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Article

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Estimating Exchange Rate Exposure over Various Return Horizons: Focusing on Major Countries in East Asia*

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In this paper, we estimate the exchange rate exposure, indicating the effect of exchange rate movements on firm values, for a sample of 1,400 firms in seven East Asian countries. The exposure estimates based on various exchange rate variables, return horizons and a control variable are compared. A key result from our analysis is that the long term effect of exchange rate movements on firm values is greater than the short term effect. And we find very similar results from using other exchange rate variables such as the U.S. dollar exchange rate, etc. Second, we add exchange rate volatility as a control variable and find that the extent of exposure is not much changed. Third, we examine the changes in exposure to exchange rate volatility with an increase in return horizon. Consequently the ratio of firms with significant exposures increases with the return horizons. Interestingly, the increase of exposure with the return horizons is faster for exposure to volatility than for exposure to exchange rate itself. Taken as a whole, our findings suggest that the so-called "exposure puzzle" may be a matter of the methodology used to measure exposure.

Keywords: Exchange Rate Exposure, Change in Exchange Rates, Exchange Rate Volatility, Stock Price, Exposure Puzzle
JEL classification: F31, F41, O53

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I. INTRODUCTION

Exchange rate movements can directly affect firm values when overseas assets are converted to domestic currency and can also indirectly influence in firm values, such as when there are changes in competitive pricing against a foreign competitor. From the perspective of an individual firm, exchange rate movements could be considered foreign exchange rate risk. Economics has defined the risk to firm values resulted from exchange rate fluctuations as a "foreign exchange rate exposure." Heckerman (1972), Shapiro (1977), Adler and Dumas (1980), Wihlborg (1980), and Hodder (1982) have developed theoretical models that can assess the effects of exchange rate movements on firms' stock prices (proxy for the firm values). However, many studies have faced a problem in that the ratio of firms that exhibit significant exposure is very lower than theoretical intuition and general expectation. These studies have made a great effort to identify the reason of this phenomenon or find an empirical methodology to solve this matter. However, there is still no clear solution proposed. Thus, this paper aims to suggest a method of accurately estimating exchange rate exposure for a sample of 1,400 firms in seven East Asian countries.

This paper is organized as follows. Chapter II includes a review of previous studies, and propose the direction of analysis. Chapter III describes the definition of exchange rate exposure, and its implications are drawn through an empirical analysis. Finally, Chapter IV concludes.

II. REVIEW OF PREVIOUS STUDIES AND RESEARCH DIRECTION

Beginning with the work by Adler and Dumas (1984), exchange rate exposure has been estimated based on a simple linear regression of stock returns on exchange rate changes. However, Bodnar and Wong (2000) argue that exchange rate exposure from previous studies is misestimated, since the results are affected not only by exchange rate movements but also by macroeconomic conditions like interest rate fluctuations. In this regard, Jorion (1990) insists that instead of measuring 'total exposure' exposure should be calculated in that way the effect of two factors could be distinguished. For that, he includes market stock returns as a control variable to the simple regression by Adler and Dumas (1984), and distinguishes this 'residual exposure' from 'total exposure'. Jorion (1990) examines the extent of exposure of

297 U.S. firms for the period of 1971 to 1987 using the nominal effective exchange rate, which is calculated as a trade-weighted basket of currencies. He finds that the number of firms with significant exposures is only 15, smaller than what he previously expected.[1] Although He and Ng (1998) find that foreign sales play an important role in the exposures of Japanese multinational corporations, they report that only 25% of the firms' stock returns were positively exposed to the exchange rate for the period of January 1979 to December 1993.

Bodnar and Wong (2000) also estimate exchange rate exposure and find that most firms are not significantly affected by exchange rate movements. Kiymaz (2003), even, analyzes 109 publically listed firms in Turkey from 1991 to 1998 and finds unexpected results in that the stock prices decrease as the lira depreciates.[2] In a study of emerging countries, Chue and Cook (2008) employ a different approach and find an evidence that firm values are affected by exchange rate movements. They provide the result that share values of most emerging market firms were negatively affected by exchange rate depreciation from 1999 to 2000, however, this negative exposure has disappeared in the more recent years (2002~2006). They focus on the exposures in absolute terms as to assess whether emerging market firms as a class are negatively affected by exchange rate depreciation and to consider the within-country correlation of stock prices that is usually higher for emerging markets than for developed market. And they use variables such as the

[1] He argued that foreign exchange rate exposure generally had a big impact on firms engaged in foreign trade compared to firms that did not engage in foreign trade.

