

MEASURING EMERGING STOCK MARKET CORRELATIONS UTILIZING THE GRAVITY MODEL

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ABSTRACT

Gravity models have been employed in determining international trade patterns among countries. In these models, geographical and cultural variables are found to be crucial factors of economic relations. This particular study suggests that application of gravity modeling also is useful for the explanation of stock market correlations. This study uses panel data to examine the effect of geographical, cultural, market size and economic variables on the stock market correlations in emerging markets. Empirical analysis found that distance, market size and legal system similarities have a profound impact on stock market correlations. This knowledge is an important prerequisite for the risk reduction.

INTRODUCTION

Gravity models borrowed the idea from Newtonian Physics, where the attraction between two objects is positively related to their mass and negatively related to their distance. The gravity models have been effectively employed in modeling bilateral trading between countries since the 1960s. The use of gravity models in international trade can be found in Bergstrand (1985) and Feenstra, Markusen & Rose (2001). These baseline models explained bilateral trade flows using gross domestic products (GDP) and distance among countries. In recent years, other distance variables, such as common language and common borders, were added into the model. Rauch (2001) suggested that cultural ties were part of the network effect which influenced international economic relations. Gravity models have indicated that distance matters for trading in product markets. The initial motivation behind this research was to assess whether this similar movement

occurred in financial markets as well. The interrelationship between international stock markets is a major issue in international risk management. In particular, the paper will examine whether the stock market correlations in twenty emerging markets are affected by geocultural differences and economic variables over the period of 1995 to 2002.

REVIEW OF RELATED LITERATURE

In the past decade, a number of empirical and theoretical studies focused on the extent of stock market linkages and the reasons behind these linkages. Previous research has studied stock market correlations in terms of time varying properties of the correlations. Hamau, Masulis and Ng (1990) examined daily opening and closing prices of major stock indices of London, Tokyo and New York stock markets. They found that there were spillovers from New York to Tokyo, London to Tokyo, and New York to London for the pre-October 1987 period. Longin and Solnik (1995) constructed a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model to investigate the behavior of monthly international equity returns from 1960 to 1990. Their results suggest that the correlation between these returns was dynamically changing in their research. Karolyi and Stulz (1996) studied the United States and Japan's indices. They discovered evidence of changing correlations in the daily returns of these countries.

More recently, Bessler and Yang (2003) found a long-run relationship between nine stock market prices. They showed that only US financial markets had a significant impact on other markets. Time series models in general allow us to study long-run and short-run relationships. However, they do not identify what drives market co-movements. Several studies have examined factors that influenced market co-movements. For example, when explaining stock market co-movements, Roll (1992) proposed a Ricardian explanation based on country specialization. However, Heston and Rouwenhorst (1994) found that country specialization by industry could not explain stock market co-movements. They found that country effects due to monetary, fiscal, cultural differences were helpful to explain co-movements. Dumas, Harvey and Ruiz (2003) studied the extent to which stock return correlations were justified by changes in national outputs by using 12 Organization for Economic Co-operation and Development (OECD) countries. Bracker, Docking, and Koch (1999) highlighted the importance of the bilateral trade. By employing data from nine countries over the 22 year period, they argued that its macroeconomic and linguistic determinants affected the extent of stock market co-

movements over time. These studies mostly relied on industrialized countries' data since their stock market data were more readily available.

