Stock Market Synchronicity and the Global Trade Network: A Random-Walk Approach.

Amat Adarov, Raja Kali and Javier Reyes[1]

Department of Economics
Sam M. Walton College of Business
University of Arkansas
Fayetteville, AR 72701

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Abstract

Do countries which are more centrally located in the global trade network have more synchronized stock markets? We use global trade data to construct a novel measure of network position, *random walk betweenness centrality* (RWBC), that is especially well suited to this question. RWBC measures the extent to which a country lies on random pathways in-between countries and is therefore more likely to be a conduit in the random transmission of a shock across global markets. We use a panel dataset for 58 countries spanning the period 1990-2000 to find that a country's position in the world trade network as described by RWBC is associated with greater stock market synchronicity. However, we find that a group of nations that form the "core" of the global trade network experience uniformly less synchronicity in their financial markets than others. The high-RWBC core is comprised of the UK, Germany, France, Italy, China and Japan. Other than China, none of these come under the usual rubric of emerging economies, belying the notion that emerging economy financial markets were "decoupled" from the U.S., at least until year 2000, which is the final year of data that we use.

JEL classification: F10; F36; F40; G01; G15

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[1] Email: aadarov@walton.uark.edu, rkali@walton.uark.edu, jreyes@walton.uark.edu

1. Introduction

During the past decade, one of the most prominent themes sounded by policymakers, observers, and analysts of international economic development has been "globalization." The world economy has become tightly knit via economic and financial interdependence among nations. Recently however, as the housing sector in the United States slowed sharply and turmoil erupted in many financial markets, a different theme has come to the foreground: "decoupling." This refers to the apparent divergence in economic performance among different regions of the world economy. In the context of these opposing discussions it seems reasonable to ask, to what extent does integration into the global economy influence synchronized movements in markets around the world? Are there meaningful differences between groups of countries in this relationship?

In this paper, we aim to cast some light on these issues by focusing on a narrow version of the questions above. Specifically, how does integration into the global economy affect synchronicity in financial markets? Our approach involves two methodological novelties. First, we construct a network of economic connectedness among nations by using the most complete data that is available, the NBER World Trade Database (Feenstra et.al, 2005). Our assumption here is that the global trade network is a meaningful proxy for economic connectedness among nations. We believe this is appropriate in this context since we are primarily interested in stock market synchronicity over a relatively long time horizon (1990-2000), and trade linkages are relatively stable over time, in addition to being highly correlated with other cross-country linkages[2].

Second, since there is still argument over the precise pathways via which transmission of shocks takes place, we use a novel approach to computing country-level connectedness that is agnostic about the way in which each country receives and transmits shocks. We assume that the path followed by a shock as it travels between

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[2] There is increasing evidence that financial flows depend on the information afforded by goods trade, and are predicted by the same gravity model that captures trade in goods (Kalemli-Ozcan et. al. 2001, 2003). And theoretically, a balance of payments view suggests integration in the goods and assets markets may go hand in hand (Rajan and Zingales, 1998; Fisman and Love, 2004).

countries in this network is a random walk. This allows us to compute a measure of country (in our network, countries are nodes of the global trade network) connectedness known as *random walk betweenness centrality* (Newman 2005).

Roughly speaking, the random walk betweenness of a node *i* is equal to the number of times that a random walk starting at *s* and ending at *t* passes through *i* along the way, averaged over all *s* and *t*. An attraction of this measure is that it is agnostic about which path a shock actually takes between any particular "source" or "epicenter" country and a "target" country with regard to the transmission of shocks. Since the propagation mechanism of international economic shocks is not well understood, with different hypotheses vying for attention in the literature, this approach seems especially useful since it does not favor one transmission mechanism over another. The network of trade relationships will itself tell us which nodes are important in the random propagation of shocks. In other words, it will yield an endogenous measure of interconnectedness for each country.

We then examine whether these country-level measures of network position are capable of explaining financial synchronicity. In order to measure interdependence we use a measure of synchronicity between stock-market indices of countries and those of a financial center such as New York that is inspired by the work of Morck, Yeung and Yu (2000). In only a slight variation of their interpretation, if stock prices are based mainly on the capitalization of country-specific information we expect a low degree of synchronicity, while a greater degree of interdependence will be reflected in higher synchronicity, ceteris paribus.

Our basic hypothesis is then the following. Other things being equal, a country that has a high measure of *random walk betweenness centrality* (RWBC) lies on more random pathways in-between countries and will therefore be more likely to be affected by an external shock, regardless of the exact transmission mechanism, than a country with a lower RWBC. This will be reflected in a higher level of synchronicity in the stock-market of a high RWBC country than a lower RWBC country. We therefore expect high RWBC to be correlated with greater stock-market synchronicity, other things equal.

Our empirical analysis supports this hypothesis. Greater connectedness of an economy in the global trade network as measured by RWBC is associated with higher stock market synchronicity, after controlling for other relevant characteristics. However, we find that a group of nations that are highly central in the global trade network (we refer to these highly connected nations as the "core" of the network) experience uniformly less synchronicity in their financial markets than others. The high-RWBC core is comprised of the UK, Germany, France, Italy, China and Japan. Other than China, none of these come under the usual rubric of emerging economies, belying the notion that emerging economy financial markets were "decoupled" from the U.S., at least until year 2000, which is the final year of data that we use.

In terms of the literature, only a few studies have attempted to take into consideration multilateral linkages in the global economy to explain stock market correlations. Forbes and Rigobon (2002) find that trade linkages are important factors for stock market dynamics and therefore a country's susceptibility to financial crisis. Reinhart and Kaminsky (2008) analyze the three emerging markets that experienced financial crises in the late 1990s: Brazil, Russia, and Thailand and suggest that financial turbulence in these countries only spreads globally when the shock reaches world financial centers and remains local otherwise. A recent paper by Kali and Reyes (2008) explicitly uses a network approach to international economic integration to study financial crisis episodes and associated contagion.

A separate strand of the literature, pioneered by Imbs (2004, 2006), focuses on business cycle synchronization and uses simultaneous equations systems to disentangle the complex interactions between trade, finance, specialization and business cycle synchronization. The overall effect of trade on business cycle synchronization is confirmed to be strong, and a sizable portion is found to work through intra-industry trade.

Our approach here is differentiated from the prior literature along several dimensions. Most importantly, we apply a network approach to understand stock market correlations. Using the network of global trade linkages enables us to use a completely multilateral approach to the propagation of financial shocks. Our measure of network position, RWBC, is, we believe, completely novel to this literature, as well as being well-suited to the application. Second, unlike most studies we address stock market synchronicity over the long run rather than focusing on financial turmoil periods alone. This is an important distinction because financial crisis years are likely to be characterized by downward financial trends in stock markets resulting in a bias towards higher synchronicity values. Our empirical analysis is based on a panel dataset spanning 1990-2000 period that includes both tranquil periods and periods of economic crises. Third, we assess stock market synchronicity for a wide range of countries from diverse regions of the world and different levels of economic development to make sure results are not driven by individual country properties.

The rest of the paper is organized as follows. Section 2 discusses our empirical strategy and data. Regression results are discussed in Section 3. Section 4 presents concluding remarks.

2. Research framework and data

As discussed in the previous section, the question the paper is focused on is whether more interconnected economies have more synchronous stock market movements. In order to test this hypothesis we develop a measure of stock market synchronicity and a measure of interconnectedness among individual economies - RWBC. In addition, we recognize that there are other factors that can potentially affect the degree of synchronicity among stock markets in different countries, and therefore also consider control variables deemed to be relevant in literature related to the discussion of stock market synchronicity at the macroeconomic level, including stock market capitalization, trade to GDP ratios, exchange rate regimes, as well as other variables.

2.1 Stock market synchronicity

To compute a synchronicity measure that is comparable across countries, we need to select a benchmark country/index to which all other countries are compared to. We use the United States of America as the benchmark country and the Dow Jones Industrial

Average (DJIA) as the benchmark index[3]. Based on our methodology, the US is the most well-integrated country in the world economy as identified by centrality in the global trade network, and, in general, it is hard to find a better representative financial center by any standard.

Our sample includes 58 countries, with data for the 1990 – 2000 period. For each country *i* we identify a representative stock market index and compute its stock market synchronicity in year *t* with respect to the benchmark country (the US) by using several techniques. Our main analysis is based on two synchronicity measures denoted further as $Synch^{(FREQ)}$ and $Synch^{(R\text{-}SQ)}$, that are inspired by the synchronicity measures of Morck, Yeung and Yu (2000). We also use a third viable measure denoted as $Synch^{(CORR)}$ as a robustness check[4]. Here we provide a detailed description of how the two benchmark synchronicity variables are developed.

Calculation of $Synch^{(FREQ)}$ involves two steps. First, we compute the frequency of stock market index comovements in year *t* for country *i* as a simple fraction:

$$Frequency_{i,t} = \frac{Comovements_{i,t}}{Days_{i,t}} \qquad (1)$$

where $Comovements_{i,t}$ denotes the number of days in year *t* in which stock market index of country *i* moves in the same direction as the DJIA, and $Days_{i,t}$ represent the number of days for which both stock markets were operating in year *t*.

Equation (1) provides an intuitive assessment of stock market comovements as a fraction of days out of the total number of days observed in a given year for which the stock market index of country *i* moves in the same direction as the stock market index of the US, the benchmark country. For instance, in the case of Brazil and its representative stock market index, the Bovespa Index, comprised of the most liquid stocks traded on the Sao Paulo Stock Exchange, the computed frequency value in 2000 is 0.6929. This means

[3] We use DJIA as it is the most widely recognized of the stock market indices. We realize it is often criticized for being a price-weighted measure, which affects its accuracy as an index representing the entire stock market. However, DJIA daily dynamics closely follow other widely recognized indices, e.g. the correlation coefficient between DJIA and S&P500 daily values over the period 01/01/1990 – 01/01/2000 is 0.996. Therefore, choosing one index as a benchmark over others should yield identical results.

