THE DETERMINANTS OF CROSS-COUNTRY STOCK MARKET CORRELATION: A GRAVITY MODEL APPROACH

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ABSTRACT

The purpose of this thematic paper is to examine the determinants of cross-country stock market correlation by applying the gravity model. The geographical variables, geographical circular distance and overlapping opening hour, are the emphasis of this study. This current research follows the idea of Flavin, Hurley, & Rousseau (2002) to measure the significant determinants of cross-country correlation by applying the gravity model, which has been successfully used in explaining the pattern of goods trade. However, it makes some additional adjustments in some aspects of the model and data used and it expects that this would provide more accurate estimations and be more relevant to the recent world situation. The current research findings confirm the importance of Overlapping hour variable as the cross-country correlation significant determinant.

KEY WORDS: DETERMINANTS/ THE GRAVITY MODEL/ CORRELATION/ GREAT CIRCULAR DISTANCE/ OVERLAPPING OPENING HOUR

42 pages

ปัจจัยที่มีผลต่อความสัมพันธ์ของตลาดหุ้นระหว่างประเทศโดยการใช้แบบจำลองความโน้มน้าว
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บทคัดย่อ

สารนิพนธ์ฉบับนี้มีวัตถุประสงค์เพื่อพิจารณาปัจจัยที่มีผลต่อความสัมพันธ์ของตลาดหุ้นระหว่างประเทศโดยการใช้แบบจำลองความโน้มน้าว ตัวแปรทางภูมิศาสตร์ซึ่งประกอบด้วยระยะทางวงกลมทางภูมิศาสตร์ และชั่วโมงการเปิดทำการของตลาดหุ้นที่ทับซ้อนกัน คือส่วนสำคัญของการศึกษานี้ การศึกษานี้ได้ทำตาม แนวคิดของ Flavin, Hurley, & Rousseau (2002) ซึ่งได้นำแบบจำลองความโน้วน้าวที่ได้ประสบความสำเร็จในการอธิบายแบบแผนการค้าระหว่างประเทศมาประยุกษ์ใช้ในการประเมินปัจจัยที่มีความสำคัญต่อความสัมพันธ์ของตลาดหุ้นระหว่างประเทศ อย่างไรก้อตามสารนิพนธ์ฉบับนี้ได้ทำการปรับปรุงแก้ไขในส่วนของรูปแบบและข้อมูลที่ใช้ในการศึกษา เพื่อหวังว่าจะสามารถนำมาซึ่งผลการศึกษาที่ถูกต้องและเหมาะสมกับสถานการณ์โลกปัจจุบันได้มากกว่า ผลของการศึกษานี้ยืนยันว่า ชั่วโมงการเปิดทำการของตลาดหุ้นที่ทับซ้อนกันเป็นตัวแปรสำคัญที่กำหนดระดับความสัมพันธ์ของตลาดหุ้นระหว่างประเทศ

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CHAPTER I
INTRODUCTION

1.1 Background

Traditionally, the gravity model has been widely and popularly applied to the study of international trade. It has been successfully used in investigating and determining the relationship between geographical variables and dependent variables such as trade flows, price differentials, migration flows and foreign direct investment flows. Due to this success, the gravity model has recently been increasingly employed to study asset trade. Portes and Rey (1999) and Chintrakarn (2007) conducted a study of bilateral gross cross-border equity flows based on static and dynamic panel sets of data by applying the gravity model to assess the impacts of information asymmetries on the geographical distribution of international asset flows. Rather than study the flows, Flavin, Hurley, and Rousseau (2002; hereafter referred to as FHR) applied the gravity model to study the connection between markets as measured by correlation coefficients of stock market returns.

The research findings based on Portes and Rey (1999), Chintrakarn (2007), and FHR confirm that geography matters, not only in goods trade, but also in asset trade as the geographical variables, especially country distance infers information. Domestic investors due to information asymmetry reluctance to move funds abroad, and this implies a home bias effect, in which investors concentrate investments mostly in domestic and nearby stock markets. Moreover, the market contagion effect provides a significant explanation about the degree of connection between stock markets. This market contagion effect follows information asymmetry; investors tend to infer information from their closer markets to determine domestic stock price so it well-explains the typically strong correlation between nearby stock markets and vice versa.

FHR provides a substantial contribution to the study of asset trade. The first interesting aspect about this research is that it suspects geographical variables, especially country distance, contain a significant explanatory power in determining

stock market connections, hence, it applies the gravity model which successfully explains goods trade in this study and the result confirms the researchers' belief. Another interesting point of FHR is relating to the research's significance and benefits. As it focuses on the study of cross-country stock market correlation, which is considered important for international diversification, the research findings benefit investors as it provides important implications for international portfolio selection in lowering investors' exposure to investment risk. However, a few shortcomings such as a short period and outdated data, small sample size, and the ignorance of lag correlation found in FHR, mainly inspired the creation of this current research. This current research follows FHR to measure the significant determinants of cross-country correlation. However, it makes adjustments in the model and the data used and expects to provide a better estimation.

1.2 Significance of the research

The significance of this research lies in its remedy to the aforementioned few shortcomings found in FHR. The research findings based on outdated information seems to be irrelevant in explaining the current real world situation. In addition, by using a short period of data, the research findings cannot provide a meaningful analysis in detecting the movement or behavior of correlation coefficients between stock markets. The findings based on a small sample size may not be good enough to provide an accurate estimation. Lag correlation, which is suspected to contain a significant explanatory power on current period's correlation coefficient between markets; however, is ignored in the model of FHR resulting in the research being unable to provide a complete analysis of stock market correlations. To remedy these shortcomings, the current research follows the ideas of FHR, but makes adjustments in data and the model used. The longer periods and updated data are used in the analysis of cross-country stock market correlation. The larger sample size is included in the study. The research provides implications for economic integration and information asymmetry. Moreover, the current research, by incorporating lag correlation in the study, determines and evinces the significance of the explanatory power of lag correlation on the current period's correlation.

1.3 Research objective

To find correlation coefficients between a pair of stock markets and examine the relationship between cross-country stock market correlation coefficients and selected independent variables of which some are geographical in nature and some are more financial market related. The main emphasis of this research is to follow the study of FHR and to examine the significant explanatory power of the 2 important variables which are geographical distance, and overlapping opening hours. Based on the current research's findings, it is expected to confirm the findings of FHR relating to the importance of the overlapping hours factor and its significant explanatory power in determining the correlation coefficients over that of the distance variable. In addition, this current research also would provide for a discussion of and support an explanation of the market contagion effect, which is possibly the reason behind the importance of the overlapping hour variable in determining the cross-country stock market correlation.

1.4 Scope

This research is a study of the connection between stock markets as measured by the correlation coefficient by applying the gravity model in determining significant explanatory power of the selected geographical variables on the cross-country stock market correlation. A panel set of data of the 47 chosen stock markets' daily realized return is used in the analysis. The correlation coefficient for each pair of stock markets which is calculated from the daily realized return during the period 2002 – 2009 is regressed against the model's independent variables including Lag correlation, Great circular distance, Overlapping opening hours between stock markets, Market capitalization and the model's dummy variables, which are border, language, and currency in a multiple linear regression model. The research findings then suggest the importance of each independent variable mainly the distance and overlapping hour factors in determining cross-country stock market correlations. Moreover, the research provides a significant potential benefit for international portfolio selection, and supports an explanation of the market contagion effect and its role in determining the importance of the Overlapping Opening Hours factor on cross-country stock market correlation.

1.5 Benefit

The current research provides benefits to both investors and scholars, who are interested in the study of cross-country stock market correlation and its determinants. For investors, this study would assist them in developing a strategic portfolio of investment which allows a lowering of investment risk as a result of diversification. In this research, as a larger sample size and a longer period of time are included in the analysis, it is expected that it would provide more interesting findings and a better estimation over that provided by FHR. Not only would investors and interested researchers benefit from the fitted model presented in this research, but also the discussion about the important role of the market contagion effect is expected to provide them with insights and knowledge in understanding the reasons behind stock price co-movement. In addition, another benefit for interested researchers is that this current research aims to find supporting evidence about the importance of the overlapping hour variable in determining the degree of correlation between stock markets and as a result expect it to benefit further study.