Physical distance is relatively less frequently applied in financial studies. Gravity modeling focuses on cross-sectional properties of the stock market correlations. The underlining forces influencing equity market correlations are psychological, financial (currencies & market sizes), and geocultural (distance & language) factors. Modeling the impact of distance on financial markets is a recent trend in the literature. Portes and Rey (2002) studied bilateral equity flows of fourteen countries in OECD from 1989 to 1996. In addition to using distance variable in the model, they included market capitalization, investor sophistication, volume of phone calls, proxies for insider trading, exchange rate stability dummy, and covariances between GDPs and growth rates. Their results were mixed. Distance had a negative effect on equity flows in 1989. The effect became positive in 1996. Wei (2000) used a gravity model to explain log bilateral FDI and bank lending. He found that the coefficients on distance were negative for both FDI and bank lending. Flavin, Harley, and Rousseou (2002) applied the gravity model to explain stock market correlations in twenty seven countries using only 1999 data. Their data set contains developed countries as well as developing countries. Their results suggest that distance matters in financial markets co-movements. Depending upon the research question, the main explanatory variables of the gravity models typically include the economic size of both countries, the distances between countries, size of population, common language and common border to name but a few.

HYPOTHESIS

Trading in financial markets is different from trading in product markets. The distance variable in goods trading is used as a proxy for transportation costs. In traditional gravity models of international trade, the literature has interpreted the distance coefficient as evidence of transportation costs. Buch, Kleirner, and Toubal (2003) and Frankel (1997) argued that the distance coefficient was an indicator of the relative importance of economic relationships between two countries. They claimed that distance costs were captured in the constant term rather than the coefficient of the distance variable. However, asset trading is weightless and therefore distance coefficients cannot approximate transportation costs. According to Portes and Rey (2002), the existence of geocultural distance creates information asymmetries between countries and affects the investment decision among them.

Locals will have information advantages compared to investors from distant countries. Coval and Moskowitz (1999) also offered the asymmetric-information-base explanations for international capital market segmentation. Informational asymmetries lead to less correlated markets. In sum, the distance coefficients can be interpreted as information costs. Thereby, stock market correlations are negatively related to distance in the model constructed in the following section.

Huberman (2001) found that the familiarity bias exists in portfolio diversification. Investors may have biases in their investment decisions. They generally prefer to invest in the companies they are more familiar with. Familiarity with destination countries plays an important role in portfolio choices. Tesar and Werner (1995) noted that geographic proximity was an important ingredient in portfolio allocation decisions. Therefore, language similarity and common border variables affect the stock market correlations.

Language variable is included as a proxy for cultural closeness. Common language brings a better understanding of the two markets. Investors pay close attention and tend to invest more in financial markets where they understand the language. Even though, some Latin American countries do not use the same language, their stock markets may be correlated because of their geographic proximity. However, this correlation is captured by a distance variable. The language familiarity variable is predicted to have a positive coefficient.

A border dummy also is included to capture the neighborhood effect on the stock market correlations. Similar to geographical distance, countries with a common border are expected to have higher correlations.

Furthermore, the larger the market capitalization (also known as market value), the more integrated the world economy would be due to better communications, better financial infrastructure and more well informed investors in other markets. Market capitalization of listed companies is the share price times the number of shares outstanding. Listed domestic companies are the domestically incorporated companies posted on the country's stock exchanges at the end of the year. Market size is a product of market capitalizations of two countries. As an indicator of financial integration, this variable is directly or positively related to the two countries' stock market correlations.

The gravity model classifies explanatory variables into "push" and "pull" factors. Push factors are distance variables and pull factor is market size. The above hypothesis leads to the following model specification. Bilateral stock market return correlations are inversely related to geographical distance but directly affected by language similarity, common border dummy, and the market size factors.

Three models are constructed due to availability of three different panel data. Each model consists of different number of observations.

MODEL 1

$$\text{CORR}_{ijt} = \beta_0 + \beta_1 \text{DISTANCE}_{ij} + \beta_2 \text{LANGUAGE}_{ij} + \beta_3 \text{BORDER}_{ij} + \beta_4 \text{SIZE}_{it} * \text{SIZE}_{jt} + \epsilon$$

where,

CORR_{ijt} are bilateral stock market return correlations or cross-market correlations in stock markets between country i and j in year t . It is then transformed into $z' = [\ln(1+r) - \ln(1-r)]$.

DISTANCE_{ij} is the geographical distance measured by the great circle between largest cities according to Fitzpatrick and Modlin (1986).