[4] The calculation of $Synch^{(CORR)}$ measure and empirical results using $Synch^{(CORR)}$ are discussed in section 3.3 *"Robustness checks"*.

that in the year 2000 the Bovespa Index moved in the same direction as the DJIA 69.29% of days. Figure 1 lists the frequency of stock market comovements for the entire sample of countries used in our study.

<Figure 1 about here>

The computed frequency variable is confined in the interval of [0,1] and therefore cannot be used in our regression analysis directly. In order to map frequency values to the real numbers set we apply the standard statistical technique of logistic transformation as follows:

$$Synch_{i,t}^{(FREQ)} = Ln\left(\frac{Frequency_{i,t}}{1 - Frequency_{i,t}}\right) \qquad (2)$$

Hence, our first stock market synchronicity measure, $Synch^{(FREQ)}$, is merely a logistic transformation of stock market comovement frequency based on the natural logarithm. $Synch^{(FREQ)}$ values for the year 2000 are presented in Figure 2[5].

<Figure 2 about here>

Although synchronicity based on a fraction of comovement days is a simple measure, we believe it is adequate for our purposes and is robust to most issues associated with alternative measures as we keep track only of the direction of stock market index dynamics.

Our benchmark analysis also uses another measure of stock market synchronicity, $Synch^{(R\text{-}SQ)}$, which is based on a goodness-of-fit approach rather than a fraction of comovement days:

[5] For brevity we present stock market synchronicity value charts and synchronicity-RWBC scatter plots only for the $Synch^{(FREQ)}$ variable as all three stock market synchronicity measures that we develop in the study are highly correlated and diagrams for $Synch^{(R\text{-}SQ)}$ and $Synch^{(CORR)}$ look virtually identical to those of $Synch^{(FREQ)}$.

$$Synch_{i,t}^{(R-SQ)} = Ln\left(\frac{R^2_{i,t}}{1-R^2_{i,t}}\right) \qquad (3)$$

where $R^2_{i,t}$ is the coefficient of determination from the linear regression $Index_{i,t} = \alpha + \beta * DJIA_{i,t} + \varepsilon_{i,t}$ regressing daily index values in year *t* (in log-differenced form) of country *i*'s stock market index on those of the Dow Jones Industrial Average. Again, as the coefficient of determination is bounded in the [0,1] interval, we apply logistic transformation to map the variable to the real number set.

For both of these synchronicity measures we drop individual values based on less than 100 days of observation since we believe these to be unreliable. The daily stock returns data for all major country indices are obtained from the Bloomberg LP stock market database, where each data point represents a daily stock market index closing value.

We construct a panel dataset for synchronicity based on daily stock market quotes with appropriate adjustments made for time zones differences in the operation of corresponding stock exchanges. For instance, a shock affecting the New York Stock Exchange on December 1st is reflected in the US in the reported December 1st daily closing prices, while the London Stock Exchange would reflect the effects of this shock, if any, in the reported December 2nd daily closing prices because of the time difference. Therefore, in calculations of synchronicity measures we shift stock market index daily closing values for economies located to the east of New York (hence, all economies not located in North America and South America) backwards by 1 day, e.g. daily closing index values reported in non-American economies on December 2 would correspond to daily closing index values of DJIA reported on December 1.

We acknowledge the fact that our synchronicity measures are imperfect since there can be scenarios which may or may not be captured by our measures explicitly. For example, if relevant news or events are announced after a stock market is closed for the day, the effects would be reflected in the next day's price, but there is no way to control for this unless we had an explicit "news" indicator. Recent studies that have looked at the effects of macroeconomic news (economic information) on stock market prices, e.g. Albuquerque and Vega (2008), Karolyi and Stulz (1996), McQueen and Roley (1993), Wongswan, J. (2006), examine the mechanisms of price discovery and spillovers on interdependent asset markets after public economic news releases. In most cases, macroeconomic news pertaining to the US stock market exogenously enters regression models explaining domestic stock returns or stock return volatility (in some cases, like in Wongswan, J. (2006), trade volumes are observed rather than returns). Notably, the literature suggests that the effect of macroeconomic announcements on stock market comovement manifests itself in high-frequency stock market data (daily or intra-day return dynamics), and in this case constitutes an important source of international stock market comovement. At low frequencies the effect is minimal.

In fact, our synchronicity variable takes advantage of high-frequency data as it is based on daily stock market index comovement dynamics, and can be viewed as a statistic summarizing the daily dynamics of relevant macroeconomic fundamentals and the effect of economic news. However, while we take advantage of the high-frequency daily data to assess stock market comovements, our analysis differs from other papers in this literature as we ultimately focus on long-term systematic factors that explain cross-country stock market synchronicity over a long time horizon.

It could also be the case that a shock may affect different markets with a time lag, for simple reasons, like holidays, or more complicated ones, such as markets not fully realizing the extent of the effects that some shocks will have since these may depend on factors related to reaction of domestic firms, regulations or other actions by domestic agencies (i.e., central banks) or international agencies (i.e., rating agencies or institutions like the International Monetary Fund). Despite these potential shortcomings of the synchronicity measures, since our study is not focused on the analysis of extreme events (shocks) and we use daily data for the whole sample period, we believe that, given the large sample size, the impact of anomalous adjustments due to the reasons mentioned here is minimal.

Summary statistics and correlations between the three alternative stock market synchronicity measures $Synch^{(FREQ)}$, $Synch^{(R\text{-}SQ)}$ and $Synch^{(CORR)}$ are reported in Table 1. As can be seen, correlations between the three synchronicity measures is fairly high, and therefore we expect regression results to be similar regardless of the specific form of the synchronicity variable.

<Table 1 about here>

2.2. Random walk betweenness centrality (RWBC)

Our hypothesis of interest calls for the application of a measure that is a proxy for the degree of economic interconnectedness among countries. In the networks literature *centrality* is a specific measure that summarizes the position of a given node in the network based on the value of its relations and relations of the nodes it is connected to. There are different measures of centrality (binary and weighted) that are based on closeness and/or betweenness. The specific one used in our study is *random walk betweennness centrality*, first suggested by Newman (2005) and later expanded by Fisher and Vega-Redondo (2006). Insightful discussion of the measure and its technical properties is provided in Newman (2005). In particular, he describes RWBC of a given node *i* as the number of times that a random walk starting at node *s* and ending at node *t* passes through *i* along the way, averaged over all *s* and *t*. This measure is appropriate for a network in which information wanders about, essentially at random, until it finds its target. It includes contributions from many paths that are not optimal in any sense, although shorter paths still tend to count for more than longer ones since it is unlikely that a random walk becomes very long without finding the target.

Fagiolo, Reyes, and Schiavo (2008) use international trade flows data provided by Gleiditsch (2002) to build time series of weighted directed networks and compute RWBC values for 159 countries over the sample period of 1981 to 2000[6]. We use their data to build a panel dataset of RWBC for the 58 countries assessed in our study over the period 1990-2000. Figure 3 depicts countries sorted by their RWBC values for the year 2000.

Observing the data reveals that RWBC values do not seem to be directly related to the level of development of a country, as high per capita GDP countries are located in the

[6] The literature applying network perspectives to the study of international economic integration has expanded substantially in recent years and the principal framework for this approach has defined linkages in terms of international trade flows (in many cases weighted by GDP). Recent studies in this area include those by Bhattacharya et al. (2007), Saramaki, et al. (2007), Fagiolo, Reyes, and Schiavo (2008), Kali and Reyes (2007), Serrano et al. (2007).

lower RWBC range together with low per capita GDP countries. At the same time, inequality in RWBC between individual economies is vast, e.g. the lowest RWBC country Malta has a RWBC value 18 times smaller than RWBC value of the highest RWBC country Germany. The benchmark country of our analysis, the US, has RWBC value of 0.6297 in 2000, which is by far higher than RWBC of any other country. This speaks in favor of the argument that the USA is a good benchmark economy to relate other countries to. For comparison, the second highest RWBC economy in the sample is Germany with the value of only 0.2743. Notably, a cluster of countries characterized by significantly higher RWBC values than the rest of the sample can be identified, including Italy, China, the UK, Germany, France and Japan. These highly-central in terms of RWBC economies will play an important role in the core-periphery argument that we develop later.

<Figure 3 about here>

2.3. Controlling for macroeconomic parameters

We also consider other variables that can affect the extent of stock markets comovement, including stock market capitalization to GDP ratio, trade to GDP ratio, exchange rate regime, and a dummy variable for financial centers.

Stock market capitalization to GDP ratio: We control for the level of stock market development by including stock market capitalization to GDP ratio in the regression. Higher values of stock market capitalization to GDP ratio should result in higher stock market synchronicity. It could simply be that higher synchronicity is the financial market size effect, with higher volumes of publicly traded stocks having greater significance of financial shocks. Stock market capitalization to GDP ratio data is obtained from the World Bank Financial Structure Dataset[7].

Trade to GDP ratio is calculated as the ratio of total international trade (exports plus imports) to GDP for a given country/year. The variable is commonly used to control

[7] World Bank Financial Structure Dataset http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:20696167~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html

for the degree of economic openness of individual nations. Higher trade to GDP ratio indicates a more open economy and therefore may lead to higher susceptibility to global shocks. Trade to GDP ratio data is based on the World Bank World Development Indicators database available at the World Bank website[8].