CHAPTER II
LITERATURE REVIEW

As this current research focuses on the study of cross-country correlations by applying the gravity model, it is useful to conduct the literature review as it relates to the gravity model and its application to trade, correlation study, and the application of the gravity model to the study of cross-country correlations.

2.1 The Gravity model

Gravity by its meaning refers to a natural phenomenon by which objects with mass attract one another (see Appendix A). The model has been applied and used in different fields of social science, in particular, international economics. In an international trade, the gravity model of trade has been an empirical success in explaining the pattern of international trade; geographical variables mainly the distance between countries and market size have been applied in different areas such as trade flows, price differentials, migration flows and foreign direct investment. Bergstrand (1985), Feenstra et al. (1998), and Anderson and Wincoop (2001) emphasize the relevancy of geography towards the pattern of trade flows between countries. Geographical variables can be considered as physical geography related and psychological geography related. McCallum (1995) applies the gravity model in investigating and explaining the determinants of trade patterns in the Canadian region. The study is conducted about the impact of Canada-U.S. border on the regional trade flow by including also the study of trade blocs and its impact on the trade flow. After comparing the trade flow between province-province (trade flow between provinces in Canada) and province-state (trade flow between Canadian provinces and U.S. states), it is found that the inter-provincial trade is more dense than the intra-provincial trade, when size and distance are controlled. Finally, the result suggests that the national border in general continues to play a significant role in determining the flow of goods trade between the countries. Engel and Rogers (1996) employs the gravity model in

examining price differential between countries. Their finding is that distance between cities in U.S. and Canada is significantly important in explaining the differences in price of the same products in different cities.

Helliwell (1997) uses the model to explain the migration flow and its effect on trade. To follow the idea of McCallum (1995), this research applies the gravity model to study the migration flow of province-province (migration flow between provinces in Canada) and province-state (migration flow between Canadian provinces and U.S. states) and to determine the pattern of relationships with trade linkage intensity. The research concludes that there is no linkage between the pattern of the flow of migration among provinces and the difference in trade densities. On the other hand, there was found an association between the migration flow of province-state, and that this pattern of migration flow is found to help in the prediction of trade flows between Canadian provinces and U.S. states. Brenton et al. (1999) based research on the gravity model to evaluate the impact of the deepening integration between EU and the Central and Eastern Europe countries on FDI flows. One of the important conclusions based on this research is that the key determinant of the growth of FDI to the region is the pace of income growth and the success of government policies in stimulating business.

2.2 Correlation

Correlation or dependence, in statistics, is used to measure a statistical relationship between two or more random variables or observed values. It explains how two variables are linearly related, and also the strength of the relationship. In Modern Portfolio Theory, diversification in investing occurs by holding a collection of investments, which are negatively correlated and as a result form less volatile and less risky investment. Due to this importance, the study of correlation has become an interesting topic among researchers and investors. Grubel (1968) conducted a study about international portfolio diversification and concluded that it is the source of welfare gains by also stating the determinants of international equity flow between countries.

Karolyi et al. (1996) determined the fundamental factors that impact cross-country stock return correlation by investigating the co-movement of U.S and Japan

stock returns. The research also provides an explanation of global and competitive shocks for asset return, and their impact on the co-movement of U.S and Japan stock returns. Meanwhile, global shocks affects the value of all firms in a similar manner, competitive shocks affects the value of firms each country differently. As a result, global shocks induce a high correlation between U.S. and Japan stock markets, whereby competitive shocks result in a low correlation between the stock markets. The research concludes that a possible explanation for the correlation between markets is due to market contagion or contagion effects. Regardless of changes in the market fundamentals, such as macroeconomic variables, changes of stocks in one market induce changes in the stocks in another market due to contagion effects. King and Wadhwani (1990) concludes that the market contagion effect which occurs due to the mistake of rational agents in inferring information from one market to another is the reason behind the fall of many major world stock markets in 1987 and it is the market contagion effect which is evidence of the linkage between stock markets.

2.3 The Gravity model and application

Recently, the gravity model is not only important for the study of goods trade, but it has been increasing applied to the study of asset trade. Portes and Rey (1999), and Chintrakarn (2007) suggest that geographical distance is an important factor in determining a country's equity flow due to information asymmetry and home bias effect. Portes and Rey (1999) apply a gravity model that is found to be successful in explaining patterns of goods trade and conducted a study based on a panel set of data of the cross-border equity flow for 14 countries during the period 1989-1996. Gross transaction flow of equity trade is the model dependent variable and it is the function of mainly geographical distance and trading cost between countries and the country's market size. Meanwhile, distance is the proxy for information costs and asymmetry; other variables in the model are considered to have some impact on the efficiency of trading. The research conclusion is that the gravity model is useful in explaining international trade of financial assets as well as goods trade. Chintrakarn (2007) follows the idea of Portes and Rey (1999) however based on the dynamic panel set of data in conducting an analysis of the equity flow and its determinants.

FHR which is the motive for the creation of this current research applies the gravity model to study cross-country stock market correlations by incorporating knowledge in both finance and economics. FHR is considered as providing a substantial contribution to the study of correlation by innovatively introducing the overlapping hour factor in their study and it is found that it contains a significant explanatory power over the country distance factor in determining cross-country correlations. This is due to the fact that it captures important effects such as market contagion. Even though, it is simple to expect that a pair of country with a short distance away should have strong correlations and vice versa, however, their research evidence that "the more hours of common trading, the greater degree of stock price co-movement". It is due to the market contagion effects that create the importance of this factor over that of the country distance factor in determining cross-country correlations. Zhu L. and Yang J. (2004) apply the gravity model to study market contagion and its determinants. Based on the research findings, psychic distance variables which are composed of geographic distance, cultural distance, development level, and membership or neighborhood effects incorporated with trade and financial linkages determine the degree of market contagion which further explains cross-country correlation thus, countries having a high degree of trade and financial linkage, the effect of contagion is as high or the same as the market correlations.

CHAPTER III
METHODOLOGY

3.1 The Model

$$Corr_{ij,t} = \beta 0 + \beta 1 Corr_{ij,t-1} + \beta 2 ln(GCD)_{ij} + \beta 3 OLOH_{ij} + \beta 4 ln(size_i \cdot size)_t + \beta 5 border_{ij} + \beta 6 Lang_{ij} + \beta 7 currency_{ij,t} + u_{ij,t}$$

Terms definition:

$Corr_{ij,t}$	Correlation coefficient of return between stock market *i* and *j* at time t
$Corr_{ij,t-1}$	Correlation coefficient of return between stock market *i* and *j* at time t – 1
$(GCD)_{ij}$	Great circular distance between country *i* and *j*
$OLOH_{ij}$	Overlapping opening hours between stock market *i* and *j*
$size_i \cdot size_j$	Size of market capitalization for stock market *i* and *j*
$border_{ij}$	Sharing common border between stock market *i* and *j*
$Lang_{ij}$	Sharing common language between stock market *i* and *j*
$currency_{ij}$	Using common currency between stock market *i* and *j*
$u_{ij,t}$	Error term
t	Current period
t – 1	Previous period of time t

The multiple-linear regression is used as a tool to measure the relationship between cross-country stock market correlation and the selected independent variables. There are 3 types of variables in the model including: dependent variable, independent variable, and dummy variable.

This current research is based on the model used by FHR; however some aspects are modified so as to create a more suitable model to provide a better

estimation. The focus of this current research remains the study of cross-country stock market correlation's determinants. Similar to FHR, a pair of country stock market correlation coefficients is the model dependent variable. The annual correlation coefficient between a pair of stocks is calculated for each pair of stock market realized daily return of the period under concern. The modification occurs mainly at the independent variables selected in this current research. Meanwhile, Great Circular Distance (GCD), Overlapping Opening Hours (OLOH), Market capitalization, Border, Language, and Currency variables remain to be selected in this current research. The variables such as Industrial composition, Concentration, Law, and Colonial linkage are not presented in this current research. Based on the research's finding of FHR, those variables were not found to play a significant role in determining cross-country stock market correlation. Moreover, as this current research's main emphasis is to investigate the role of GCD and OLOH variables on cross-country stock market correlation, those variables are not found to have any significant relevancy.