LANGUAGE_{ij} denotes the language similarity ranging from 0 (nobody speaks the same primary language in the two countries) to 10,000 (everybody speaks the same primary language. For further details, see Boisso and Ferrantino (1997).

BORDER_{ij} is the common border dummy. It is one if two countries have a common border.

$\text{SIZE}_{it} * \text{SIZE}_{jt}$ represents the financial market size between two countries. It is the multiplication of two countries' market capitalizations.

ϵ is a stochastic error or disturbance term.

MODEL 2

This study further investigates the impact of legal characteristics of the countries on the stock market correlations. Legal system similarities influence regulatory environments, corporate governance, the investment climates and might reduce contracting costs and information asymmetries. LaPorta, et al. (1998) indicated four major law families. The proximity of legal system dummy is added to capture the effect of similar legal system on stock market correlations according to LaPorta, et al. (1998). The second empirical model is specified below.

$$\text{CORR}_{ijt} = \beta_0 + \beta_1 \text{DISTANCE}_{ij} + \beta_2 \text{LANGUAGE}_{ij} + \beta_3 \text{BORDER}_{ij} + \beta_4 \text{SIZE}_{it} * \text{SIZE}_{jt} + \beta_5 \text{LEGAL SYSTEM}_{ij} + \epsilon$$

where:

LEGAL SYSTEM_{ij} is a dummy variable that takes the value of one if two countries' legal system originates from the same system, and zero otherwise.

The legal system and language variables are constructed to ensure relatively low correlation. Language variable is a continuous variable ranging from 0 to 10,000 as determined by Boisso and Ferrantino (1997) while the legal system is a dummy variable according to La Porta et al. (1998).

MODEL 3

Economics variables represent interdependence and interaction among countries. Economic linkages affect the stock market correlations. In general, economic integration should raise the degree of co-movements across national economies. Three economic variables are added to determine the effect on stock market return correlations in emerging market co-movements: (1) Bilateral trade is a direct link between equity market integration. It is expected to affect stock market return correlations positively. If two countries are isolated from each other with no trade, the stock market returns should be less correlated. (2) When the interest rate rises, the cost of capital will increase. Subsequently, equity investments and the prices of stock will fall. If the money markets in a pair of countries have a higher level of linkage, then their interest rates tend to move in the same direction causing higher correlation. (3) Inflation has a negative impact on the stock market returns. The third model with these additional three variables is presented below.

$$\begin{aligned} \text{CORR}_{ijt} = & \beta_0 + \beta_1 \text{DISTANCE}_{ij} + \beta_2 \text{LANGUAGE}_{ij} + \beta_3 \text{BORDER}_{ij} \\ & + \beta_4 \text{SIZE}_{it} * \text{SIZE}_{jt} + \beta_5 \text{LEGAL SYSTEM}_{ij} + \beta_6 \text{BTRADE} \\ & + \beta_7 \text{INTRATE}_{ij} + \beta_8 \text{INFRATE}_{ij} + \epsilon \end{aligned}$$

where:

BTRADE represents product of trade/GDP ratios.

INTRATE_{ij} is the annual correlation of percentage change in short term interest rates transformed into z'.

INFRATE_{ij} is the annual correlation of inflation rates transformed into z'.

DATA

The list of twenty countries under study is provided in Table 1. These markets are classified as emerging markets according to the classification criterion adopted by the World Bank's International Financial Corporation (IFC). The IFC definition includes those countries with income levels classified by the World Bank from low to middle income levels.