Exchange rate regime: Exchange rate regime is claimed to be an important macroeconomic characteristic that could influence observed synchronicity as part of the financial shock may be mediated by exchange rates. However, tracking exchange rate regime of individual countries over time is problematic, as although de-jure most countries in the sample claim to have floating exchange rates, de-facto their governments use some sort of peg and hence the real exchange rate regime is either fixed or intermediary for any given year with only few countries using truly floating exchange rates. Therefore, in our analysis we use the database provided in Levy-Yeyati and Sturzenegger (2005), which describes de-facto exchange rate regimes in individual countries on a yearly basis with a 3-way classification (fixed, intermediate and flexible exchange rate regime). We include a fixed exchange rate regime and an intermediate exchange regime dummy variables in our regression model to account for de-facto government control of exchange rates based on this dataset.

Financial center: Possible effects of large financial centers on stock market synchronicity are accounted for with the financial center dummy variable. Some empirical studies (e.g. Reinhart and Kaminsky, 2008) suggest that countries hosting financial centers may be important in further propagation of a shock. The dummy variable takes the value of unity for countries hosting a major financial center (Japan, Germany and the UK) and zero otherwise.

3. Model specification and results

Our empirical analysis is based on a panel dataset of 58 countries spanning the period 1990-2000. The choice of countries was made contingent upon data availability for the key variables - RWBC and stock market synchronicity. The complete list of

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[8] World Bank World Development Indicators:
http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=135

countries assessed in our study and corresponding stock market indices can be found in Table 7 at the end of the paper. As our sample covers all geographic regions and major income-level groups, we believe it is a relatively good representation of the world economy.

3.1 Benchmark model: panel data regression analysis

To analyze the effects of RWBC on stock market synchronicity we estimate several versions of a regression equation of the form:

$$Synch_{i,t} = \alpha + \beta * RWBC_{i,t} + \boldsymbol{\gamma} * \boldsymbol{\Gamma} + \varepsilon_{i,t} \qquad (4)$$

where $Synch_{i,t}$ is the stock market synchronicity variable, $RWBC_{i,t}$ is *random walk betweenness centrality*, $\boldsymbol{\Gamma}$ is the vector of control variables, subscripts i and t denote country and year respectively.

Depending upon specification, in equation 4 the benchmark analysis uses $Synch^{(FREQ)}$ or $Synch^{(R\text{-}SQ)}$ developed in section 2.1 as the dependent variable of stock market synchronicity ($Synch_{i,t}$). $RWBC_{i,t}$ is random walk betweenness centrality of country i in year t in the global trade network as defined in section 2.2. Vector $\boldsymbol{\Gamma}$ incorporates a combination of control variables that includes, depending on specification, stock market capitalization to GDP ratio, trade to GDP ratio, financial center dummy variable, fixed exchange rate regime and intermediate exchange rate regime dummy variables. Table 2 presents descriptive statistics for the explanatory variables of the model.

<Table 2 about here>

Several versions of the benchmark equation above are estimated with varying combinations of control variables to assess whether results are robust to inclusion of additional explanatory variables. We check pairwise correlations between the regressors to make sure multicollinearity is not a problem.[9] The panel data regression model is estimated with the random effects model, which is more appropriate for describing cross-country variation and we use robust standard errors to account for heteroskedasticity that could arise for different reasons, for example periods of financial turmoil[10].

Before expanding on the results of the econometric specification, we perform a brief exploratory analysis in which we simply plot stock market synchronicity against RWBC for our sample of countries. The scatter plots with the fitted linear regression line for $Synch^{(FREQ)}$ are presented in Figure 4 (as diagrams for $Synch^{(R\text{-}SQ)}$ look virtually identical, we only focus on the discussion of the scatter plot for $Synch^{(FREQ)}$). Each dot in the diagram represents an individual observation for a given country in a given year. The top panel of the figure plotting the data for the whole sample period considered, 1990-2000, while the bottom one considers only year 2000.

<Figure 4 about here>

The scatter plots present a clear positive relationship between RWBC and $Synch^{(FREQ)}$. Notably, the full sample of countries naturally splits into the high-RWBC "core" cluster comprised of the UK, Germany, France, Italy, China and Japan and the low-RWBC "periphery" cluster at the threshold level of RWBC at approximately 0.15. It should be noted that in the networks literature (Kali and Reyes, 2007) the core-periphery structure of the world trade network has been identified and its presence is clearly observable in Figure 4. As can be seen, the observed positive relationship between RWBC and $Synch^{(FREQ)}$ is significantly stronger for the "periphery" cluster than for the "core" economies. Therefore, it is logical to consider not only the connectedness of individual economies in the world trade network, but also its clustering properties, and interpret our main hypothesis of interest along with the "decoupling" hypothesis. For robustness, we first address both the case where the entire sample of countries is treated as a non-clustered network and then, in the following section, we consider clustering in

[9] The correlations are quite low; therefore, according to standards of applied econometrics (Ch. 11, Kennedy, 2003) we are not concerned about multicollinearity problems. The correlation matrices are available upon request from the authors.

[10] Estimating the benchmark equations with the fixed effects model yields results similar to the random effects estimation.

the global economic network by identifying and controlling for the densely connected “core” in relation to the less interconnected “periphery”.

Along these lines, the following econometric analysis provides a more rigorous analysis, testing whether or not the positive effect of RWBC on synchronicity is identified after controls for other economic characteristics are included. Estimation results are presented in Table 3 for $Synch^{(FREQ)}$ and Table 4 for $Synch^{(R\text{-}SQ)}$. Columns 1-4 of both tables (regression results for the full sample of countries, not controlling for the core-periphery structure of the world economy) indicate that in both cases RWBC has a positive and statistically significant effect on stock market synchronicity. In particular, for $Synch^{(FREQ)}$ the coefficient of RWBC is greater than 0.80 across the different specifications and it is significant at the five percent probability level, while for the $Synch^{(R\text{-}SQ)}$ the coefficient of RWBC is greater than 8.1 and statistically significant at the 1% level. Magnitude-wise, using the estimated coefficient for RWBC in column 1 of Table 3, one standard deviation of RWBC (which is equal to 0.0721 for the 1990-2000 period) translates into a change in $Synch^{(FREQ)}$ of 0.0616, or about 20% of a standard deviation of $Synch^{(FREQ)}$ (which is equal to 0.3091).[11] In the case of $Synch^{(R\text{-}SQ)}$ one standard deviation of RWBC translates to about 25% a standard deviation of $Synch^{(R\text{-}SQ)}$.

<Tables 3 and 4 about here>

With regards to the control variables, as expected, stock market capitalization to GDP ratio is positive and statistically significant in all equations, and therefore constitutes another major factor explaining stock market synchronicity. Its magnitude effects are relevant as well. For instance, for regression results with $Synch^{(FREQ)}$, using the estimated coefficient for stock market capitalization to GDP ratio in column 2 of Table 3, a one standard deviation change in stock market capitalization (equal to 0.4943 for the 1990-2000 period) translates into a change in $Synch^{(FREQ)}$ of 0.0403, or about 13% of a standard deviation of $Synch^{(FREQ)}$. These results are robust and intuitive, since stock market capitalization to GDP ratio describes the level of financial development of a

[11] The change in stock market synchronicity is computed by multiplying the estimated coefficient for RWBC in column 1 of Table 3 by the standard deviation of RWBC (0.8539*0.0721 = 0.0616).

country. Higher stock market capitalization implies higher market value of stocks comprising the underlying stock market index. Stock market capitalization to GDP ratio suggests a greater proportion of publicly traded stocks in the economy. Hence, it will result in higher synchronicity as publicly traded equity is the most susceptible asset of a firm that quickly adjusts for relevant news. Therefore, it constitutes a single major source of the market value volatility of individual firms which translates to stock market indices, with the magnitudes of this effect on the entire economy contingent upon the stock market capitalization level. On the contrary, other control variables – trade to GDP ratio, exchange rate regime and financial center dummy variables - do not seem to enhance the model in most cases.

3.2. Addressing the core-periphery structure of the world trade network

As discussed before, the international trade network clearly presents a core-periphery structure that cannot be ignored in empirical analysis. In order to explore this clustering effect we estimate the regression model with adjustments made for the core economies (the UK, Germany, France, Italy, China and Japan). We use two viable methods to address this. First, we estimate the equations with additional controls for the core economies and report results in columns 5 and 6 of Tables 3 and 4. As can be seen from the scatter plots and linear regression lines of Figure 4, the cluster of the core economies differs from the rest of the sample in terms of both its fixed effect (different intercept) and the slope coefficient of the RWBC variable. Therefore, as one approach, we include a dummy variable (*Core economies*) and an interaction term (*RWBC*Core economies)* in the regression equations to properly address the core-periphery argument. The second approach involves estimating the regression model based on a restricted sample, where the core economies are completely excluded. Results with the restricted sample are reported in column 7 of Tables 3 and 4.

As expected, the results for the two benchmark synchronicity measures $Synch^{(FREQ)}$ (Table 3) and $Synch^{(R\text{-}SQ)}$ (Table 4) are similar and speak in favor of our hypothesis of interest. In particular, the results reported in columns 5 and 6 suggest that the intercept and the slope coefficient of RWBC for the core and the periphery economies differ (intercept is lower and the slope coefficient is higher for the core economies). For both synchronicity measures the slope coefficient of RWBC remains statistically significant at the 1% probability level. For robustness, we also perform the Wald Chi-squared test that confirms the slope coefficient of RWBC and intercepts are statistically significantly different from each other for the core and non-core subsamples of countries[12].