Great Circular Distance (denoted by GCD) is the geographical distance between countries, which is constant over time. The geographical distance between each pair of countries is gathered for use in the analysis. In the study of goods trade, Great Circular Distance variables play a significant role in determining and explaining patterns of trade or trade flows between countries, as it normally infers transaction costs and ease of trade between a pair of countries. Portes & Rey (1999) and Chintrakarn (2007) confirm the importance of this variable in the study of asset trade. By applying this variable in the study of equity flow between countries, GCD is found as a significant determinant to the flow as it infers information asymmetry. As domestic and international investors have different abilities in gathering and accessing information, they are normally reluctant to move funds or to invest abroad, and concentrate investment in home and nearby markets. That is, the equity flow is negatively related to the distance between countries. In other words, this imply "The greater the distance between countries the lesser the flow" and vice versa. However, it is found that the important role of GCD is weaker, when considering cross-country stock market correlations. FHR conducted their study aimed at confirming the role of GCD in asset trade, and found that GCD is an insignificant factor in determining cross-country stock market correlations. Rather than considering only the distance

between countries, a country's time zone should be also considered relevant in determining co-movement of stock prices between countries. In this current research, a similar assumption is held about the role of GCD on cross-country stock market correlation, when considering common hours between stock markets.

Overlapping Opening Hours (denoted by OLOH) refers to the common trading hours between each pair of stock markets. One of the important contributions of FHR is their innovative way to introduce this variable in the study and to investigate its relevancy on cross-country stock market correlation. The finding of FHR was to present new knowledge to the study of cross-country stock market correlation. That is, rather than GCD, common trading hours between countries (which is the geographical distance proximity variable) play a significant role in determining the degree of cross-country correlation. FHR provide three possible explanations to support this finding. First, the simultaneous reaction of market participants in response to global news, which result in immediate price changes lead to a strong correlation between markets. Second, market contagion or herd behavior, which is the situation when investors or traders infer information of price changes in other markets and invest accordingly. Third, ease of conducting business or trading with active markets, which would reduce information asymmetry. In this current research, the focus will be on GCD and OLOH variables and
the researcher expects to confirm findings of those by FHR.

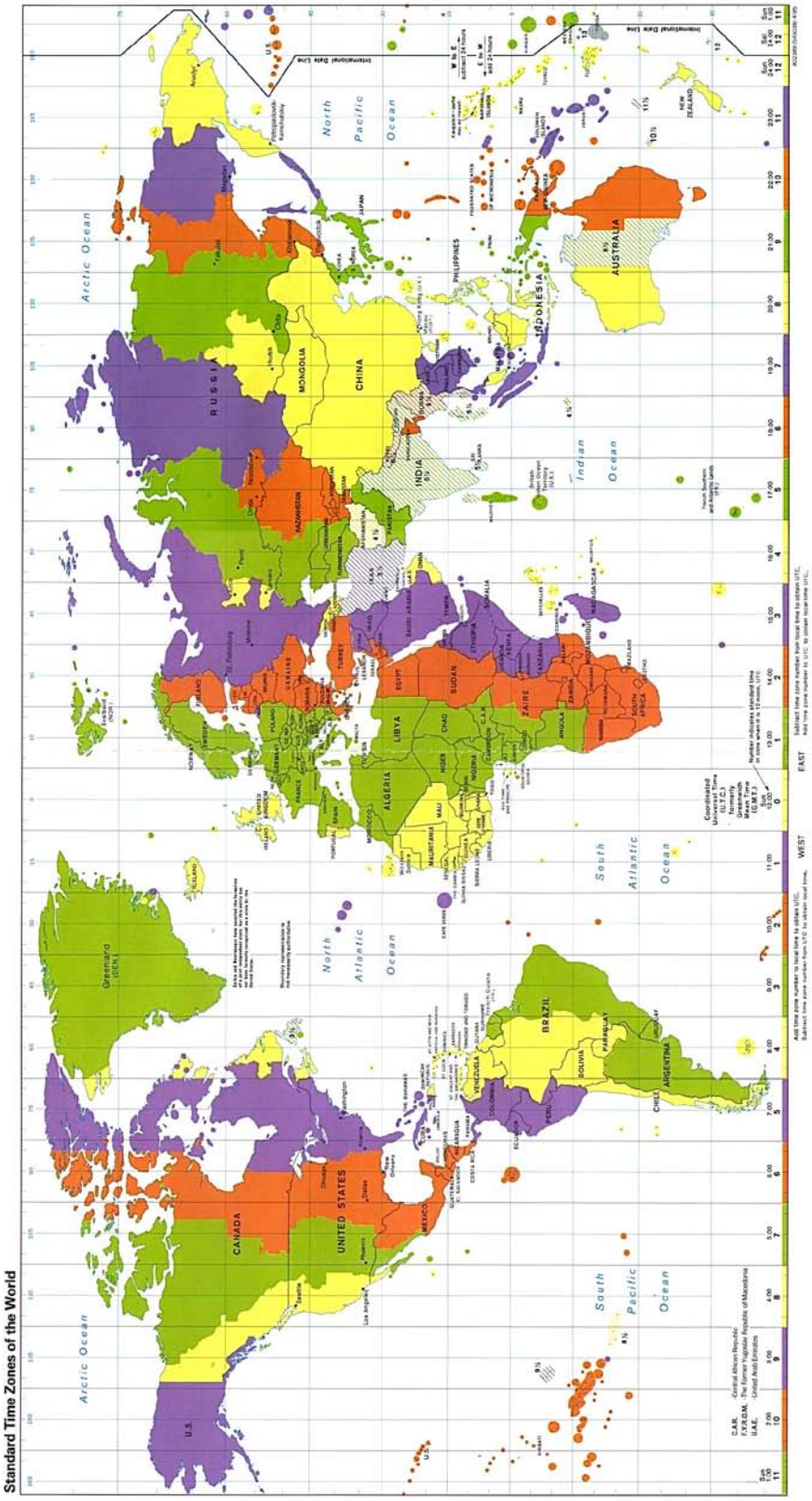

Figure 3.1 Standard Time Zones of the World Map

Source: (http://sydaby.eget.net/swe/pics/time_zones.jpg)

Figure 3.1 presents a World map indicating the World's Standard Time Zones. It shows the geographical location of all countries in the World by having vertical lines generally indicating the time zone separation. Different colors are used to differentiate each country and the relevant time zone. The coordinated Universal Time or U.T.C. (or practically referred to as Greenwich Mean Time or G.M.T) is the time in Greenwich, London. It is the world standard time based on International Atomic Time so as to compensate for the Earth's slowing rotation. Value 0 is indicated at a range of the vertical line of U.T.C. Moving to the east of the U.T.C, the number of hours increase by one, representing the local time of the countries located in that time zone. On the other hand, the number of hours decrease by one when moving west, representing the local time of the countries located in that time zone. For example, if it is 12.00 hours (noon) at U.T.C., the local time of the countries located in the time zones to the east of the U.T.C. is 13.00 hours, and onwards. However, the local time of the countries located in the time zone to the west of the U.T.C. is 11.00 hours, and onwards.

This World Standard Time Zone map provides important implications in some aspects, especially in that it implies the importance of geographical distance between countries and the overlapping hours of stock market trading to the cross-country stock market correlations. Considering 3 countries, with 2 pair 3 of stock markets, named countries A, B, and C, the geographical distance between country A and B is similar to the geographical distance between country A and C. The difference is that country A and B are far apart on the horizontal axis, meanwhile country A and C are far apart on the vertical axis but they are still located in the same time zone (vertical range). Based on a lot of researches, mainly King and Wadhwani (1990) and FHR, "Market contagion", where the timing of market participants' reactions to adjusting prices plays a significant role in determining cross-country stock correlation; the more common the trading hours between countries, the stronger the chance of market contagion or herd behavior in investment will occur. As this current research is conducted based on agreement with this idea, it is expected to reach a similar conclusion with regard to the explanation of the power of geographical distance, versus overlapping trading hours, on cross-country stock market correlations.