[2] Jorion (1990) conducted analysis of foreign exchange rate exposure by using the rate of change in exchange rate compared to a previous period as the variable representing exchange risk. After that, many researchers used the same method. However, Kang and Lee (2011) used the standard deviation of the exchange rate rather than rate of exchange change compared to a previous period to analyze and compare the foreign exchange rate exposure of 392 Korean firms. Their studies reflect some meaningful implications. First, when the rate of change in the exchange rate was used as a variable representing exchange risk, the number of firms with negative exchange rate exposure was greater than the number of firms with positive exchange rate exposure despite the fact that Korea had a high export rate. Even when a lagged variable of the rate of change in the exchange rate was included, such phenomenon did not change. Second, when the standard deviation of exchange was an explanatory variable reflecting exchange risk, the number of firms exhibiting significant foreign exchange rate exposure increased. Third, when the rate of change in exchange rate was used as a variable representing exchange risk, the number of export-oriented manufacturing firms subject to foreign exchange rate exposure was small compared to firms in non-manufacturing industry, therefore producing confusion. However, when the standard deviation of the exchange rate was used, the result was the reverse, thereby corresponding with theoretical inference.

US Fed Funds rate, and the yen-dollar and euro-dollar cross-rates as instruments to identify the direct effects of exchange rate movements on firm value.

As most studies have illustrated, the ratio of firms exposed to exchange rates has been lower than what has been generally expected, and the relationship between exchange rate movements and stock returns does not correspond to the predictions of economic theory. Thus, this phenomenon has been identified as the "foreign exchange rate exposure puzzle,"[3] and many researchers have undertaken multi-dimensional efforts to investigate its cause. Bodnar and Gentry (1993) obtain the results that are somewhat of an improvement when compared to previous studies by categorizing the subjects by industry rather than by individual firm. They find that the ratio of industries with significant exposures is 23% in the U.S. and 25% in Japan. Second, Bastov and Bodnar (1994), Chow, Lee and Solt (1997), Bodnar and Wong (2003), and Dominguez and Tesar (2006) conduct empirical analysis by paying attention to the fact that it takes time for exchange rate movements to affect stock prices[4] and by taking the lag into account in the variables for exchange rate. However, the improvement is insignificant and there is multicollinearity among the lagged variables. Therefore, these analysis could not be a fundamental solution to the exposure puzzle. Third, studies that analyze specific countries fail to find strong evidence of exposure of firms to exchange rate risk, and there is an attempt to conduct a global analysis by examining various countries in the European, Asian, and American continents (Bartram and Karolyi, 2006; Doidge, Griffin, and Williamson, 2006). Fourth, the analysis is conducted by using the effective exchange rate as an exchange rate variable as well as the exchange rate against the currency of a country that has the biggest influence in the region (Doidge, Griffin and Williamson, 2006; Dominguez and Tesar, 2006).[5] For example, exchange rate against Japanese yen is used for Asian region, and exchange rate against the German deutsche marks is used for Europe. Although the results of these analysis provide a greater ratio of exchange rate exposure, still the exposure is lower than

[3] Bartram and Bodnar (2007) argued that because firms hedge exchange rates, the result of lower exchange risk is a natural result and accordingly, it is not puzzle.

[4] They explained that a market participant needs time to recognize the effect of change in exchange rate on firm value.

[5] For various case studies on measuring exchange exposure, refer to Dominguez and Tesar (2001, 2006)

generally expected. Other methods have been utilized and target countries and periods are changed, all have failed to acquire significantly improved results.[6]

The existing studies have shown the low level of significant exchange rate exposures than theoretical intuition and general expectation. The explanation for this phenomenon (called 'exposure puzzle) can be that, as is argued by Bartram and Bodnar (2007), firms deploy hedging strategies at the management level, such as relocating overseas operations and product pricing, in preparation for and in consideration of the exchange rate movements and the associated risks. Furthermore, firms have shown an increasing tendency to reduce short-term exchange rate risk by using financial derivatives. Bartram, Brown and Minton (2010) also report that the low exposure, which has been considered a puzzle, is somewhat explained by effect of channels such as operational hedging, financial risk management and etc.