Economic effect of RWBC on stock market synchronicity in terms of standard deviations in this case is also notable. In the case of $Synch^{(FREQ)}$, using the estimated coefficient for RWBC in column 7 of Table 3, the magnitude effect of a one standard deviation change in RWBC translates to a change in stock market synchronicity of 0.1148, or 36% of one standard deviation in synchronicity.[13] Similarly, for $Synch^{(R\text{-}SQ)}$, a one standard deviation change in RWBC translates to a change in synchronicity of 0.7862, or 30% of one standard deviation in $Synch^{(R\text{-}SQ)}$.

Importantly, results for both synchronicity measures suggest the core economies are characterized by different RWBC-stock market synchronicity relationship properties than the non-core cluster. In particular, we observe a negative interaction term between RWBC and core economies dummy variable that is significant at the 1% level for $Synch^{(FREQ)}$ and significant at the 5% level for $Synch^{(R\text{-}SQ)}$. In the case of $Synch^{(FREQ)}$, the core economies dummy variable is also positive (slope coefficient of about 0.42) and significant at the 5% level of statistical significance.

An alternative approach with the restricted sample regressions for both stock market synchronicity variables yields similar results suggesting RWBC is a highly significant (1% statistical significance level) determinant of stock market comovement. Superior by all means estimation results relative to the benchmark model, where we do

[12] We perform a conventional Wald chi-squared test to examine whether the slope coefficient of RWBC and the intercept are statistically significantly different from each other in the case of the core and non-core economies. In particular, we use the pooled regression model with the panel data that includes the *RWBC*Core economies* interaction term and the *Core economies* dummy variable (specifications 5 and 6 in Tables 3 and 4) and test a series of hypotheses that the coefficients of the interaction term and the intercept are jointly and independently statistically significant from zero (e.g. in the model involving $Synch^{(FREQ)}$ and the full array of control variables (column 6 of Table 3) the Wald test for the joint significance of *RWBC*Core economies* and *Core economies* from zero yields χ^2 statistic of 18.14 with the associated P-value of 0.0001).

[13] In this case, we use the non-core countries sample to compute the effects on stock market synchronicity of a one standard deviation increase in RWBC.

not control for clustering, again speak in favor of the argument that the structure of the global trade network does have significant implications for vulnerability of individual stock markets and supporting the “decoupling” hypothesis. These results remain robust to the inclusion of additional controls like GDP, GDP per capita, hi-GDP/low-GDP country variables that we used for robustness checks.

Hence, summarizing the discussion of the core-periphery structure of the world trade network and its implications for financial shock propagation, several key features can be explicitly recognized as a result of our analysis. First, the position of a country in the global trade network, in our case measured by RWBC, is an important factor determining its stock market synchronicity along with stock market capitalization, with higher values of RWBC associated with higher stock market synchronicity. Second, confirming the “decoupling” hypothesis, the world trade network has a clearly identifiable core-periphery structure. Based on the position of a country in the world trade network as evaluated by the RWBC measure, the UK, Germany, France, Italy, China and Japan form a consistent over the period 1990-2000 cluster of high-RWBC countries, while the rest of the sample forms a cluster of low-RWBC economies. Third, the core-periphery structure of the world economy has critical implications for global stock market synchronicity patterns. Specifically, for the non-core economies the slope coefficient of RWBC is substantially higher than for the core economies across specifications, suggesting their greater susceptibility to global financial shocks. At the same time, the core economies, although highly central in the global trade network, have uniformly lower levels of stock market synchronicity and lower sensitivity to RWBC than the non-core economies.

3.3. Robustness checks

As a robustness check, we replicate the analysis using a cross-section approach instead of a panel data approach to check whether results hold for economically tranquil periods. The results for the most recent year of our analysis, year 2000, are presented in Table 5. As expected, the effects of RWBC on synchronicity are positive and statistically significant, while their magnitude differs from the panel-data case. Specifically, for

$Synch^{(FREQ)}$, regression results for the full sample controlling for the core economies (column 1 of Table 5) suggest that a one standard deviation change in RWBC in 2000 (0.0656 in 2000) translates to a change in $Synch^{(FREQ)}$ of 0.1893, which corresponds to 70% of a standard deviation of $Synch^{(FREQ)}$ in 2000 (equals 0.2694). In the case of $Synch^{(R\text{-}SQ)}$ (column 4 of Table 5), a one standard deviation change in RWBC in 2000 translates to a change in $Synch^{(R\text{-}SQ)}$ of 1.69, which corresponds to 78% of a standard deviation of $Synch^{(R\text{-}SQ)}$ in 2000.

<Table 5 about here>

We also estimate all regression models with an alternative stock market synchronicity measure, which is also based on daily stock market index data with proper adjustments for time zone differences, but rather involves correlations between stock market indices:

$$Synch_{i,t}^{(CORR)} = Ln\left(\frac{Corr_{i,t}+1}{1-Corr_{i,t}}\right) \quad (5)$$

where $Corr_{i,t}$ is the correlation coefficient between daily index values (in log-differenced form) of the Dow Jones Industrial Average and country *i*'s stock market index in year *t*. The correlation coefficient is bounded in the [-1,1] interval, hence logistic transformation is applied in this case also. We replicate the same set of estimations as performed with the benchmark measures with $Synch^{(CORR)}$ and report results in Table 6.

<Table 6 about here>

As mentioned earlier, pairwise correlation coefficients between the three alternative measures of synchronicity are fairly high. Therefore, it is not surprising that regression analysis utilizing $Synch^{(CORR)}$ yields outcomes similar to those involving the baseline synchronicity measures. Results confirm statistical significance of RWBC (RWBC is significant at the 1% level of significance across all specifications), supporting the original hypothesis that a country's position in the global trade network is one of the key factors of stock market comovement, as well as provide additional evidence in favor of the core-periphery argument presented earlier. Regarding the economic effect of RWBC, in the case of panel data estimation controlling for the core economies (column 1 of Table 6) a one standard deviation change in RWBC translates to a change in $Synch^{(CORR)}$ of 0.45, which corresponds to 98% of a standard deviation of $Synch^{(CORR)}$. For the 2000 year data, a one standard deviation change in RWBC in 2000 translates to a change in $Synch^{(CORR)}$ of 0.29, which corresponds to 83% of a standard deviation of $Synch^{(CORR)}$.

4. Conclusion

In this paper we apply a network approach to analyze stock market synchronicity between nations. We demonstrate that random walk betweenness centrality of a country in the world trade network and stock market capitalization levels are the two significant and robust factors explaining stock market synchronicity. We find that a group of nations that form the "core" of the global trade network experience uniformly less synchronicity in their financial markets than others. The high-RWBC core is comprised of the UK, Germany, France, Italy, China and Japan. Other than China, none of these come under the usual rubric of emerging economies, belying the notion that emerging economy financial markets were "decoupled" from the U.S., at least until year 2000, which is the final year of data that we use.

A logical next step in this research program is to examine whether this pattern of synchronicity and decoupling was any different during the most recent period of financial turmoil. As complete data on the global trade network becomes available past 2000, it should be possible to extend the analysis to more recent events.

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Figure 1. Frequency of stock market comovement, year 2000.

Frequency of stock market comovement is computed as a fraction of days in which stock market index of a given country moves in the same direction as the DJIA in the total number of days during which both stock markets were operating in a given year. Frequency of stock market comovement is reported for the entire sample of 58 countries assessed in the study. Countries are sorted by frequency values in ascending order.