Market capitalization or Market value of stock markets is considered another important variable in the study of the determinants of cross-country stock market correlation. Market capitalization or market value in asset trade is equivalent to market size in the study of goods trade. Meanwhile, in the study of goods trade, market size normally refers to country GDP or the total numbers of a country's population. In the study of asset trade, market value is considered to be financially related in nature and more relevant in its application. Market value refers to the equity trading volume of each stock market. In this current research, as the analysis is based on daily realized return data, daily market value is collected and applied correspondingly. The importance of market value to the study of cross-country correlation is due to the fact that market value infers market liquidity. Also, as the magnitude of liquidity is on average positively related to market value, the larger market caps the stronger market liquidity. FHR also provide few possible explanations about the significance of market value in determining cross-country correlation. First, the larger markets are more liquid than the small markets. Meanwhile, there are more frequent price movements in the larger markets; the small markets react more slowly to relevant information, because some stocks are traded infrequently. Second, the larger markets, as they consist of more diversified industry, are more influenced by global common news than the smaller markets. Third, it is the large sample markets in the study that drive this result, especially the U.S. and Japanese stock markets, which hold approximately 60% of the world's portfolio.

Border refers to the geographical national border between countries. Similar to FHR, it is treated as a dummy variable in this study. A value of 1 is assigned to a pair of countries sharing a common border, and 0, otherwise. Even though, FHR concludes that, other than OLOH, border is another significant geographical variable that is found to contain explanatory power regarding cross-country stock market correlation (the countries that share common border move together). It seems FHR do not provide a sufficient explanation of the role of border in determining cross-country correlations. As a result, this current research expects to uncover some interesting findings based on the different sets of sample countries and periods as to whether they confirm or reject the findings presented by FHR.

Language refers to the official language used in each country. Similar to FHR, it is treated as a dummy variable in the study. A value of 1 is assigned to a pair of countries using the same official language and 0 otherwise. Based on the findings of FHR, Language is not found to be a significant determinant in cross-country correlations. The explanation based on FHR about the importance of this variable to the correlation is that investors are normally comfortable using English as the main language to communicate when trading. It is expected to find a similar conclusion in this current research as well.

Currency refers to the legal tender used in each country. Similar to FHR, this variable is treated as a dummy variable, other than Border and Language variables, in which the value of 1 is assigned to a pair of countries using the same legal tender, and 0 otherwise. The findings based on FHR are found to be consistent with other studies about the insignificance of currency variables on cross-country correlations. That is, currency risk is found to be more relevant to the study of bonds than equities due to long-term bond contractual relationships. Also, the currency risk is only considered as small portion of total equity risk. This current research also expects to reach similar findings.

The introduction of lag correlation variables in the model is considered an innovation offered by this current research. It is simple to expect that general stock prices exhibit some trend of movement and that is historical stock prices could benefit future stock price estimations or predictions. Moreover, based on various studies, historical price is used in future price forecasting. As a result, it is believed that lag correlation should play a significant role in determining cross-country stock market correlation. However, this factor is ignored in the study of FHR, so the introduction of this variable in the current study should be considered an important contribution to the correlation study.

Another innovation in this research is the introduction of an additional dummy variable which is the country dummy variable. Dummy country variable is added so as to control the impact of country-specific effects, which is a time invariant. In other words, the estimation given from the model is free from the effect of any particular situation or financial crisis that occurs in any of the sample countries.

All in all, the current research considers the model used by FHR a good model, however, after careful consideration, there are some weaknesses. After making necessary modifications to the model and introducing some additional more interesting variables, it is expected that the model used in this current research should be a more suitable model and thus provide a better estimation for cross-country stock market correlations.

3.2 Data

The data for the dependent variable, correlation coefficients between a pair of stock markets, are calculated based on the collected daily realized return of a sample group of national stock markets for 47 countries (see Appendix B) which give rise to 1,081 annual correlation coefficients. The daily stock price index in local currency for the 47 countries for the period during 2002 – 2009 are retrieved from DataStream and are converted to a panel set of daily realized return data for the computation of correlation coefficients. This research conducts the study based on local currency return correlations as it is uncontaminated by exchange rate movements. Thus, it will result in more accurate estimations when compared to the use of USD currency data. The data for independent variables are from DataStream, the CIA world fact book, and various websites. Information about market capitalization is retrieved from DataStream, meanwhile the information about geographical variables is gathered mainly from the CIA world fact book and the rest is from various websites.

CHAPTER IV
RESULTS AND DISCUSSION

4.1 Result and Discussion

In goods trade, geographical distance is found to be an important determinant of trade patterns between countries as it infers transportation cost and ease of trade. Similarly, Portes and Rey (1999), and Chintrakarn (2007) conclude that the distance factor also plays an important role in determining the flow of equity between countries due to information asymmetry and the home bias effect in investment. However, FHR concludes that unlike in goods trade or equity flow, the determinant of stock market connection is not as simple as geographical distance between countries, instead it is the overlapping hour variable which is the true determinants of cross-country stock market correlation. FHR explain the importance of the overlapping hour variable in relation to the study of cross-country correlation.

Given that there is a weak correlation between geographical distance and overlapping hour variables, without incorporating the overlapping hour factor in the model as it will lead to bias estimations. It is simple to expect that the countries that are far apart might operate in the same time zone; that is having more common trading hours, and vice versa. Based on the current research's sample of stock markets, even though the geographical distance between Russia and China is only about 1,739 miles, however they share zero common trading hours. Meanwhile, Chile and The United States of America (U.S.A.) is approximately 4,982 miles geographically far away from each other, but they share 7 common trading hours, which is considered relatively high.

Based on this information, the explanatory power of GCD and OLOH on cross-country correlations has come to the author's attention; as a result it is considered the main emphasis of this current research. Corresponding to FHR, this research's hypothesis is that OLOH plays a more significant role over GCD in determining the cross-country correlation. As evidence of this, OLOH is first ignored

from the model in the first regression run and is then included in the second regression run. Based on the given result, the estimate and t-statistic of GCD based on the first run and the second run are compared and analyzed. The purpose is to observe the changes in coefficient estimates and t-statistic of GCD before and after the introduction of the OLOH variable. The result suggests that similar to the findings of FHR, OLOH is found to contain a significant explanatory power over GCD, the geographical distance between stock markets. Based on the result shown in Table 4.1, in almost every year from 2003 – 2009, coefficient estimates of GCD are lower in number, after the introduction of OLOH in the model and a re-run of the regression.

Comparing the coefficient estimate based on the analysis of the annual correlation coefficient in 2005, the estimate is lower from -0.019 to -0.002 when including OLOH in the model. Similarly to the t-statistic, it is reduced from -4.55 to -0.31. This infers that GCD is clearly a significant determinant of cross-country correlation when OLOH is ignored; however, it becomes an insignificant determinant after the introduction of OLOH. This hidden information is that OLOH is the true determinant factor of the correlation. The research result strongly confirms that considering geographical distance between stock markets alone is not enough to provide an accurate estimation of cross-country stock market correlation. The shorter distance between stock markets does not always infer a strong correlation and vice versa. On the other hand, the higher the number of common trading hours between stock markets, the stronger the correlation between stock markets and vice versa. The current research, by including OLOH, suggest the true explanatory power of GCD and introducing, also the true determinant of cross-country correlation, leads to a better and more accurate estimation.

Table 4.1 Coefficient estimates and t-statistic of Great Circular Distance (GCD) versus Overlapping Opening Hour (OLOH) variables

Panel A presents the coefficient estimates and t-statistic of GCD variables when excluding OLOH in the model. Panel B presents the coefficient estimates and t-statistic of GCD variable, when OLOH is introduced in the model and the coefficient estimate and t-statistic of OLOH variables.