However, when a firm cannot hedge the exchange rate risk due to the additional cost of hedging such risk or to the difficulty in measuring the exchange rate risk, the firm values have exposures to exchange rates. In fact, the reality is that many firms do not have a complete foreign exchange rate risk management system, with the exception of some global firms. To begin with, the return horizon, which is used to measure changes in stock prices and the exchange rats, is expanded from one month to at least six months or one year, as similar to Chow, Lee and Solt (1997), and Bodnar and Wong (2003).[7] There are several important reasons for this. First, it can help to mitigate the effect of disturbing noise in short term, which has been pointed out as a contributing factor for the low significant exposures in many studies. Furthermore, it can help to focus on long-term changes in exchange rate that affect the decision-making of investors. Second, there is a strong possibility that many firms measure exchange rate exposure by comparing the exchange rates at the current time against the exchange rates at the time that management plan was established, which could have been three months ago, six months ago, or a year ago. Today, most firms perform accounting evaluations over three-month

[6] Generally, the trade weight exchange rate is used as the exchange rate. However, Bartram (2004) pointed out the problem of the effect of exchange exposure as being diversified and thus, attempted to use the bilateral exchange rate. In this case, exchange exposure somewhat increased.

[7] Bodnar and Wong (2003) showed that foreign exchange rate exposure is more easily identified by expanding the measurement period of each rate of change, given the difficulty in measuring foreign exchange exposure due to involvement of short-term noise when change of stock price and exchange rate are used to estimate foreign exchange rate exposure.

periods, and such a fact needs to be considered. In other words, the reality is that a certain lag is inevitable for the effect of exchange rate changes on a firm's value. Third, to resolve the multicollinearity, which arises when numerous lagged variables of the exchange rate change are included in the regression, the return horizon used to measure the changes in stock prices and exchange rates needs to be expanded to conduct an analysis. Additionally, the implied volatility based on the Black Scholes model is considered to examine the effect of exchange rate risk, which is hard for individual firms to completely resolve. In particular, this paper conducts an empirical analysis by paying attention to the fact that East Asian countries tend to focus on trade for economic growth, and therefore targets firms in seven countries in East Asia.

This paper is therefore organized with the following considerations. First, the return horizon, used to measure changes in stock prices and exchange rates, is expanded from one month to three, six and twelve months, and the extent of significant exposures is examined across the four return horizons. Second, as for the exchange rate variable, three different indicators (nominal effective exchange rates, exchange rates against the dollar, and the exchange rates against the yen) are used. Since the influence of the exchange rate against the yen can be very large for firms in East Asia,[8] it is included with our analysis. The effect of exchange rate against the dollar on a firm's stock price and that of exchange rate against the yen can be compared, and the difference in the influence of the two currencies over firm values in East Asia can be explored. This comparison has rarely been discussed in previous studies for East Asian countries. Third, we also use the implied volatility in the currency option price, based on the Black-Scholes model, as a control variable for the analysis. The effect of the intrinsic foreign exchange rate risk, which is difficult for a firm to hedge against the firm stock price, is further explored by considering this variable as an additional foreign exchange rate risk index. Chowdhury (1993), Cushman (1988), Thursby and Thursby (1987), and Kenen and Rodrik (1986) confirm that a fluctuation in the exchange rate has a clear negative impact on trade and investment. The reason for this is that firms have a tendency to avoid trade and investment when fluctuations in the exchange rate increase, making it difficult for firms to forecast changes in the profits earned. Thus,

[8] Kang, Kim and Wang (2005) analyzed that the yen/dollar exchange rate had a big impact on the won/dollar exchange rate and industrial production. They explained that this was because Japan is Korea's third largest trading partner and a country that carries out large-scale capital investment.

to accurately analyze the exposure to exchange rates, the effects of the fluctuation in exchange rate needs to be controlled. Even in this case, various return horizons are used to confirm whether there are changes in the extent of exposure to exchange rate, for establishing accurate models and enhancing the robustness of the models. Last, the exposure to exchange rate volatility is examined with the increase in the return horizons used to measure changes in exchange rates and stock prices.