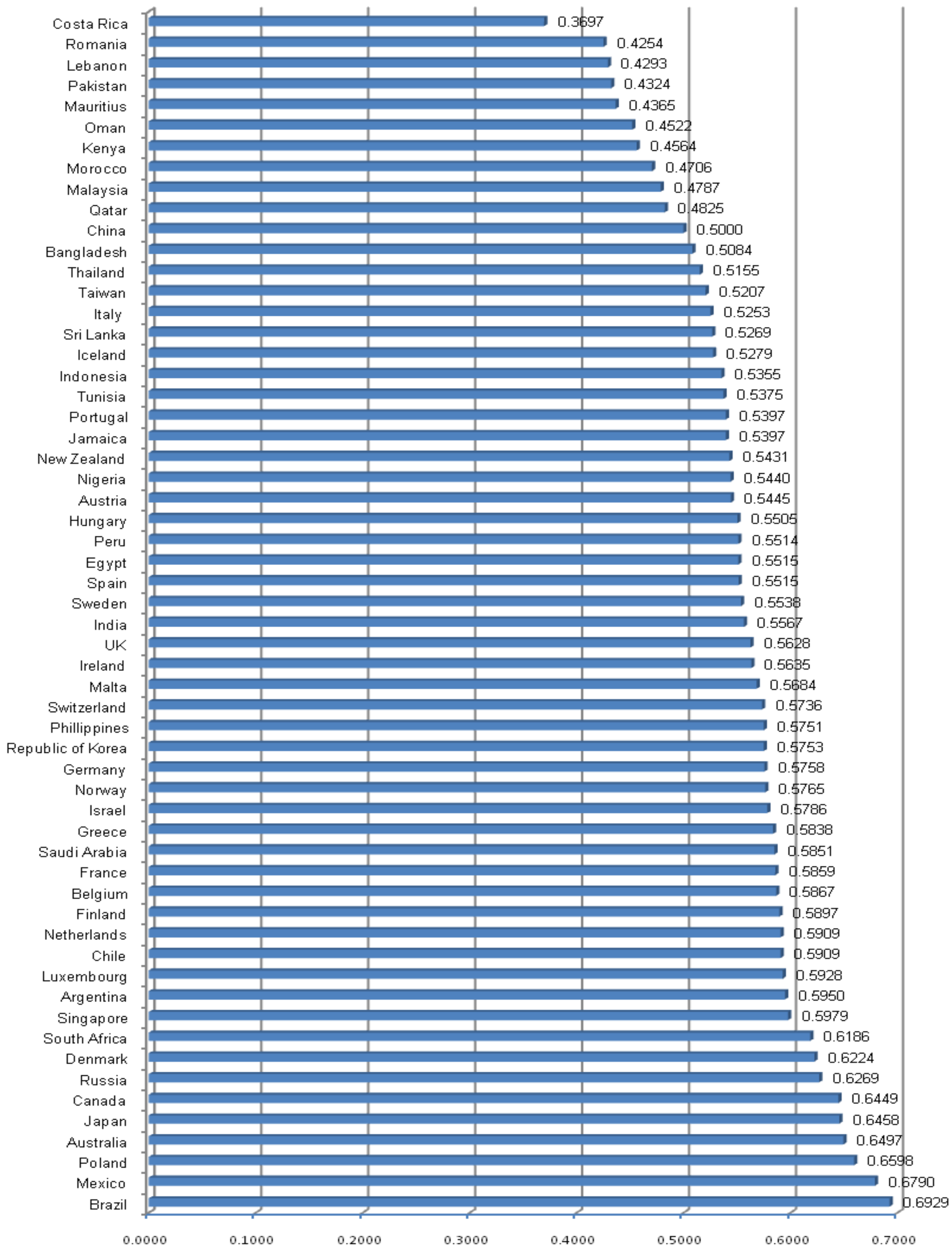


Figure 2. Stock market synchronicity *Synch*$^{(FREQ)}$, year 2000.

Synch$^{(FREQ)}$ is calculated as $Ln\left(\frac{Frequency_{i,t}}{1-Frequency_{i,t}}\right)$, where *Frequency* measures a fraction of days in the total number of days observed in a given year for which stock market index of a given country moves in the same direction as the DJIA. Synchronicity calculations are based on daily closing index values reported by the Bloomberg LP with adjustment for time differences. Synchronicity values are reported for the 58 countries we use in the analysis, sorted in ascending order.

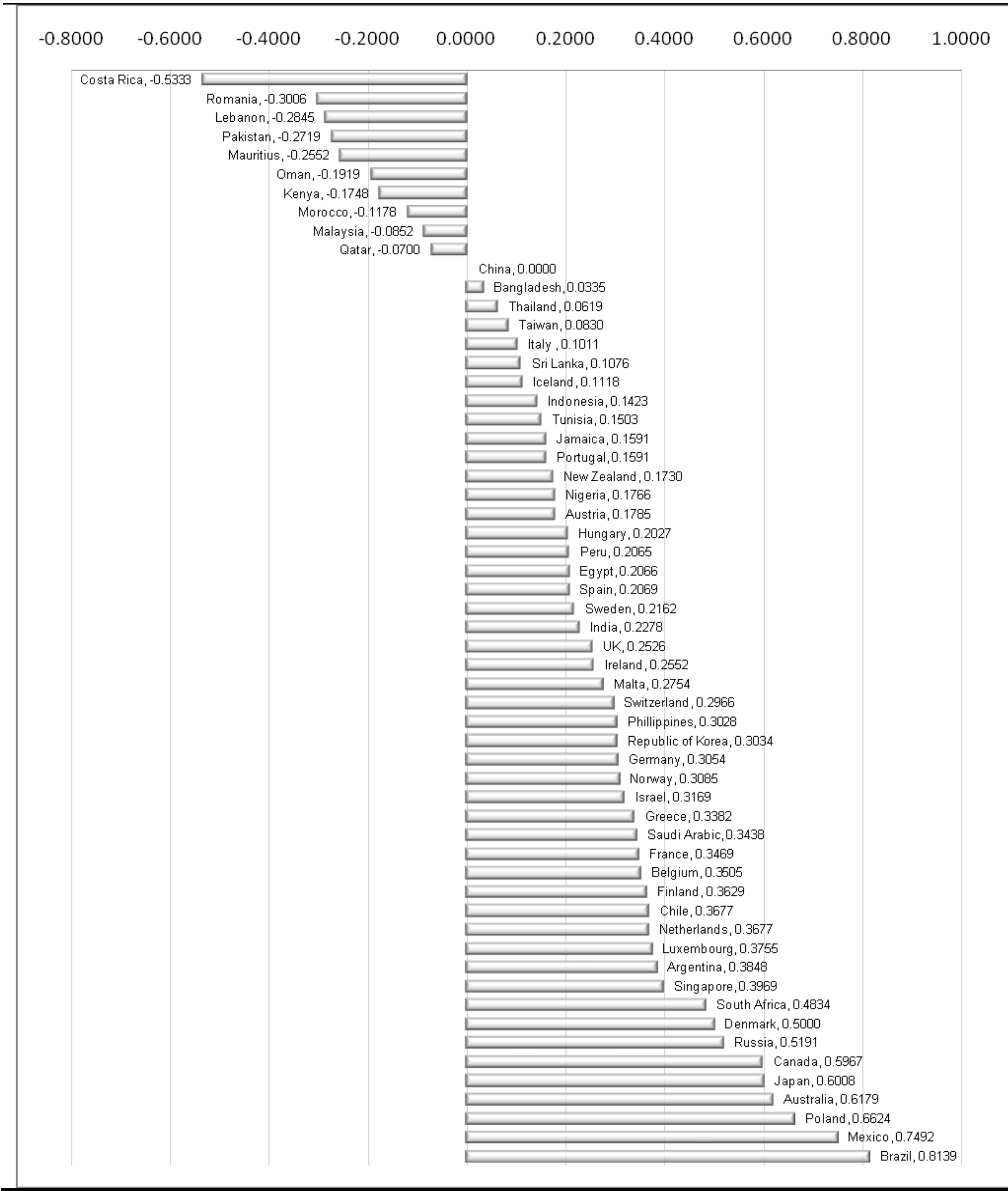


Figure 3. *Random walk betweenness centrality*, year 2000.

Random walk betweenness centrality of a country in the global trade network (RWBC) measures how well connected an economy is in the global trade network. Higher values of RWBC denote higher probability that a given node (country) is passed through by a random walk traveling between two other nodes, where probabilities of random walk paths are proportional to trade-flow weights of nodes. Countries are sorted by RWBC values in ascending order.

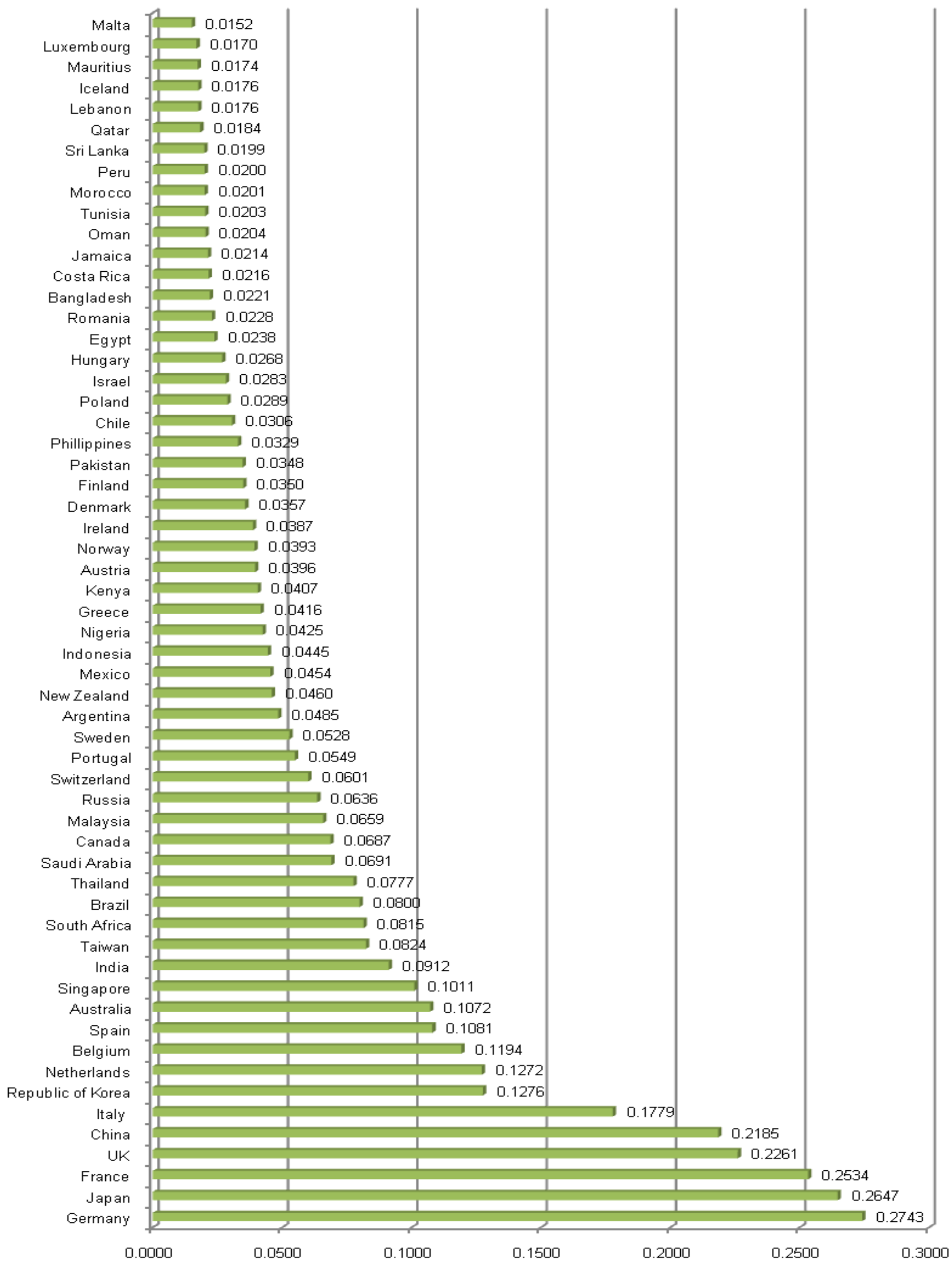
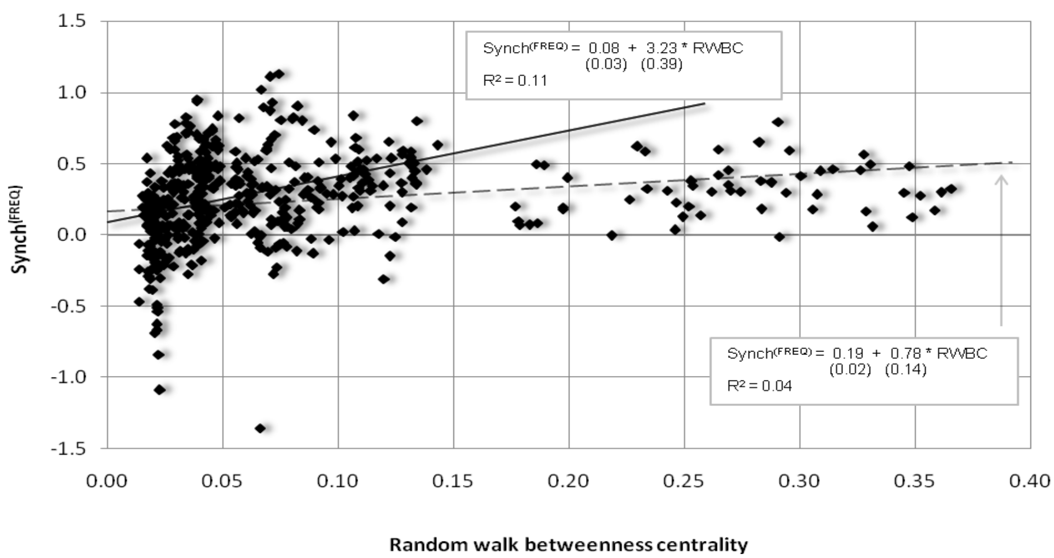