Panel A							
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
GCD							
Estimate excl. OLOH	-0.008	-0.020	-0.019	-0.037	-0.023	-0.027	-0.024
t-statistic excl. OLOH	-1.99	-5.13	-4.55	-7.51	-5.98	-7.79	-5.98
Panel B							
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
GCD							
Estimate incl. OLOH	-0.006	-0.015	-0.002	0.017	0.002	-0.013	0.008
t-statistic incl. OLOH	-1.01	-2.62	-0.31	2.74	0.47	-2.92	1.43
OLOH							
Estimate	0.001	0.002	0.007	0.023	0.012	0.007	0.017
t-statistic	0.66	1.50	4.52	13.02	7.16	4.68	8.78

Figure 4.1 clearly shows that the coefficient estimate of GCD is getting weaker in almost every year during 2003-2009 when OLOH is added to the model. As expected, the negative sign of estimates implies that the farther the distance between countries, the correlation gets weaker and vice versa. However, after observing the variable's t-statistic as presented by Figure 4.2, it identifies that the variable is somehow not a significant determinant of the cross-country correlation, after OLOH variable is included. Based on this information, it is evidence that the number of common trading hours is instead the true determinant of the correlation.

Figure 4.1 Coefficient estimate of GCD variable for the period during 2002 – 2009

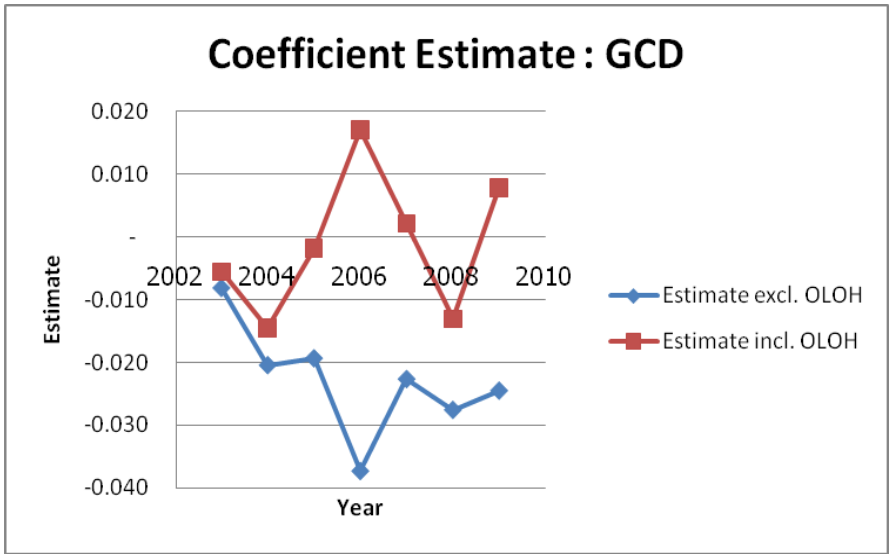

Figure 4.1 Compares the estimated coefficient of GCD when OLOH is (and not) included in the model. Overall, GCD is found to have a decreasing role in its estimate when OLOH is introduced in the model.

Figure 4.2 t-statistic of GCD variable for the period during 2002 - 2009

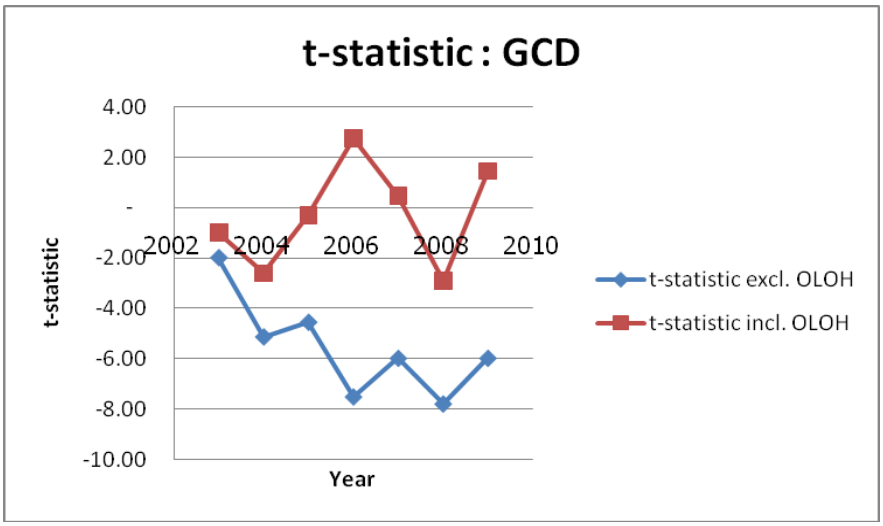

Figure 4.2 Compares the t-statistic of GCD variables, when OLOH is (and not) included in the model. Overall, GCD is not found to contain an explanatory power on cross-country correlation, when OLOH is introduced in the model.

The research results suggest interesting findings about the other geographical variables applied in the model and also provide important implications in

various other aspects. Based on this current research results, the findings about some variables are found to be similar to those found in FHR; however, others are found to be different. Their estimates and t-statistic are presented in Table 4.2.

Similarly to FHR, a common currency is found an insignificant explanatory variable on cross-country stock market correlation. As mentioned in FHR, currency risk basically accounts for only a small proportion of total investment risk. Common language is also found to insignificantly impact cross-country correlation. In the transmission of market contagion which determines the correlation between stock markets, investors are normally based on the observed price as the source of information. They refer to the price observed from other stock markets and react in creating any price changes in their own markets in which language is not importantly required.

Border and Market capitalization variables by following FHR, are considered important geographical variables that are expected to containing a certain degree of importance in determining cross-country correlation. However, the research findings based on FHR and this current research found otherwise. Border is closely related to GCD and OLOH variables. It refers to a common physical border between each pair of countries. When countries share a border, the neighborhood effect is expected to occur as a result of trade and financial linkage between countries which represent a channel of any market contagion transmission. In FHR, it is found that the variable is the cross-country correlation's significant explanatory variable, however, it was found as an insignificant factor, based on this current research's findings. An in-depth analysis based on the panel set of raw data used in this research provides 2 possible supporting reasons: 1. from 1,081 pairs of countries, there are 682 pairs of countries that are not found to have common border, but have overlapping hours in their trading markets (see Appendix C). When OLOH is found to be more relevant and closely related to market contagion effect, the role of neighborhood effect seems to be weaker. 2. The current research, due to the modification in the model and data aspects by introducing interesting variables, namely lag correlation and dummy country variables, and using different panel sets of data, with a larger sample size, provides a better estimation compared to FHR.

Market capitalization is considered another important variable in the estimation of the correlations. In collecting data for stock market values, daily market value of each stock market is first retrieved from DataStream, and then converted to an average annual market value. The average numbers of each country are then multiplied so as to infer the magnitude of the pair of stock markets. Unlike FHR findings, the market capitalization variable is not found to be a significant determinant of cross-country stock market correlation in this current research. The model's modification and the different panel sets of data, with a larger sample size applied and used in this current research, could be a possible explanation of the result. In FHR, the selected 27 stock markets are considered the world's most important stock markets and represent more than 98% of the world's market capitalization. FHR focuses on a set of samples which exhibit less variation; hence the given estimations may not be accurate. Compared to this current research in which the set of sample presents more variations; that is the selected 47 stock markets exhibited more variation. Another important possible explanation to support this result is that the dummy country variable, which is introduced in the current research's model, captures a specific effect which possibly impacts the significant explanatory power of the market capitalization variable on cross-country stock market correlation.

An interesting aspect of this research is the introduction of lag correlation and which is treated as an important variable in determining cross-country correlation. Based on various researches, historical prices are normally used as the basis for the prediction of future stock prices (referred to as "Time series method of forecasting - Rolling forecasting technique"). The research's results are evidence that there is a significant relationship between the previous and current period's correlations.

Table 4.2 Coefficient estimates and t-statistic of each independent variable for the period during 2003 to 2009

This table presents Coefficient estimates and t-statistic of each independent variable for the period during 2003 to 2009.