Table 1: Emerging Markets Under Study			
ASIA	LATIN AMERICA	AFRICA & MIDDLE EAST	EASTERN EUROPE
China	Argentina	Egypt	Hungary
India	Brazil	Israel	Poland
Indonesia	Chile	South Africa	Turkey
Korea	Mexico	Morocco	Greece
Malaysia	Peru		
Philippines			
Thailand			

The annual pair-wise correlations of emerging stock market returns in twenty countries were calculated from daily stock market returns for each year. All daily stock market data were taken from Standard & Poor (S&P)'s International Financial Corporation database. The target coverage of the S&P's Global index is about 65 to 75 percent of total market capitalization. Stocks were drawn in order of their liquidity. The daily Total Return Index (U.S. dollar denominated) was used to calculate annual stock market correlations between two countries. The daily stock index from twenty emerging markets for the period of eight years generated $(20 \times 19) / 2 = 190$ cross-country correlations (pair wise) each year.

Physical distance, language similarity and common border are a subset of the gravity model database of Boisso and Ferrantino (1997). These data are available at web page: <http://csf.colorado.edu/mail/itcp/2001/msg00005.html>. Data for land borders come from the Central Intelligence Agency (CIA) World Factbook. Market capitalization data in current U.S. dollars are from World Development Indicators (WDI) database, S&P's Emerging Stock Markets Fact Book and Supplemental S&P's data.

La Porta et al. (1998) classifies countries in their study into four categories according to their legal origin: English, French, German, and Scandinavian. The legal system variable is constructed using these classifications and the information from CIA World Factbook.

Monthly interest rate, inflation rate, and annual GDP data are from International Monetary Fund (IMF)'s International Financial Statistics (IFS) database. Bilateral trade data is obtained from IMF's Direction of Trade Statistics (DOTs) database.

METHODOLOGY

The generalized least square (GLS) method is employed to test the above hypotheses. The stock market correlations are used as dependent variable. Because correlation coefficients is bounded between 1 and -1 , this might cause bias in the estimates when it takes extreme values. Moreover, the sampling distribution of Pearson's correlation (r) was not normally distributed. Fisher (1915) developed a transformation now called "Fisher's z' transformation" that converts Pearson's r to the normally distributed variable z' . The formula for the transformation is: $z' = [\ln(1+r) - \ln(1-r)]$. This transformed variable, FISHER1, was employed as a dependent variable. Flavin, Hurley & Rousseau (2002); and Bayoumi, Fazio, Kumar & MacDonald (2003) also adopted a modified form of this transformation with the weight, 0.5. Thus, $z' = 0.5[\ln(1+r) - \ln(1-r)]$. This transformation, FISHER2, was also used as dependent variable. Only FISHER1 results are reported in Table 2 because regression results of transformed variables (FISHER1 and FISHER2) are virtually similar.

The pooled data was preformed so that the pooled series were restricted to have the same coefficient across all members of the panel data and with weighted least squares (Generalized Least Square method with equal weights).

The border length data were also collected. The preliminary regression testing suggests that the border length data are not significant. An alternative variable called "border dummy" was implemented instead in order to differentiate the impacts of countries with and without common border.

EMPIRICAL RESULTS

Table 2 presents strong regression results. The results are as expected for the physical distance variable (DISTANCE) in the regression equation (1) with

CORR, FISHER1 as dependent variables. The DISTANCE coefficients are significant at 1 percent level under CORR model and at 5 percent level for the FISHER1 specification. The signs are all negative, as predicted.