III. MEASUREMENT OF ESCHANGE RATE EXPOSURE AND EMPIRICAL ANALYSIS

1. Measurement of Exchange Rate Exposure

The extensive literature on exchange rate exposure defines exposure as the effect of exchange rate changes on the economic value of firms, rather than on the accounting value. Following this, we use the firm's stock price for a proxy of firm value, and the coefficient resulting from the regression of stock price on exchange rates could be interpreted as the exposure (Dumas, 1978; Adler and Dumas, 1980; Hodder, 1982).

The appreciation in local currency could make exporting goods more expensive in terms of the foreign currencies, and this may lead to a fall in foreign demand, then the value of domestic asset could shrink. By contrast, in the case of importing firms which import goods from other countries and sell them to domestic customers or have production facilities abroad could get more profit from the appreciation in local currency. However, firms, centering on large-sized firms, could use a variety of method to hedge the exchange rate risk. Resulting from this, the correlation between firm values and exchange rates is likely to weaken for multinational or large-sized firms.

The existing literature on exchange rate exposure have found that the ratio of firms with significant exposures is lower than general expectation. There can be various reasons for this result. First, the result can be caused by the exclusion of a variable explaining macroeconomic conditions in the regression analysis, such as when the analysis is conducted by using the basic Formula shown in Formula (1). For example, when the exchange rate appreciates due to a very strong domestic economy, a firm's stock price increases. If only the change in exchange rate is included as an explanatory variable, the appreciation of exchange rate can be incorrectly interpreted to cause the increase in the firm's stock price.

(1) $\mathbf{SR_{it} = \alpha + \beta_1 ER_t + \epsilon_t}$

($\mathbf{SR_{it}}$ represents the change in stock price of firm i at time t, and $\mathbf{ER_t}$ is the change in an exchange rate at time t)

In response, Jorion (1990) conducts an analysis by adding the market stock price index in the regression, as seen in Formula (2). In Formula (2), the condition of the domestic economy is reflected in order to address the above-mentioned problem.

(2) $\mathbf{SR_{it} = \alpha + \beta_1 ER_t + \beta_2 MSTR_t + \epsilon_t}$

($\mathbf{SR_{it}}$ represents the change of stock price of firm i at time t, $\mathbf{ER_t}$ represents the change in an exchange rate at time t, and $\mathbf{MSTR_t}$ is the change in market stock index)

Bodnar and Wong (2000) identify from Formula (1) as the total exposure and from Formula (2) as residual exposure. In an empirical analysis, exchange rate exposure is generally analyzed by defining it as the residual exposure. Although, Bodnar and Wong (2000) find statistically low significant exposures at 5% significance level with the model including exchange rate volatility. Thus, it may not be a fundamental solution to address the low exposure phenomenon.

(3) $\mathbf{SR_{it} = \alpha + \beta_1 ER_t + \beta_2 ERVOL_t + \beta_3 MSTR_t + \epsilon_t}$

($\mathbf{SR_{it}}$ is the change of the stock price of a firm i at time t, $\mathbf{ER_t}$ is the change in the exchange rate at t, $\mathrm{ERVOL_t}$ is the exchange rate volatility at times t, and $\mathrm{MSTR_t}$ is the change in the market index at time t)

By the way, if a key variable that influences stock price is excluded, the effect of exchange rate on stock price cannot be accurately measured. Thus, a control variable that can influence stock price needs to be added to the analysis. This makes it possible to compare the result of analysis including a control variable and without a control variable, and the robustness and the accuracy of the analysis of the exchange rate exposure can be judged. For instance, Formula (3) includes exchange rate volatility as a control variable to Formula (2) in order that we reflect instability of the financial markets and conduct a more precise analysis of exchange rate exposure.

2. Empirical Analysis

In section 2, we analyze the extent of exchange rate exposure for a sample of 1,400 firms in seven East Asian countries, including China, Indonesia, Japan, Korea, Malaysia, Singapore, Thailand. As the dependent variable, firm' stock price is used and as the independent variables foreign exchange rates, exchange rates volatility and market stock indexes are used. To select a sample of 200 firms for each country, the data availability is considered by priority, and then it is finally chosen according to market capitalization. As for exchange rate indicators, nominal effective exchange rate, exchange rate against the dollar, and exchange rate against the yen are used. The average stock price in each country is used as a market stock index, representing the returns in the financial markets. Three-month implied volatility in the currency option prices[9] is used as a representative of the volatility in foreign exchange rate. Meanwhile, the period of the analysis is set to the available time series of three-month ATM (at the money) implied volatility, considering that it is the shortest time series among the variables. Table 1-1 represents the available time series of three-month ATM implied volatility and Table 1-2 indicates the market indexes of each of the countries.