Year		2003	2004	2005	2006	2007	2008	2009
_cons								
Estimate incl. OLOH	*β0*	(0.615)	0.062	(0.398)	(1.110)	(0.283)	0.340	0.124
t-statistic incl. OLOH		- 4.64	0.61	- 1.94	- 4.24	- 2.59	1.42	1.59
lagcorr								
Estimate incl. OLOH	*β1*	0.741	0.593	0.631	0.760	0.629	0.673	0.756
t-statistic incl. OLOH		31.80	24.85	24.79	25.80	29.30	30.65	29.10
ldist								
Estimate incl. OLOH	*β2*	(0.006)	(0.015)	(0.002)	0.017	0.002	(0.013)	0.008
t-statistic incl. OLOH		- 1.01	- 2.62	- 0.31	2.74	0.47	- 2.92	1.43
overlap								
Estimate incl. OLOH	*β3*	0.001	0.002	0.007	0.023	0.012	0.007	0.017
t-statistic incl. OLOH		0.66	1.50	4.52	13.02	7.16	4.68	8.78
lnmkt								
Estimate incl. OLOH	*β4*	0.036	0.001	0.018	0.038	0.015	(0.003)	(0.006)
t-statistic incl. OLOH		7.19	0.25	2.48	4.08	3.58	- 0.37	- 2.36
border								
Estimate incl. OLOH	*β5*	0.020	0.018	0.042	(0.018)	0.017	(0.014)	0.022
t-statistic incl. OLOH		1.41	1.18	2.94	- 1.12	1.30	- 1.54	1.91
comlang								
Estimate incl. OLOH	*β6*	(0.004)	0.001	0.002	(0.006)	0.013	(0.002)	(0.006)
t-statistic incl. OLOH		- 0.47	0.06	0.17	- 0.51	1.39	- 0.24	- 0.68
comcurr								
Estimate incl. OLOH	*β7*	0.022	0.056	0.040	0.008	0.016	0.021	(0.013)
t-statistic incl. OLOH		1.84	4.69	3.46	0.59	1.90	2.42	- 1.39

4.2 Market Contagion Effect

The study of market contagion effect has become an interesting topic among financial researchers, especially after the recent occurrence of major financial crises in most of the world's countries or regions. Based on the research of Zhu L. and Yang J. (2004), market contagion effect can be distinguished into 2 main types including "fundamentals-based contagion" and "true contagion" or "pure contagion." Only true contagion is relevant to this current research, as it explains the degree of relationship between the overlapping hour variables and cross-country stock market correlation. Zhu L. and Yang J. (2004) stated that "true contagion – a cross market herd behavior in the format of speculation, mimic, or rush for exit, that is not related to a country's macroeconomic fundamentals, but due to changes in expectations based on incomplete information or in psychological perceptions."

King and Wadhwani (1990) conclude that the transmission of the market contagion effect occurs as market participants, due to a lack of information, attempt to infer information from other markets through the observed price and it is the channel through which a mistake from one market is transferred to another market and resulted in the fall of major stock markets in 1987. In addition, King and Wadhwani (1990) also found evidence that the market contagion effect is even supported by time zone trading. FHR also confirm this finding by indicating that the number of common trading hours is in a positive direction with the transmission of the market contagion effect. This corresponds with the current research findings that for cross-country correlations, it is not the geographical distance which is the relevant factor but instead the number of common trading hours between countries.

CHAPTER V
CONCLUSION

International asset allocation (portfolio selection) and the diversification effect are the driving forces behind the importance of cross-country stock market correlation studies. It has become an interesting topic, not only among investors, but also financial researchers. However, no research is found to provide a clear explanation of the reasons behind correlations between international stock markets. Unlike investing in domestic markets, international investors are basically exposed to additional investment risks, such as exchange rate risk and an inability in gathering and accessing information about other markets. King and Wadhwani (1990) conclude that the market contagion effect explains the situation of the uniform fall of major world stock markets in 1987 and that the common trading hours between stock markets influence the degree of the effect.

Zhu L. & Yang J. (2004) applies the gravity model to study market contagion and its determinants. The *true contagion* which results in herd behavior is not related to a country's *macroeconomic fundamentals*; however it is due to the change in expectations based on incomplete information or in psychological perceptions. The research results evidence that trade and financial linkages determine the degree of market contagion effect and its transmission between countries. It is simple to expect that the countries that have a strong trade and financial linkages tend to be more affected by the effect and have strong correlation. This is due to the fact that between countries having more common trading hours there tends to be a significant degree of trade and financial linkages.

The research of FHR, which is the motive for the creation of this current research, concludes that rather than the geographical distance factor (GCD), the overlapping hour factor (OLOH) is the cross-country correlation's significant determinant. Similar to this current research, the research results evidence the importance of this factor and confirm the research conclusions of FHR. The strength

of the research of FHR is their introduction of OLOH variable in the study of cross-country correlations. Due to differences in the nature of goods and financial trade, the geographical factor alone is not enough to explain the correlation, even though it works well in explaining cross-country trading patterns. After the introduction of OLOH factor in the model, the country distance explanatory power drops significantly as it is not a true cross-country correlation determinant. This current research follows the research of FHR. However, it makes some additional adjustments in some aspects of the model and data used and it expects that it would provide more accurate estimations and be more relevant to the recent world situation.

The current research findings confirm the importance of OLOH as the cross-country correlation significant determinant. By making use of the different set of stock market samples and the data of other periods or considering the study of cross-country correlations by focusing on a specific region or zone countries' data and investigating the impact of the other important geographical variables, such as a common currency, this could be a subject for further research.

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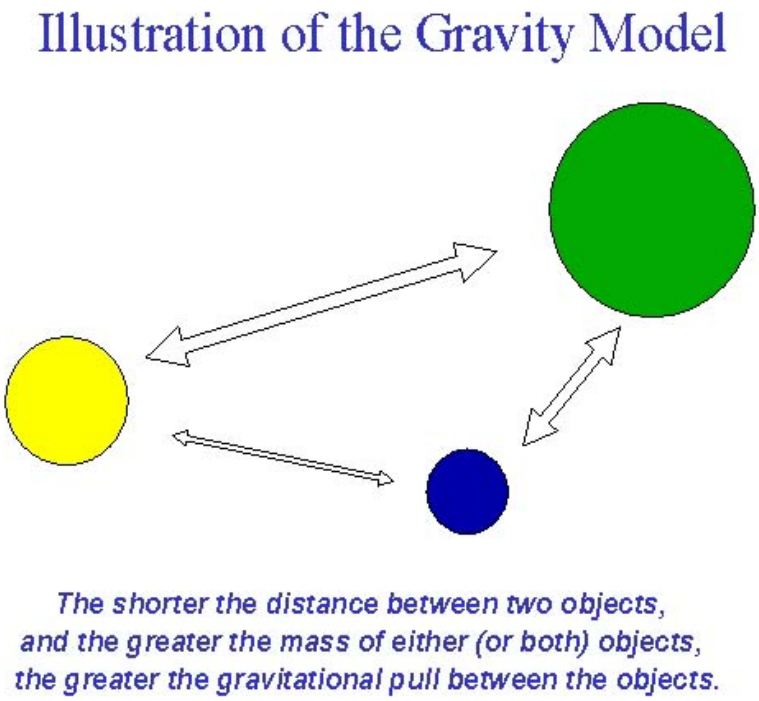
APPENDICES

APPENDIX A

THE GRAVITY MODEL



Source: (http://www.rri.wvu.edu/WebBook/Goetz/img002.JPG)

APPENDIX B

LIST OF SAMPLE COUNTRY AND STOCK INDEX

The 47 chosen national stock markets and indices are listed below:

No.	Country	Index	Index reference
1	ARGENTINA	WIAGGTL(PI)	FTSE ARGENTINA - PRICE INDEX
2	AUSTRALIA	ASX300I(PI)	S&P/ASX 300 - PRICE INDEX
3	AUSTRIA	TOTMKOE(PI)	AUSTRIA-DS Market - PRICE INDEX
4	BELGIUM	WIBELGL(PI)	FTSE BELGIUM/LUX - PRICE INDEX
5	BRAZIL	TOTMKBR(PI)	BRAZIL-DS Market - PRICE INDEX
6	BULGARIA	BSSOFIX(PI)	BSE SOFIX - PRICE INDEX
7	CHILE	WICHILL(PI)	FTSE CHILE - PRICE INDEX
8	CHINA	CHSASHR(PI)	SHANGHAI SE A SHARE - PRICE INDEX
9	COLUMBIA	TOTMKCB(PI)	COLOMBIA-DS Market - PRICE INDEX
10	CYPRUS	TOTMKCP(PI)	CYPRUS-DS Market - PRICE INDEX
11	CZECH	WICZCHL(PI)	FTSE C. REPUBLIC - PRICE INDEX
12	EGYPT	EGHFINC(PI)	EGYPT HERMES FINANCIAL - PRICE INDEX
13	FRANCE	FRCAC40(PI)	FRANCE CAC 40 - PRICE INDEX
14	GERMANY	WIWGRME(PI)	FTSE GERMANY E - PRICE INDEX
15	FINLAND	WIFINDE(PI)	FTSE FINLAND E - PRICE INDEX
16	GREECE	TOTMKGR(PI)	GREECE-DS Market - PRICE INDEX
17	HONG KONG	TOTMKHK(PI)	HONG KONG-DS Market - PRICE INDEX
18	HUNGARY	TOTXTHN(PI)	HUNGARY-DS DS-MARKET EX TMT - PRICE INDEX
19	INDIA	WIIDIAL(PI)	FTSE INDIA - PRICE INDEX
20	INDONESIA	TOTMKID(PI)	INDONESIA-DS Market - PRICE INDEX
21	IRELAND	ISEQUIT(PI)	IRELAND SE OVERALL (ISEQ) - PRICE INDEX
22	ISRAEL	ISTA100(PI)	ISRAEL TA 100 - PRICE INDEX
23	ITALY	WIITALL(PI)	FTSE ITALY - PRICE INDEX
24	JAPAN	JAPDOWA(PI)	NIKKEI 225 STOCK AVERAGE - PRICE INDEX
25	KOREA	KORCOMP(PI)	KOREA SE COMPOSITE (KOSPI) - PRICE INDEX
26	MALAYSIA	WIMALYL(PI)	FTSE MALAYSIA - PRICE INDEX
27	MEXICO	TOTMKMX(PI)	MEXICO-DS Market - PRICE INDEX
28	MOROCCO	WIMORCL(PI)	FTSE W MOROCCO - PRICE INDEX
29	NETHERLANDS	WINETHE(PI)	FTSE W NETHERLANDS E - PRICE INDEX
30	NEW ZEALAND	WINZEAL(PI)	FTSE W NEW ZEALAND - PRICE INDEX
31	PERU	WIPERUL(PI)	FTSE W PERU - PRICE INDEX
32	NORWAY	WINWAYL(PI)	FTSE W NORWAY - PRICE INDEX
33	PAKISTAN	WIPAKIL(PI)	FTSE W PAKISTAN - PRICE INDEX
34	PHILIPPINES	WIPHILL(PI)	FTSE W PHILIPPINES - PRICE INDEX
35	POLAND	WIPLNDE(PI)	FTSE W POLAND E - PRICE INDEX
36	PORTUGAL	WIPORTL(PI)	FTSE W PORTUGAL - PRICE INDEX
37	ROMANIA	RMBETRL(PI)	ROMANIA BET (L) - PRICE INDEX
38	RUSSIA	TOTXTRS(PI)	RUSSIA-DS DS-MARKET EX TMT - PRICE INDEX
39	SINGAPORE	WISNGPL(PI)	FTSE W SINGAPORE - PRICE INDEX
40	AFRICA	TOTXTSA(PI)	SOUTH AFRICA-DS DS-MARKET EX TMT - PRICE INDEX
41	SPAIN	TOTXTES(PI)	SPAIN-DS DS-MARKET EX TMT - PRICE INDEX
42	SWEDEN	WISWDNL(PI)	FTSE W SWEDEN - PRICE INDEX
43	SWITZERLAND	WISWITL(PI)	FTSE SWITZERLAND - PRICE INDEX
44	TAIWAN	WITAIWL(PI)	FTSE W TAIWAN - PRICE INDEX
45	THAILAND	WITHAIL(PI)	FTSE W THAILAND - PRICE INDEX
46	UK	FTALLSH(PI)	FTSE ALL SHARE - PRICE INDEX
47	USA	WIUSAME(PI)	FTSE W UNITED STATES E - PRICE INDEX

APPENDIX C

SHARING COMMON TRADING HOUR VERSUS SHARING COMMON BORDER

This table presents the total number of pair of country sharing common country border and / or sharing common stock markets trading hours which can be divided into 4 groups with below explanation:

1. **Both sharing common trading hours and sharing common border:** there is 43 pair of countries both sharing common trading hours, and sharing common border
2. **Sharing common trading hours, but not sharing common border:** there is 682 pair of countries sharing common trading hours, but not sharing common border.
3. **Sharing common border, but not sharing common trading hours:** there is 1 pair of countries sharing common border, but not sharing common trading hours.
4. **Neither sharing common trading hours nor sharing common border:** there is 355 pair of countries sharing common border, but not sharing common trading hours.

Total Sample national stock indices	**47**
Total Pair of country	**1081**

Unit : Pair of country	No OLOH	Yes OLOH	Total
Border = 0; No border	355	**682**	1037
Border = 1: Yes border	1	43	44
Total	**356**	**725**	**1081**

Unit : % of total pair of country	No OLOH	Yes OLOH	Total
Border = 0; No border	32.84%	**63.09%**	95.93%
Border = 1: Yes border	0.09%	3.98%	4.07%
Total	**32.93%**	**67.07%**	**100.00%**

From total 1,081 pair of sample national stock index, there is as high as 64% of the total pair of country that has no common border, but there is OLOH.

APPENDIX D

CORRELATION COEFFICIENT FOR ALL VARIABLES

	lagcorr β1	ldist β2	overlap β3	lnmkt β4	comlang β5	border β6	comcurr β7
lagcorr	1						
ldist	-0.396	1					
overlap	0.496	-0.772	1				
lnmkt	0.137	0.224	-0.161	1			
comlang	0.069	-0.020	0.044	0.050	1		
border	0.139	-0.376	0.246	0.001	0.134	1	
comcurr	0.343	-0.377	0.389	-0.205	-0.059	0.065	1

APPENDIX E

MULTIPLE LINEAR REGRESSION RESULTS – EXCLUDING OVERLAPPING OPENING HOUR VARIABLE FOR YEAR 2003-2009

Number of obs	**1,081.00**
R-squared	**0.89**
Root MSE	**0.07**

Year
2003

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.74	0.02	33.20	-	0.70	0.79
ldist	-0.01	0.00	-1.99	0.05	-0.02	-0.00
lnmkt	0.04	0.00	7.33	-	0.03	0.05
comlang	-0.00	0.01	-0.44	0.66	-0.02	0.01
border	0.02	0.01	1.34	0.18	-0.01	0.05
comcurr	0.02	0.01	1.86	0.06	-0.00	0.05
_cons	-0.60	0.13	-4.64	-	-0.85	-0.35

Number of obs	**1,081.00**
R-squared	**0.88**
Root MSE	**0.07**

Year
2004

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.60	0.02	25.54	-	0.55	0.65
ldist	-0.02	0.00	-5.13	-	-0.03	-0.01
lnmkt	0.00	0.00	0.50	0.62	-0.01	0.01
comlang	0.00	0.01	0.11	0.91	-0.02	0.02
border	0.01	0.01	0.98	0.33	-0.01	0.04
comcurr	0.06	0.01	4.77	-	0.03	0.08
_cons	0.10	0.10	1.00	0.32	-0.10	0.29

APPENDIX E

MULTIPLE LINEAR REGRESSION RESULTS – EXCLUDING OVERLAPPING OPENING HOUR VARIABLE FOR YEAR 2003-2009 (CONT.)

Number of obs	**1,081.00**
R-squared	**0.87**
Root MSE	**0.07**

Year 2005

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.65	0.03	25.71	-	0.60	0.70
ldist	-0.02	0.00	-4.55	-	-0.03	-0.01
lnmkt	0.02	0.01	3.07	0.00	0.01	0.04
comlang	0.00	0.01	0.28	0.78	-0.02	0.02
border	0.03	0.01	2.24	0.03	0.00	0.06
comcurr	0.04	0.01	3.62	-	0.02	0.07
_cons	-0.29	0.19	-1.52	0.13	-0.68	0.09

Number of obs	**1,081.00**
R-squared	**0.86**
Root MSE	**0.09**

Year 2006

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.84	0.03	28.41	-	0.78	0.90
ldist	-0.04	0.00	-7.51	-	-0.05	-0.03
lnmkt	0.05	0.01	4.86	-	0.03	0.07
comlang	-0.00	0.01	-0.21	0.83	-0.03	0.02
border	-0.05	0.02	-3.14	0.00	-0.08	-0.02
comcurr	0.01	0.01	0.86	0.39	-0.02	0.04
_cons	-0.76	0.28	-2.75	0.01	-1.30	-0.22

APPENDIX E

MULTIPLE LINEAR REGRESSION RESULTS – EXCLUDING OVERLAPPING OPENING HOUR VARIABLE FOR YEAR 2003-2009

(CONT.)