Figure 4. *Random walk betweenness centrality* plotted against *Synch*$^{(FREQ)}$.

The figure presents scatter plots of *Random walk betweenness centrality* against *Synch*$^{(FREQ)}$ for the period 1990-2000 (Panel A) and for the year 2000 (Panel B). Each dot denotes one yearly observation for one of the 58 countries we assess. In both panels the entire sample of countries naturally splits into the high-RWBC "core" cluster (comprising the UK, Germany, France, Italy, China and Japan) and a "periphery" cluster of low-RWBC economies at a threshold level of RWBC at approximately 0.15. Observations are plotted along with fitted linear regression lines for the full sample (dashed line) and a sample comprising only "periphery" economies (solid line).

Panel A. Years 1990-2000.



Panel B. Year 2000.

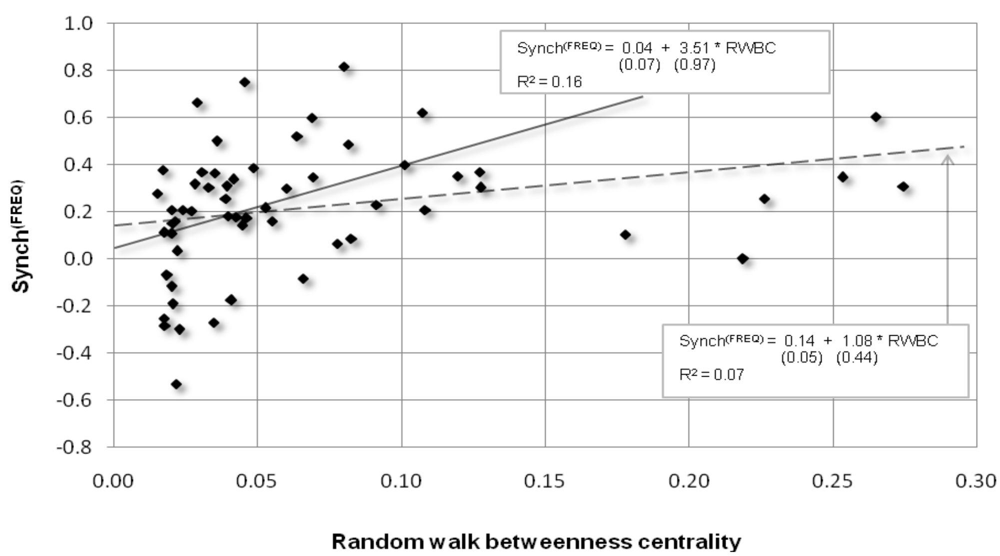


Table 1. Summary statistics for stock market synchronicity measures.

The table provides descriptive statistics for stock market synchronicity measures: $Synch^{(FREQ)}$, $Synch^{(R\text{-}SQ)}$ and $Synch^{(CORR)}$ for years 1990, 1995, 2000 and for the period 1990-2000. Summary statistics are presented in Panel A for the entire sample of countries and in Panel B for the restricted sample of countries (with the "core" economies excluded). Panels C and D list pairwise correlation coefficients between the alternative synchronicity measures for the full and the restricted samples.

Panel A. Full sample (58 countries).

Variable		Mean	Std. deviation	Min	Max	N. of obs.
$Synch^{(FREQ)}$	1990	0.2772	0.2918	-0.3848	0.8109	29
	1995	0.2202	0.2790	-0.6208	0.8277	43
	2000	0.2140	0.2694	-0.5333	0.8139	58
	1990-2000	0.2536	0.3091	-1.3558	1.1314	489
$Synch^{(R\text{-}SQ)}$	1990	-3.0913	3.0189	-12.8862	-0.4429	29
	1995	-3.5025	1.7113	-7.1333	-1.2538	43
	2000	-3.7404	2.1544	-12.5577	-1.0163	58
	1990-2000	-3.4653	2.5564	-21.2825	0.3630	489
$Synch^{(CORR)}$	1990	0.6570	0.4939	-0.3211	1.4675	29
	1995	0.4220	0.3447	-0.3281	1.0233	43
	2000	0.4084	0.3434	-0.2750	1.1404	58
	1990-2000	0.5230	0.4507	-0.4034	2.0307	489

Panel B. Restricted sample (52 economies, the core economies excluded).

Variable		Mean	Std. deviation	Min	Max	N. of obs.
$Synch^{(FREQ)}$	1990	0.2620	0.3106	-0.3848	0.8109	25
	1995	0.2222	0.2909	-0.6208	0.8277	37
	2000	0.2078	0.2765	-0.5333	0.8139	52
	1990-2000	0.2470	0.3209	-1.3558	1.1314	432
$Synch^{(R\text{-}SQ)}$	1990	-3.3303	3.1927	-12.8862	-0.4429	25
	1995	-3.5781	1.7964	-7.1333	-1.2538	37
	2000	-3.7867	2.2399	-12.5577	-1.0163	52
	1990-2000	-3.5690	2.6451	-21.2825	0.3630	432
$Synch^{(CORR)}$	1990	0.6220	0.5233	-0.3211	1.4675	25
	1995	0.4235	0.3515	-0.3281	1.0233	37
	2000	0.4128	0.3446	-0.2750	1.1404	52
	1990-2000	0.5110	0.4613	-0.4034	2.0307	432

Panel C. Pairwise correlations between stock market synchronicity measures (full sample).

	$Synch^{(FREQ)}$	$Synch^{(R\text{-}SQ)}$	$Synch^{(CORR)}$
$Synch^{(FREQ)}$	1		
$Synch^{(R\text{-}SQ)}$	0.6571	1	
$Synch^{(CORR)}$	0.7975	0.7812	1

Panel D. Pairwise correlations between stock market synchronicity measures (restricted sample).

	$Synch^{(FREQ)}$	$Synch^{(R\text{-}SQ)}$	$Synch^{(CORR)}$
$Synch^{(FREQ)}$	1		
$Synch^{(R\text{-}SQ)}$	0.6524	1	
$Synch^{(CORR)}$	0.7961	0.7739	1

Table 2. Summary statistics for explanatory variables of regression models.

The table provides descriptive statistics for explanatory variables used in the regression analysis (RWBC, stock market capitalization to GDP ratio, trade to GDP ratio), for years 1990, 1995, 2000 and the period of 1990-2000. Besides the variables listed in the table the following dummy variables are used in the analysis: financial center, fixed exchange rate regime, intermediate exchange rate regime. Summary statistics are presented in Panel A for the entire sample of countries and in Panel B for the restricted sample of countries, comprising only the "periphery" countries.

Panel A. Full sample (58 countries).