Table 1. The available time series of the implied volatility and of each country's market stock price indices

Table 1-1. Three-month ATM Implied Volatility

	Available time series
Korea	1999.3-2013.3
China	1999.3-2013.3
Japan	1996.1-2013.3
Singapore	2001.1-2013.3
Malaysia	2006.4-2013.3
Thailand	1999.1-2013.3
Indonesia	2002.1-2013.3

Source: Bloomberg

[9] Some studies used monthly standard deviation of daily exchange rate as a representative of exchange rate volatility. But it is highly correlated with rate of change in exchange rate, the main indicator of foreign risk. Thus, to prevent the multicollinearity problem and reflect the potential exchange rate fluctuation that is hardly captured in past exchange rate fluctuation, implied volatility in currency option price is used in this paper.

Table 1-2. Market Stock Price Indices

	Index
Korea	KOSPI (Korea Composite Stock Price Index)
China	SSE (Shanghai Stock Exchange) Composite Index
Japan	NIKKEI225
Singapore	STI (Straits returns Index)
Malaysia	KLCI (Kuala Lumpur Composite Index)
Thailand	SET (Stock Exchange of Thailand Index)
Indonesia	JCI (Jakarta Composite Index)

Source: Bloomberg.

As mentioned above, two types of model are used in analysis. First, the basic model where the dependent variable is stock return and the independent variables are exchange rate change and market return, is used to measure exposures (Formula (4)). Second model additionally includes exchange rate volatility as a control variable (Formula (5)).

(4) $\Delta_n \mathbf{S_{it}} = \boldsymbol{\alpha} + \boldsymbol{\beta_1} \Delta_n \mathbf{FX_t} + \boldsymbol{\beta_2} \Delta_n \mathbf{M_t} + \boldsymbol{\epsilon_t}$

(Δ_n represents the rate of change compared to previous n month, $\mathbf{S_{it}}$ is the stock price of firm i at time t, $\mathbf{FX_t}$ is the exchange rate at time t, and $\mathbf{M_t}$ is the market index at time t)

(5) $\Delta_n \mathbf{S_{it}} = \boldsymbol{\alpha} + \boldsymbol{\beta_1} \Delta_n \mathbf{FX_t} + \boldsymbol{\beta_2} \Delta_n \mathbf{IV_t} + \boldsymbol{\beta_3} \Delta_n \mathbf{M_t} + \boldsymbol{\epsilon_t}$

(Δ_n represents the rate of change with respect to the value at the previous n month, S_{it} is the stock price of a firm i at time t, $\mathbf{FX_t}$ the exchange rate at time t, $\mathbf{IV_t}$ is the implied volatility in the currency option price at time t, and $\mathbf{M_t}$ is the market index at time t)

In this paper, we estimate exchange rate exposures in the following three aspects. First, the fluctuation in the ratio of firms with significant exchange rate exposures is analyzed as the return horizon increases from one month to three, six and twelve months, respectively. Additionally three kinds of exchange rates, including a nominal exchange rate, an exchange rate against U.S. dollar and Japanese yen, are used for the robustness of our analysis. Second, we add exchange rate volatility to the basic model for two objectives. One of the objectives is to confirm whether there is a change in the extent of exposure to exchange rate when the control

variable is included. The other is focusing on the exposure to the volatility itself. We empirically demonstrate the argument that the high degree of exchange rate volatility can be associated with firm values. Meanwhile, standard error by Newey-West method is applied to consider autocorrelation and heteroskedasticity of error-term that are frequently occurred in time series analysis.

Table 2 and Graph 1 show the results from the basic model for a sample of 1,400 firms in seven East Asian countries. The numbers in the Tables and bars in the graphs represent the number of firms that exhibit statistically significant exposures at 5% significance level. As shown in the tables, we attempt to estimate exposure allowing for changes in the return horizons from one month to three months, six months and one year. Furthermore three exchange rate variables are used for comparison and the results from each case are as follows.