Number of obs	**1,081.00**
R-squared	**0.92**
Root MSE	**0.06**

Year
2007

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.69	0.02	34.38	-	0.65	0.73
ldist	-0.02	0.00	-5.98	-	-0.03	-0.02
lnmkt	0.00	0.00	0.12	0.90	-0.01	0.01
comlang	0.02	0.01	1.52	0.13	-0.00	0.03
border	0.00	0.01	0.20	0.84	-0.02	0.03
comcurr	0.02	0.01	1.86	0.06	-0.00	0.03
_cons	0.41	0.14	2.96	0.00	0.14	0.69

Number of obs	**1,081.00**
R-squared	**0.92**
Root MSE	**0.06**

Year
2008

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.72	0.02	36.92	-	0.68	0.76
ldist	-0.03	0.00	-7.79	-	-0.03	-0.02
lnmkt	-0.00	0.01	-0.29	0.77	-0.02	0.01
comlang	-0.00	0.01	-0.18	0.86	-0.02	0.01
border	-0.02	0.01	-2.43	0.02	-0.04	-0.00
comcurr	0.02	0.01	2.32	0.02	0.00	0.04
_cons	0.47	0.23	2.02	0.04	0.01	0.92

APPENDIX E

MULTIPLE LINEAR REGRESSION RESULTS – EXCLUDING OVERLAPPING OPENING HOUR VARIABLE FOR YEAR 2003-2009 (CONT.)

Number of obs	**1,081.00**
R-squared	**0.92**
Root MSE	**0.06**

Year
2009

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.86	0.02	37.21	-	0.82	0.91
ldist	- 0.02	0.00	- 5.98	-	- 0.03	- 0.02
lnmkt	- 0.00	0.00	- 0.91	0.36	- 0.01	0.00
comlang	- 0.00	0.01	- 0.50	0.62	- 0.02	0.01
border	0.00	0.01	0.37	0.71	- 0.02	0.03
comcurr	- 0.01	0.01	- 1.33	0.19	- 0.03	0.01
_cons	0.36	0.09	3.83	-	0.17	0.54

APPENDIX F

MULTIPLE LINEAR REGRESSION RESULTS – INCLUDING OVERLAPPING OPENING HOUR VARIABLE FOR YEAR 2003-2009

Number of obs	**1,081.00**
R-squared	**0.89**
Root MSE	**0.07**

Year
2003

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.74	0.02	31.80	-	0.70	0.79
ldist	-0.01	0.01	-1.01	0.31	-0.02	0.01
overlap	0.00	0.00	0.66	0.51	-0.00	0.00
lnmkt	0.04	0.00	7.19	-	0.03	0.05
comlang	-0.00	0.01	-0.47	0.64	-0.02	0.01
border	0.02	0.01	1.41	0.16	-0.01	0.05
comcurr	0.02	0.01	1.84	0.07	-0.00	0.05
_cons	-0.62	0.13	-4.64	-	-0.88	-0.36

Number of obs	**1,081.00**
R-squared	**0.88**
Root MSE	**0.07**

Year
2004

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.59	0.02	24.85	-	0.55	0.64
ldist	-0.01	0.01	-2.62	0.01	-0.03	-0.00
overlap	0.00	0.00	1.50	0.14	-0.00	0.01
lnmkt	0.00	0.00	0.25	0.80	-0.01	0.01
comlang	0.00	0.01	0.06	0.95	-0.02	0.02
border	0.02	0.01	1.18	0.24	-0.01	0.05
comcurr	0.06	0.01	4.69	-	0.03	0.08
_cons	0.06	0.10	0.61	0.54	-0.14	0.26

APPENDIX F

MULTIPLE LINEAR REGRESSION RESULTS – INCLUDING OVERLAPPING OPENING HOUR VARIABLE FOR YEAR 2003-2009 (CONT.)

Number of obs	**1,081.00**
R-squared	**0.87**
Root MSE	**0.07**

Year
2005

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.63	0.03	24.79	-	0.58	0.68
ldist	-0.00	0.01	-0.31	0.76	-0.01	0.01
overlap	0.01	0.00	4.52	-	0.00	0.01
lnmkt	0.02	0.01	2.48	0.01	0.00	0.03
comlang	0.00	0.01	0.17	0.86	-0.02	0.02
border	0.04	0.01	2.94	0.00	0.01	0.07
comcurr	0.04	0.01	3.46	0.00	0.02	0.06
_cons	-0.40	0.20	-1.94	0.05	-0.80	0.00

Number of obs	**1,081.00**
R-squared	**0.88**
Root MSE	**0.08**

Year
2006

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.76	0.03	25.80	-	0.70	0.82
ldist	0.02	0.01	2.74	0.01	0.00	0.03
overlap	0.02	0.00	13.02	-	0.02	0.03
lnmkt	0.04	0.01	4.08	-	0.02	0.06
comlang	-0.01	0.01	-0.51	0.61	-0.03	0.02
border	-0.02	0.02	-1.12	0.27	-0.05	0.01
comcurr	0.01	0.01	0.59	0.55	-0.02	0.03
_cons	-1.11	0.26	-4.24	-	-1.62	-0.60

APPENDIX F

MULTIPLE LINEAR REGRESSION RESULTS – INCLUDING OVERLAPPING OPENING HOUR VARIABLE FOR YEAR 2003-2009 (CONT.)

Number of obs	**1,081.00**
R-squared	**0.92**
Root MSE	**0.06**

Year
2007

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.63	0.02	29.30	-	0.59	0.67
ldist	0.00	0.00	0.47	0.64	-0.01	0.01
overlap	0.01	0.00	7.16	-	0.01	0.02
lnmkt	0.02	0.00	3.58	-	0.01	0.02
comlang	0.01	0.01	1.39	0.16	-0.01	0.03
border	0.02	0.01	1.30	0.20	-0.01	0.04
comcurr	0.02	0.01	1.90	0.06	-0.00	0.03
_cons	-0.28	0.11	-2.59	0.01	-0.50	-0.07

Number of obs	**1,081.00**
R-squared	**0.92**
Root MSE	**0.06**

Year
2008

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.67	0.02	30.65	-	0.63	0.72
ldist	-0.01	0.00	-2.92	0.00	-0.02	-0.00
overlap	0.01	0.00	4.68	-	0.00	0.01
lnmkt	-0.00	0.01	-0.37	0.71	-0.02	0.01
comlang	-0.00	0.01	-0.24	0.81	-0.02	0.01
border	-0.01	0.01	-1.54	0.12	-0.03	0.00
comcurr	0.02	0.01	2.42	0.02	0.00	0.04
_cons	0.34	0.24	1.42	0.16	-0.13	0.81

APPENDIX F

MULTIPLE LINEAR REGRESSION RESULTS – INCLUDING OVERLAPPING OPENING HOUR VARIABLE FOR YEAR 2003-2009 (CONT.)

Number of obs	**1,081.00**
R-squared	**0.93**
Root MSE	**0.06**

Year
2009

corr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagcorr	0.76	0.03	29.10	-	0.70	0.81
ldist	0.01	0.01	1.43	0.15	-0.00	0.02
overlap	0.02	0.00	8.78	-	0.01	0.02
lnmkt	-0.01	0.00	-2.36	0.02	-0.01	-0.00
comlang	-0.01	0.01	-0.68	0.50	-0.02	0.01
border	0.02	0.01	1.91	0.06	-0.00	0.04
comcurr	-0.01	0.01	-1.39	0.17	-0.03	0.01
_cons	0.12	0.08	1.59	0.11	-0.03	0.28

BIOGRAPHY

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