Table 2: Panel Regressions for Emerging Stock Market Correlations 1995-2002						
	CORR			FISHER1		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	0.273	0.215	-0.005	0.479*	0.362	0.192
	(1.3674)	(1.0685)	(-0.0242)	(1.7157)	(1.2927)	(0.6615)
Distance	-0.041***	-0.044***	-0.029*	-0.054**	-0.058***	-0.062***
	(-2.6410)	(-2.8023)	(-1.6656)	(-2.4150)	(-2.5819)	(-2.6248)
Language	0.003	0.001	0.006	0.004	0.001	0.004
	(0.5094)	(0.1303)	(0.9311)	(0.4372)	(0.0545)	(0.4253)
Border	0.042	0.009	-0.033	0.101	0.051	-0.008
	(0.6344)	(0.1503)	(-0.4231)	(1.00618)	(0.5093)	(-0.0713)
Market Size	0.021***	0.024***	0.029***	0.022**	0.027**	0.038***
	(2.7599)	(3.0419)	(3.4126)	(2.0306)	(2.4639)	(3.3615)
Legal System		0.080***	0.061**		0.126***	0.109***
		(3.3200)	(2.4165)		(3.7471)	(3.3147)
Bilateral Trade			0.000			0.000
			(1.4866)			(0.8297)
Interest Rate			-0.054			-0.014
			(-1.5372)			(-0.7455)
Inflation			-0.008			-0.002
			(-0.3769)			(-0.2766)
R-square	0.13	0.14	0.16	0.07	0.09	0.13
Adjusted R-square	0.12	0.13	0.15	0.07	0.08	0.13
F- Statistics	51.38	44.59	27.48	28.58	26.52	20.75
Number of observations	1,428	1,420	1,181	1,428	1,420	1,181
Note: The parentheses are t-values.						
*, **, and *** indicate the significant levels at 10, 5, and 1 percent, respectively.						

Both coefficient estimates of the language similarity and border dummy variables have expected positive signs but are not statistically significant.

The market size is positively related to the stock market correlations for all empirical specifications. The coefficient estimates are significant at 1 percent level for CORR model and at 5 percent level for FISHER1 model.

When the legal system dummy are added into model 2, the distance variable, and market size variables are still significant with correct signs. This suggests that controlling the legal environment does not take away the explanatory power of the physical distance and market size variables. The coefficient estimates of the legal system similarity are significant at 1 percent with positive sign. The legal system similarity is also an important factor in explaining equity market correlations. The third panel, consisting of additional economic variables, confirms model 2 results. Distance and legal variables still maintain a significant effect in explaining cross market correlations while all economic linkage variables are insignificant.

While these models provide strong significant levels on coefficient estimates of distance, market size and legal system variables, the coefficient of multiple determination (R^2 and adjusted R^2) ranges from 0.07 to 0.16. This indicated that the variations of distance, market size and legal system variables could explain 7 to 16 percent of variation in the bilateral stock market return correlations. The overall explanatory power of the model (R^2) is relative low compared to other articles that use the gravity model. Among other articles that employed the gravity model, Flavin, et al (2002) found the R^2 equaled 0.75 while other studies ranged from 0.35 to 0.60. Flavin, et al found high R^2 when they used only 1999 cross sectional data from 27 developed countries. However, it is rather common to obtain low explanatory power when emerging market panel data is employed as found in this paper. This may be due in part to the dispersion of the emerging market correlations throughout the sample. One year correlations between country-pairs seem to be stronger than multiple year correlations. Emerging markets are not strongly connected amongst themselves. For example, there are few financial institution connections between South Africa and South Korea compared to those in developed countries. The correlation between US and UK stock markets is high as markets are more integrated and more efficient.

Furthermore, including additional independent variables such as currency or industrial sector index as used by Flavin, et al (2002) may increase R^2 . It is beyond the scope of the gravity model in this paper which aims only at geographical, cultural and legal factors. Case in point, it may be less justifiable to

compare R^2 of various gravity models with different applications, specifications and focuses. The estimated coefficients in this paper should be stable and statistically acceptable when the model is properly specified and accepted econometric methods are employed in the analysis. Therefore, the benefits of this research extend beyond the low R^2 values typical of emerging market panel data.

DISCUSSION

There is evidence that physical distance does matter to the linkages between two emerging financial markets, even though some studies show that the impact of physical distance on the stock market correlations is not clear among the developed financial markets. Our results confirm the findings of Flavin, Hurley, and Rousseou (2002) and Portes and Rey (2002).

