. We now examine both the role of culture and informational asymmetries in stock market synchronization. Cultural similarity is measured by our common language variable. Table 5 presents the results.

TABLE 5 HERE

A potential problem is that we introduce common language and distance both directly and indirectly into these two regressions. Indeed, these two variables have been used to construct an instrument for bilateral trade intensity. Therefore, we can expect a problem of multicollinearity in the sense that introducing either of the two variables would make the coefficient on trade intensity insignificant. Although the correlation between the logarithm of distance and our instrument for trade intensity is very high (-0.75), the coefficient on trade remains strongly significant in both equations (now at the 5% level when we include distance directly). Its value, however, is reduced. Hence, the significant coefficients on common language and distance show that, having controlled for a host of cross-country and global effects, a common language and informational asymmetries are determinants of stock market synchronization. In other words, countries sharing the same language and being close to each other exhibit more correlated stock markets.

6 Concluding remarks

This paper studies the macroeconomic determinants of stock market synchronization. We make use of a structural regression framework in order to understand which macroeconomic variables underlie comovements among stock market returns across countries. Theoretical models generate ambiguous predictions and therefore, assessing the relevance of different explanatory factors remains ultimately an empirical question. Our sample contains fifteen industrialised countries over the period 1973 to 1997. The explanatory variables include the intensity of trade relations, the degree of financial openness between countries, as well as the nature of the exchange rate regime. Controlling for global disturbances, we find that trade and financial integration contribute positively to stock market synchronization. A fixed exchange rate also fosters comovements, especially when the institutional mechanism supporting the regime is mutual.

We provide some sensitivity analysis and include other potential factors. The similarity of the economic structure also induces more correlated stock markets, whereas informational asymmetries reduce such comovements. There is evidence that a common language raises synchronization beyond its effect on international trade.

As an increasing number of countries integrate into the global economy, it is therefore very likely that country-specific shocks will be transmitted internationally with greater scope and strength. Not only will stock market comovements increase during episodes of financial turbulence, but cross-country linkages bring about transmission of country-specific shocks at all times. Although the benefits of openness are commonly thought of as being welfare-enhancing for countries which follow the path of trade and financial liberalization, such countries should ensure that they can react to common shocks as well as country-specific disturbances which are spread through international financial markets.

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Table 1: Gravity equations for trade intensities

Regressors	Trade (1)	Trade (2)
Constant term	-7.08^{***}	-4.43^{***}
Distance	-0.54^{***}	-0.71^{***}
Product of GDPs	0.26^{***}	0.17^{***}
Common language	0.30^{**}	0.40^{***}
Common border	0.64^{***}	0.46^{***}
Adjusted R^2	0.618	0.668
Number of obs.	2625	2625

Table 2: Synchronization: baseline model

Regressors	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
Constant term	−2.17***	−2.55***	−2.04***	−2.01***	1.99***	2.22***	−2.13***	−2.19***	−2.22***
US rate	−4.59***	−3.20***	−4.88***	−4.76***	−4.54***	−5.76***	−4.73***	−4.57***	−4.57***
BD rate	−1.24**	−1.54**	−1.97***	−1.30***	−2.26***	−1.99***	−1.51***	−1.27**	−1.27**
JP rate	3.72***	2.44***	3.85***	3.52***	1.30**	2.39***	3.44***	3.62***	3.62***
Gold prices	0.59***	0.52***	0.63***	0.59***	0.39***	0.51***	0.54***	0.59***	0.59***
Oil shocks	−0.13***	0.21**		−0.13***	−0.02	−0.10***	−0.10***	−0.13***	−0.13***
Positive oil shocks			−0.18***						
Negative oil shocks			0.35**						
Trade (inst (1))	0.14***	0.15***	0.14***		0.16***	0.19***	0.14***	0.16***	0.16***
Trade (inst (2))				0.14***					
Quinn	0.44***	0.49***	0.44***	0.45***			0.44***	0.46***	0.45***
Chinn and Ito					0.03**				
D(Quinn)						0.13	0.03		
ERM dummy	0.16***	0.14***	0.16***	0.14***	0.19***	0.16***	0.16***		
0-1-2 index								0.03	
Both fix dummy									0.08*
One fix dummy									0.07
Adjusted R^2	0.144	0.130	0.147	0.150	0.092	0.124	0.140	0.141	0.141
Number of obs.	2625	1890	2625	2625	1616	2520	2520	2625	2625

Table 3: Robustness analysis

Regressors	(X)	(XI)
Constant term	-4.25^{***}	-0.53^{**}
US rate	-4.48^{***}	-1.60^{***}
BD rate	-1.73^{***}	-0.40^{**}
JP rate	1.08^{***}	1.34^{***}
Gold prices	0.17^{***}	0.21^{***}
Oil prices	-0.07^{**}	-0.05^{***}
Trade (inst)	0.08^{***}	0.07^{***}
Quinn index	0.66^{***}	0.14^{***}
ERM dummy	0.15^{***}	0.05^{***}
Adjusted R^2	0.153	0.154
Number of obs.	2625	2625

Table 4: Similarity of economic structures

Regressors	(XII)
Constant term	-2.18^{*}
US rate	-3.48^{***}
BD rate	-1.19
JP rate	2.04^{***}
Gold prices	0.56^{***}
Oil prices	-0.05
Trade (inst.)	0.13^{***}
Quinn index	0.41^{***}
ERM dummy	0.18^{**}
Structural similarity	-0.19^{***}
Adjusted R^2	0.106
Number of obs.	1345

Table 5: Culture and informational asymmetries

Regressors	(XIII)	(XIV)
Constant term	-1.99^{***}	-2.23^{***}
US rate	-4.71^{***}	-4.78^{***}
BD rate	-1.29^{**}	-1.31^{**}
JP rate	3.57^{***}	3.49^{***}
Gold prices	0.59^{***}	0.59^{***}
Oil prices	-0.13^{***}	-0.13^{***}
Trade (inst.)	0.12^{***}	0.07^{**}
Quinn index	0.41^{***}	0.47^{***}
ERM dummy	0.21^{***}	0.14^{***}
Common language	0.24^{***}	
Distance		-0.06^{***}
Adjusted R^2	0.153	0.148
Number of obs.	2625	2625