Table 2-1 and Graph 1-1 present the number of firms significantly exposed to the nominal exchange rate. At the monthly return horizon, only 198 firms of 1,400 firms exhibit statistically significant exposures at 5% significance level. Looking across countries, the number of firms exposed to nominal exchange rate ranges from a minimum of 14 in China and Singapore to a maximum of 58 in Japan. The number of firms with exposures for a sample of 1,400 firms increases to 376 at the quarterly, 579 at the half-yearly and 747 at the yearly horizons, respectively. This result suggests that it takes some time for exchange rates to affect stock prices. Also, it implies that a long-term changes in exchange rate is more influential for establishing expectations of stock investors.

By the way, the rate of increase in the number of firms showing significant exposures with increase in return horizons varies across the countries. In Singapore, only 14 firms exhibit significant exposures at the monthly return horizon, but it increases to 111 firms at the yearly horizon. On the other hand, the number of Japanese firms with significant exposures increases from 58 to 144 as the return horizon increases from one month to one year, showing the most high exposure among seven East Asian countries. One possible reason for this could be that relatively more firms in Japan and Singapore engage in extensive foreign sales and hold international assets, thus, exchange rate movements are likely to affect these firms' value more than firms in other countries. Meanwhile the number of firms with significant exposures in Singapore increases 7.5 times when the return horizon increases from one month to one year, and it is faster than any other

country. It shows that firms' stock prices in Singapore are affected by long-term changes of exchange rates rather than by short-term changes.

Table 2-2 and Graph 1-2 represent the results using exchange rate against the U.S. dollar. The number of firms with significant exposures increases sharply with increase in the return horizon, in all of the seven East Asian countries as similarly as the results using the nominal exchange rate above. At the monthly return horizon, Malaysia appears to be the most exposed country to U.S. dollar exchange rate in our sample. At the annual return horizon, however, Japan still shows the largest number of firms exposed to exchange rate. Meanwhile, as the return horizon increases from one month to one year, the number of firms with significant exposures in China increases 23.4 times from 5 to 117, a greater change than that of other countries. This result suggests that in China long-term changes in exchange rate against U.S. dollar more affect firms' stock prices than short-term changes. One potential explanation for the rapid increase in exposures with increase in the return horizons is that exchange rate against U.S. dollar was almost fixed in short-term because of Chinese exchange rate regime, which was a peg to the U.S. dollar until July 2005. Thus it is quite reasonable that exchange rate movement is unlikely to be captured in short-term, and that the relationship between exchange rate movements and stock return is more obvious in longer-term.

Table 2-3 and Graph 1-3 represent the number of firms with significant exposures to exchange rate against Japanese yen at 5% significance level for a sample of 1,200 firms in six countries with the exception of Japan. The results are similar as those using exchange rate against U.S. dollar where the number of firms with significant exposures increases with the return horizons. In particular, the number of firms with significant exposures increases 6.7 times from 19 to 128 in Singapore, when the return horizon is changed from one month to one year. Malaysia, however, shows almost no change, reporting 111 firms at the monthly horizon, and 112 firms at the yearly horizon, respectively.

Table 3 and Graph 2 show the exposure estimates based on the regression which adds exchange rate volatility to the basic model as an explanatory variable. The statistical significance of a regression coefficient $\boldsymbol{\beta_1}$, indicating the effect of exchange rate movements on stock return, is examined. To begin with, the result of using a nominal effective exchange rate is presented in Table 3-1 and Graph 2-1. At the monthly return horizon, 188 out of 1,400 firms in seven East Asian countries show significant exposures. That is fewer than that in the analysis without

considering exchange rate volatility. However at the yearly horizon, it increases to 750 firms as similar with that in the analysis without considering exchange rate volatility. Looking across countries, at the monthly horizon, China and Singapore have only 12 and 15 firms showing significant exposures, respectively, Japan has 51 firms with significant exposures. The total number of firms showing significant exposures increases to 373 at the quarterly horizon, to 587 at the half-yearly horizon and to 750 at the yearly horizon. In particular, Singapore reports the most rapid increase in the number of firms with significant exposures, when the return horizon increases. Also, Malaysia shows the increasing number of firms with significant exposures, and this result is different from the analysis without considering exchange rate volatility.