The language variable in all three models is found to be insignificant. The language similarity ranges from 0 (nobody speaks the same primary language in the two countries) to 10,000 (everybody speaks the same primary language). The spread of this data among those countries under study may be too “wide” in the sense that it generates the “bipolar” data measures. The data is skewed by the fact that it relies on either every one speaking the same language (10,000) or different languages (0). Due to the extreme data distribution, the log transformation was performed on this variable. However, it did little to improve the empirical estimations. The insignificance of a border dummy provided no further insight into whether the bordered countries have higher financial market linkages in emerging markets.

However, the significant market size variable indicates that larger and greater developed markets react to the news more rapidly with better financial connection. Market size variable can also be interpreted as a measure of financial integration between two countries. Thus, the results suggest that more integrated financial markets induce the stronger market co-movements.

The legal system of a country influences business and in turn financial markets. Equity markets bears imprints of legal characteristics of the countries they developed within. LaPorta et al. (1997) studied the influence of legal environment on capital markets across countries. Their results suggested that there were differences among countries with different legal origins in the size of their capital markets. The result confirms that legal system similarity has positive influence on cross market correlations.

Bilateral trade, interest and inflation rate correlations have expected sign but are not statistically significant. This might be due to the well documented significant influence of distance variable on bilateral trade.

CONTRIBUTIONS

This paper makes three contributions to the literature on gravity equation. First, the early literature estimated the gravity models with cross-sectional data. This research explored 1995-2002 panel data to determine the annual pair-wise correlations of emerging stock market returns. It covered a longer time horizon compared with only one year cross sectional data used by Flavin, Harley, and Rousseou (2002). Second, the paper focuses on twenty emerging stock markets. This is particularly important because of their relative isolation from developed capital markets. Bekaert and Harvey (1997) explained that emerging market equities had different characteristics than equities from developed capital markets. Third, it is evident from this research that the gravity model can be employed effectively in the financial market. The empirical results suggested that distance, market size, and legal system similarities play a significant role in emerging stock market co-movements.

PRACTICAL IMPLICATIONS

Does gravity play a role on the co-movements of financial markets in emerging economies? Answers to this question have implications for portfolio diversification and cross-market hedging of macroeconomic risks in the emerging markets. If the correlation between stock market returns is the key to international diversification decisions then its determinants also have implications for diversification. Most researches in stock market co-movements concentrate on equity market co-movements in industrialized countries rather than in emerging markets. Results in this paper suggest that distance is an important determinant of international financial activity among emerging markets. Increasing distance diminishes linkages among different financial markets. Early literature found evidence of the benefits from diversely investing in outside domestic markets. Investment in assets outside domestic markets provides risk reduction opportunities (Grubel 1968). Hence, from an investor's point of view, international diversifications among physically distant emerging markets may benefit investors.

The market size variable can be interpreted as a sign of financial integration. Financial integration induces stronger market co-movements. In retrospect, the results provide useful information about future vulnerabilities in emerging markets since, physical closeness, market size, and legal system variables are important linkages between stock market correlations among countries.

CONCLUSION

Much of the previous literature placed emphasis on estimation and forecasting of correlations among stock market indices over time. These researches mainly focused on equity market data of industrialized countries. Gravity models have been successfully adapted in modeling international trade patterns for product markets. This paper investigated whether the model performed as well in explaining financial market correlations in emerging markets. In the gravity model, distance variables or push factors, and market size or pull factors, play an important role. Therefore, this research explained stock market correlations by focusing essentially on gravity modeling variables such as physical distance, language, and market size. Furthermore, legal system similarity, trade linkages, interest rate change and inflation rate correlations were integrated into this gravity model to determine prevailing explanatory power of distance. The physical distance and market size variables were found to be significant among all variables. In addition, the legal system similarities as a sign of corporate work environment also had significant explanatory power across market correlations.

Further research might incorporate the exchange rate risk into the gravity model framework. It is imperative for international investors to recognize the importance of exchange rate risk and its intensity that affect stock market co-movements.

AUTHORS' NOTE

Note: The authors acknowledge financial support from the Purdue Research Foundation. The ideas expressed in this paper are solely of authors and do not reflect those of their affiliations.

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