Variable		Mean	Std. deviation	Min	Max	N. of obs.
Random walk betweenness centrality	1990	0.0686	0.0801	0.0138	0.3614	58
	1995	0.0692	0.0744	0.0137	0.3305	58
	2000	0.0681	0.0656	0.0152	0.2743	58
	1990-2000	0.0682	0.0721	0.0137	0.3654	638
Stock market capitalization to GDP ratio	1990	0.3310	0.3432	0.0134	1.2259	44
	1995	0.4469	0.4868	0.0021	2.3847	54
	2000	0.6920	0.6588	0.0219	3.0344	58
	1990-2000	0.4735	0.4943	0.0002	3.0344	581
Trade to GDP ratio	1990	0.6576	0.3816	0.1499	1.8976	55
	1995	0.7138	0.3984	0.1603	2.0130	56
	2000	0.8277	0.5013	0.2052	2.7899	56
	1990-2000	0.7128	0.4132	0.1375	2.7899	612

Panel B. Restricted sample (52 countries, the core economies excluded).

Variable		Mean	Std. deviation	Min	Max	N. of obs.
Random walk betweenness centrality	1990	0.0460	0.0329	0.0138	0.1509	52
	1995	0.0480	0.0330	0.0137	0.1319	52
	2000	0.0487	0.0316	0.0152	0.1276	52
	1990-2000	0.0474	0.0318	0.0137	0.1509	572
Stock market capitalization to GDP ratio	1990	0.3041	0.3208	0.0134	1.2074	39
	1995	0.4482	0.4986	0.0021	2.3847	48
	2000	0.6632	0.6699	0.0219	3.0344	52
	1990-2000	0.4636	0.4994	0.0002	3.0344	517
Trade to GDP ratio	1990	0.6897	0.3909	0.1499	1.8976	49
	1995	0.7480	0.4064	0.1603	2.0130	50
	2000	0.8673	0.5144	0.2172	2.7899	50
	1990-2000	0.7475	0.4223	0.1375	2.7899	546

Table 3. Regression results for *Synch*$^{(FREQ)}$ (panel data 1990-2000).

Regressions of *Synch*$^{(FREQ)}$ on random walk betweenness centrality, stock market capitalization to GDP ratio, trade to GDP ratio, fixed exchange rate regime, intermediate exchange rate regime, financial center and the core economies dummy variables, and the interaction term between RWBC and the core economies dummy variable. The equations are estimated with the random effects model with robust standard errors. Regressions 1-4 consider the full sample of 58 countries not controlling for the core economies (Japan, the UK, Germany, France, Italy and China). Specifications 5 and 6 include additional control variables for the core economies. Regression 7 estimates the model with the core economies dropped from the sample. Standard errors are included in parentheses. *, **, *** denote statistical significance at the 1%, 5% and 10% levels.

Synch$^{(FREQ)}$	Full sample, not controlling for the core economies				Full sample, controlling for the core economies		Restricted sample (core economies are dropped)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Intercept	0.2096* (0.0498)	0.1791* (0.0504)	0.1240 (0.0770)	0.1486** (0.0730)	0.0250 (0.0770)	0.0280 (0.0765)	0.0299 (0.0765)
Random walk betweenness centrality	0.8539** (0.4629)	0.8400** (0.4307)	0.9300** (0.4665)	0.8725** (0.4425)	3.6923* (0.8340)	3.6720* (0.8281)	3.6094* (0.8235)
Stock market capitalization to GDP ratio	-	0.0816* (0.0285)	-	0.0718** (0.0305)	0.0497*** (0.0289)	0.0531** (0.0288)	0.0535*** (0.0310)
Trade to GDP ratio	-	-	0.1114*** (0.0674)	0.0458 (0.0669)	0.0507 (0.0690)	0.0488 (0.0686)	0.0420 (0.0688)
Fixed exchange rate regime	-0.0447 (0.0331)	-0.0513 (0.0333)	-0.0505 (0.0350)	-0.0545 (0.0350)	-0.0582 (0.0357)	-0.0615*** (0.0352)	-0.0441 (0.0386)
Intermediate exchange rate regime	-0.0381 (0.0335)	-0.0410 (0.0342)	-0.0414 (0.0350)	-0.0450 (0.0355)	-0.0424 (0.0349)	-0.0447 0.0349	-0.0497 (0.0358)
Financial center	-0.1078 (0.1578)	-0.1374 (0.1440)	-0.0903 (0.1576)	-0.1275 (0.1476)	0.1206 (0.1498)	-	-
Core economies	-	-	-	-	0.4265** (0.1922)	0.4202** (0.1937)	-
Random walk betweenness centrality * Core economies	-	-	-	-	-4.6485* (1.1247)	-4.3716* (1.0499)	-
Within R^2	*0.0016*	*0.0054*	*0.0075*	*0.0069*	*0.0302*	*0.0287*	*0.0214*
Between R^2	*0.0992*	*0.2124*	*0.1060*	*0.1969*	*0.2222*	*0.2231*	*0.2415*
Overall R^2	*0.0331*	*0.0662*	*0.0284*	*0.0542*	*0.0750*	*0.0751*	*0.0871*
Number of observations	*412*	*403*	*401*	*392*	*392*	*392*	*337*
Wald χ^2 *test statistic for the regression (P-values in parenthesis)*	*6.71* *(0.1518)*	*14.20* *(0.0144)*	*8.75* *(0.1196)*	*13.43* *(0.0367)*	*32.40* *(0.0001)*	*31.97* *(0.0000)*	*28.49* *(0.0000)*

Table 4. Regression results for *Synch*$^{(R\text{-}SQ)}$ (panel data 1990-2000).

Regressions of *Synch*$^{(R\text{-}SQ)}$ on random walk betweenness centrality, stock market capitalization to GDP ratio, trade to GDP ratio, fixed exchange rate regime, intermediate exchange rate regime, financial center and the core economies dummy variables, and the interaction term between RWBC and the core economies dummy variable. The equations are estimated with the random effects model with robust standard errors. Regressions 1-4 consider the full sample of 58 countries not controlling for the core economies (Japan, the UK, Germany, France, Italy and China). Specifications 5 and 6 include extra control variables for the core economies. Regression 7 estimates the model with the core economies dropped from the sample. Standard errors are included in parentheses. *, **, *** denote statistical significance at the 1%, 5% and 10% levels.

Synch$^{(R\text{-}SQ)}$	Full sample, not controlling for the core economies				Full sample, controlling for the core economies		Restricted sample (core economies are dropped)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Intercept	-3.8544* (0.3844)	-4.0874* (0.3931)	-4.7799* (0.6090)	-4.6907* (0.5799)	-5.3913* (0.6167)	-5.3551* (0.6115)	-5.2770* (0.5969)
Random walk betweenness centrality	8.8034* (3.0653)	8.1782* (2.7980)	9.7690* (3.0767)	9.1347* (2.8907)	26.0469* (6.3375)	25.7459* (6.2821)	24.7244* (6.0707)
Stock market capitalization to GDP ratio	-	0.6480* (0.2062)	-	0.4656** (0.2053)	0.3334*** (0.1934)	0.3704*** (0.1903)	0.4129** (0.2059)
Trade to GDP ratio	-	-	1.1659** (0.4781)	0.8366*** (0.4699)	0.8143*** (0.4613)	0.7929*** (0.4580)	0.6880 (0.4503)
Fixed exchange rate regime	-0.2654 (0.3119)	-0.2921 (0.3113)	-0.2846 (0.3250)	-0.2961 (0.3242)	-0.2446 (0.3266)	-0.2768 (0.3162)	-0.1593 (0.3525)
Intermediate exchange rate regime	-0.4932 (0.3144)	-0.5271*** (0.3183)	-0.4805 (0.3311)	-0.5153 (0.3338)	-0.4824 (0.3317)	-0.5081 (0.3292)	-0.5465 (0.3425)
Financial center	-0.8396 (0.8191)	-0.9348 (0.7564)	-0.6793 (0.8124)	-0.8140 (0.7793)	0.8124 (0.6996)	-	-
Core economies	-	-	-	-	0.0257 (1.5845)	-0.1910 (1.6123)	-
Random walk betweenness centrality * Core economies	-	-	-	-	-19.7839** (8.4616)	-17.1172** (8.5057)	-
Within R^2	*0.0085*	*0.055*	*0.0164*	*0.0114*	*0.0225*	*0.0209*	*0.0219*
Between R^2	*0.1159*	*0.2480*	*0.1578*	*0.2287*	*0.2930*	*0.2957*	*0.2818*
Overall R^2	*0.0494*	*0.0949*	*0.0642*	*0.0842*	*0.1063*	*0.1069*	*0.0953*
Number of observations	*412*	*403*	*401*	*392*	*392*	*392*	*337*
Wald χ^2 *test statistic for the regression (P-values in parenthesis)*	*13.88*	*21.26*	*19.31*	*22.10*	*34.5* *(0.0000)*	*32.5* *(0.0000)*	*30.19* *(0.0000)*

Table 5. Regression results for *Synch*$^{(FREQ)}$ *and Synch*$^{(R\text{-}SQ)}$, controlling for the core economies (year 2000).

Regressions of *Synch*$^{(FREQ)}$ *and Synch*$^{(R\text{-}SQ)}$ on random walk betweenness centrality, stock market capitalization to GDP ratio, trade to GDP ratio, fixed exchange rate regime, intermediate exchange rate regime, financial center and the core economies dummy variables, and the interaction term between RWBC and the core economies dummy variable. The equations are estimated with the linear regression model. Specifications 1, 2, 4 and 5 include the full sample of countries (58) and add control variables for the core economies (Japan, the UK, Germany, France, Italy and China). Regression 3 and 6 estimate the model with the core economies excluded from the sample. Standard errors are included in parentheses. *, **, *** denote statistical significance at the 1%, 5% and 10% levels.