Table 3-2 and Graph 2-2 represent the results of using exchange rate against the U.S. dollar as an exchange rate variable. Similar to the analysis without considering exchange rate volatility, exposure increases sharply with the return horizon. Malaysia was the most exposed country at the monthly horizon, but the number of firms with significant exposures decreases from 109 to 89, when compared with the analysis without exchange rate volatility. At the yearly horizon, Japan, still, is the most exposed to foreign exchange rate risk. Similar results are obtained when using exchange rate against the Japanese yen as an exchange rate variable, and the results are presented in Table 3-3 and Graph 2-3. If we compare Table 3 from Formula (5) and Table 2 from Formula (4), most of the results are in correspondence with each other. That is, there is no big change, whether exchange rate volatility is added to the model, or not.

From now, we estimate exposure to exchange rate volatility in the same sample above. Exchange rate volatility is observed in the corresponding month, thus the return horizon is not considered. However we allow for changes in the return horizon to measure the fluctuation in firm values and exchange rate itself. The extent of exposure is measured as the number of significant coefficient $\boldsymbol{\beta_2}$ (at 5% significance level) in Formula (5).

First, the nominal effective exchange rate is used as an exchange rate variable, and in the results, the number of firms with significant exposures is represented in Table 4-1 and Graph 3-1. At the monthly horizon, 120 firms out of 1,400 firms are affected by exchange rate volatility. The number of exposed firms sharply increases to 376 at the quarterly, 616 at the half-yearly and 774 at the yearly

horizons. In detail, only 12 firms in Korea and 26 firms in Japan are exposed to exchange rate volatility.

Table 4-2 and Graph 3-2 show the result of using exchange rate against the U.S. dollar as an exchange rate variable. The number of firms exposed to exchange rate volatility increases sharply with the return horizons in seven East Asian countries. At the monthly horizon, the most exposed country is Japan and it is Malaysia at the yearly horizon. Similar results are obtained when exchange rate against Japanese yen is used. In comparison with the case of using U.S. dollar exchange rate, the country most influenced by exchange rate volatility changes from Malaysia to China.

The estimation result of $\boldsymbol{\beta_2}$ is compared with the result of $\boldsymbol{\beta_1}$, representing exposure to exchange rate, in the same Formula (5) and the following implication is found. First, the ratio of firms affected by exchange rate volatility, increases with the return horizons. When the return horizon increases, the degree of increase in the number of firms exposed to exchange rate volatility is slightly more than that of firms exposed to exchange rate movement. Second, countries that are the most exposed to exchange rate are somewhat different from countries that are the most exposed to exchange rate volatility. For example, Malaysia ranks 5 out of 7 countries, with only 98 firms showing significant exposures to exchange rate at the yearly horizon, as seen in Table 3-1. However, Malaysia ranks at the top, with 125 firms showing significant exposures to exchange rate volatility at the yearly horizon as seen in Table 4-1.

Table 2. The Number of Firms with a Significant Exchange Rate Exposure According to the Return of Horizon

Table 2-1. In Case of a Nominal Effective Exchange Rate as an Exchange Rate Variable

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	26	44	72	100
China	200	14	40	74	99
Japan	200	58	88	123	145
Singapore	200	14	55	81	111
Malaysia	200	42	41	67	86
Thailand	200	23	41	68	82
Indonesia	200	21	67	94	124
Total	1,400	198	376	579	747

Table 2-2. In Case of Exchange Rate against the U.S. Dollar as an Exchange Rate

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	25	55	75	114
China	200	5	35	74	117
Japan	200	52	73	100	128
Singapore	200	16	40	76	95
Malaysia	200	109	54	77	118
Thailand	200	14	47	83	103
Indonesia	200	15	51	83	136
Total	1,400	236	355	568	811

Table 2-3. In Case of the Exchange Rate against the Japanese Yen as an Exchange Rate

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	23	56	80	123
China	200	23	58	55	100
Singapore	200	19	58	89	128
Malaysia	200	111	85	91	112
Thailand	200	14	59	76	91
Indonesia	200	23	56	80	123
Total	1200	213	372	471	677

Notes: These tables show the results of exposure analysis obtained from Formula (4).