	Synch$^{(FREQ)}$			*Synch*$^{(R\text{-}SQ)}$		
	Full sample		Restricted sample (the core economies are dropped)	Full sample		Restricted sample (the core economies are dropped)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Intercept	0.1332 (0.1160)	0.1328 (0.1143)	0.1285 (0.1144)	-5.3387* (1.0928)	-5.3257* (1.0759)	-5.3771* (1.0806)
Random walk betweenness centrality	2.8863* (0.9784)	2.8870* (0.9682)	2.8531* (0.9557)	25.7296* (6.9915)	25.7042* (6.8847)	25.5561* (6.8744)
Stock market capitalization to GDP ratio	0.1275* (0.0354)	0.1270* (0.0352)	0.1314* (0.0369)	0.8355* (0.2254)	0.8550* (0.2233)	0.8463* (0.2332)
Trade to GDP ratio	-0.1025 (0.0863)	-0.1025 (0.0853)	-0.0999 (0.0838)	-0.02375 (0.5822)	-0.0230 (0.5768)	-0.0044 (0.5721)
Fixed exchange rate regime	-0.0585 (0.0801)	-0.0573 (0.0750)	-0.0555 (0.0824)	-0.1859 (0.6353)	-0.2302 (0.5891)	-0.1431 (0.6566)
Intermediate exchange rate regime	-0.2300*** (0.1172)	-0.2293*** (0.1142)	-0.2293*** (0.1165)	-0.9377 (0.8737)	-0.9662 (0.8469)	-0.9162 (0.8717)
Financial center	-0.0143 (0.1198)	-	-	0.5462 (0.6537)	-	-
Core economies	-0.8326** (0.3843)	-0.8101** (0.3647)	-	-3.5850** (1.4863)	-4.4442* (1.5536)	-
Random walk betweenness centrality * Core economies	1.1182 (1.8896)	0.9923 (1.7591)	-	-5.9678 (9.5696)	-1.1507 (9.3123)	-
R^2	*0.3231*	*0.3231*	*0.3000*	*0.2757*	*0.2746*	*0.2551*
Number of observations	*53*	*53*	*47*	*53*	*53*	*47*
F statistic for the regression (P-values in parenthesis)	*4.49* *(0.0005)*	*5.23* *(0.0002)*	*5.60* *(0.0005)*	*7.72* *(0.0000)*	*7.87* *(0.0000)*	*5.89* *(0.0003)*

Table 6. Regression results for $Synch^{(CORR)}$, controlling for the core economies (panel data 1990-2000 and year 2000).

Regressions of $Synch^{(CORR)}$ on random walk betweenness centrality, stock market capitalization to GDP ratio, trade to GDP ratio, fixed exchange rate regime, intermediate exchange rate regime, financial center and the core economies dummy variables, and the interaction term between RWBC and the core economies dummy variable. The equations are estimated with the random effects model with robust standard errors. Regressions 1, 2, 4 and 5 include the full sample of 58 countries and add control variables for the core economies (Japan, the UK, Germany, France, Italy or China). Specifications 3 and 5 estimate the model with the core economies dropped from the sample. Standard errors are included in parentheses. *, **, *** denote statistical significance at the 1%, 5% and 10% levels.

	Panel data 1990-2000			Year 2000		
	Full sample		Restricted sample (the core economies are dropped)	Full sample		Restricted sample (the core economies are dropped)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Intercept	0.1868*** (0.1018)	0.1948*** (0.1009)	0.1952*** (0.1013)	0.2865** (0.1300)	0.2915** (0.1285)	0.2789** (0.1284)
Random walk betweenness centrality	6.1428* (1.2029)	6.0848* (1.1940)	5.9947* (1.1828)	4.3617* (1.2144)	4.3519* (1.1889)	4.3464* (1.1960)
Stock market capitalization to GDP ratio	-0.0261 (0.0390)	-0.0162 (0.0389)	-0.0121 (0.0410)	0.1475* (0.0441)	0.1551* (0.0448)	0.1471* (0.0449)
Trade to GDP ratio	0.1044 (0.0907)	0.0997 (0.0900)	0.0876 (0.0904)	-0.1099 (0.0894)	-0.1097 (0.0889)	-0.1053 (0.0869)
Fixed exchange rate regime	-0.0959 (0.0599)	-0.1057*** (0.0590)	-0.0786 (0.0639)	-0.1071 (0.1023)	-0.1242 (0.0959)	-0.0990 (0.1051)
Intermediate exchange rate regime	-0.0885 (0.0550)	-0.0951*** (0.0546)	-0.0955*** (0.0562)	-0.2608** (0.0999)	-0.2719* (0.0966)	-0.2560** (0.1002)
Financial center	0.2962 (0.2197)	-	-	0.2115 (0.1892)	-	-
Core economies	0.3208 (0.3099)	0.2859 (0.3106)	-	-0.8510 (0.6286)	-1.1837*** (0.6670)	-
Random walk betweenness centrality * Core economies	-6.4254* (1.7081)	-5.6629* (1.6110)	-	-0.9009 (2.9237)	0.9645 (2.9208)	-
Within R^2	*0.0332*	*0.0302*	*0.0301*	-	-	-
Between R^2	*0.2560*	*0.2222*	*0.2510*	-	-	-
Overall R^2	*0.0973*	*0.0750*	*0.0933*	*0.3681*	*0.3618*	*0.3322*
Number of observations	*392*	*392*	*337*	*53*	*53*	*47*
Wald χ^2 *(col. 1-3) / F statistic(col. 4-6)* *(P-values in parenthesis)*	*34.93* *(0.0000)*	*32.40* *(0.0001)*	*31.01* *(0.0000)*	*5.29* *(0.0001)*	*6.18* *(0.0000)*	*6.99* *(0.0001)*

Table 7. Countries and corresponding stock market indices used in the analysis.

N	Country	Stock market index	Bloomberg ticker
1	Argentina	The Argentina Merval Index	MERVAL
2	Australia	S&P/ASX 300	AS52
3	Austria	The Austrian Traded Index	ATX
4	Bangladesh	DSE General Index DGEN	DHAKA
5	Belgium	The BEL 20 Index	BEL20
6	Brazil	The Bovespa Index	IBOV
7	Canada	The S&P/Toronto Stock Exchange Composite Index	SPTSX
8	Chile	The IPSA Index	IPSA
9	China	The Shanghai Stock Exchange Composite Index	SHCOMP
10	Costa Rica	The BCT Corp Costa Rica Stock Market Index	BCT
11	Denmark	The OMX Copenhagen 20 index	KFX
12	Egypt	The Hermes Financial Index (HFI)	HERMES
13	Finland	The Helsinki Stock Exchange General Index	HEX
14	France	The CAC-40 Index	CAC
15	Germany	The German Stock Index	DAX
16	Greece	The Athens Stock Exchange General Index	ASE
17	Hungary	The Budapest Stock Exchange Index	BUX
18	Iceland	The OMX ICEX 15 Index	ICEXI
19	India	The S&P CNX Nifty	NIFTY
20	Indonesia	The Jakarta Stock Price Index	JCI
21	Ireland	The ISEQ Overall Index	ISEQ
22	Israel	Tel Aviv Stock Exchange	TA100
23	Italy	The Milan MIB Telematico Index	MIBTEL
24	Jamaica	Jamaica Stock Exchange (JSE) Market Index	JMSMX
25	Japan	The Nikkei-225 Stock Average	NKY
26	Kenya	Kenya Stock Exchange NS	KNSMIDX
27	Lebanon	The BLOM Stock Index	BLOM
28	Luxembourg	The Luxembourg LuxX Index	LUXXX
29	Malaysia	The Kuala Lumpur Stock Exchange Composite Index	KLCI
30	Malta	The Malta Stock Exchange (MSE) index	MALTEX
31	Mauritius	The SEMDEX Index	SEMDEX
32	Mexico	The Mexican Bolsa Index	MEXBOL
33	Morocco	Morocco CFG 25 Index CF	MCSI
34	Netherlands	The AEX-Index	AEX
35	New Zealand	The New Zealand Exchange Limited 10 index	NZSE10
36	Nigeria	The Nigerian Stock Exchange (NSE)	NGSEINDX
37	Norway	Oslo All-Share Index	OSEAX
38	Oman	The Muscat Securities Market Index	MSM30
39	Pakistan	The Karachi Stock Exchange KSE100 Index	KSE
40	Peru	The IGBVL Index	IGBVL
41	Phillippines	The Philippine Stock Exchange PSEi Index	PCOMP
42	Poland	Warsaw Stock Exchange WIG INDEX	WIG
43	Portugal	The PSI Geral (General) Index	BVLX
44	Qatar	The DSM 20 Index	DSM
45	Rep. of Korea	The Korea Composite Stock Price Index	KOSPI
46	Romania	Bucharest Exchange Trading Index (BET)	BET
47	Russia	The Russian Trading System Index	RTSI
48	Saudi Arabia	the Tadawul All Share Index	SASEIDX
49	Singapore	The Straits Times Index	STI
50	South Africa	The FTSE/JSE Africa All Shares Index	JALSH
51	Spain	The IBEX 35	IBEX
52	Sri Lanka	Sri Lanka Stock Market Colombo All-Share Index	CSEALL

53	Sweden	The OMX Stockholm Benchmark Index	SBX
54	Switzerland	The Swiss Market Index	SMI
55	Taiwan	the Taiwan Stock Exchange Index	TWSE
56	Thailand	The Stock Exchange of Thailand	SET
57	Tunisia	The Tunis Stock Exchange TUNINDEX	TUSISE
58	UK	The FTSE 350	NMX