(4) $\Delta_n \mathbf{S_{it}} = \boldsymbol{\alpha} + \boldsymbol{\beta_1} \Delta_n \mathbf{FX_t} + \boldsymbol{\beta_2} \Delta_n \mathbf{M_t} + \boldsymbol{\epsilon_t}$

In Formula (4), Δ_n represents the rate of change compared to previous n months, S_{it} is the stock price of firm i at time t, $\mathbf{FX_t}$ is the exchange rate at time t, and $\mathbf{M_t}$ is the market index at time t, $\boldsymbol{\beta_1}$ indicates the effect of change in exchange rate on change in firm's stock price. Thus, the number samples for which $\boldsymbol{\beta_1}$ is significant at a 5% significance level can be interpreted as the number of firms that have a statistically significant exposure.

Table 3. The Number of Firms with a Significant Exchange Rate Exposure According to the Return Horizon in Case of Including Exchange Rate Volatility as a Control Variable

Table 3-1. In Case of a Nominal Effective Exchange Rate as an Exchange Rate Variable

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	21	48	77	97
China	200	12	40	81	105
Japan	200	51	77	105	127
Singapore	200	15	50	82	114
Malaysia	200	41	44	72	98
Thailand	200	23	46	75	79
Indonesia	200	25	68	95	130
Total	1,400	188	373	587	750

Table 3-2. In Case of the Exchange Rate against the U.S. Dollar as an Exchange Rate

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	26	56	78	110
China	200	5	36	70	117
Japan	200	46	73	85	129
Singapore	200	19	43	79	97
Malaysia	200	89	43	83	126
Thailand	200	16	50	86	114
Indonesia	200	16	61	86	136
Total	1,400	217	362	567	829

Table 3-3. In Case of the Exchange Rate against the Japanese Yen as an Exchange Rate

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	32	65	85	111
China	200	25	57	63	105
Singapore	200	17	54	86	112
Malaysia	200	97	80	94	111
Thailand	200	17	54	86	112
Indonesia	200	29	66	92	130
Total	1200	217	376	506	681

Notes: These tables show the results of exposure analysis obtained from Formula (5).

(5) $\Delta_n \mathbf{S_{it}} = \boldsymbol{\alpha} + \boldsymbol{\beta_1}\Delta_n \mathbf{FX_t} + \boldsymbol{\beta_2}\Delta_n \mathbf{IV_t} + \boldsymbol{\beta_3}\Delta_n \mathbf{M_t} + \boldsymbol{\epsilon_t}$

In Formula (5) , Δ_n represents the rate of change with respect to the value at the previous n months, S_{it} is the stock price of a firm i at time t, FX_t the exchange rate at time t, $\mathbf{IV_t}$ is the implied volatility in the currency option price at time t, and $\mathbf{M_t}$ is the market index at time t, $\boldsymbol{\beta_1}$ indicates the effect of change in the exchange rate on change in firm's stock price. Thus, the number samples for which $\boldsymbol{\beta_1}$ is significant at a 5% significance level can be interpreted as the number of firms that have a statistically significant exposure.

Table 4. The Number of Firms Influenced by Exchange Rate Volatility According to the Return Horizon

Table 4-1. In Case of a Nominal Effective Exchange Rate as an Exchange Rate Variable

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	12	43	79	114
China	200	12	41	82	113
Japan	200	26	71	96	119
Singapore	200	12	50	83	105
Malaysia	200	20	64	106	125
Thailand	200	16	36	76	99
Indonesia	200	22	62	94	104
Total	1,400	120	367	616	779

Table 4-2. In Case of the Exchange Rate against the U.S. Dollar as an Exchange Rate

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	13	48	77	113
China	200	14	45	85	111
Japan	200	28	78	107	139
Singapore	200	12	51	80	106
Malaysia	200	11	54	106	129
Thailand	200	17	38	76	92
Indonesia	200	25	63	98	104
Total	1,400	120	377	629	794

Table 4-3. In Case of the Exchange Rate against the Japanese Yen as an Exchange Rate

	The No. of Firms	One Month	Three Months	Six Months	One Year
Korea	200	9	53	81	96
China	200	12	47	86	126
Singapore	200	11	54	76	95
Malaysia	200	10	48	88	119
Thailand	200	13	44	76	91
Indonesia	200	28	67	99	109
Total	1,200	83	313	506	636

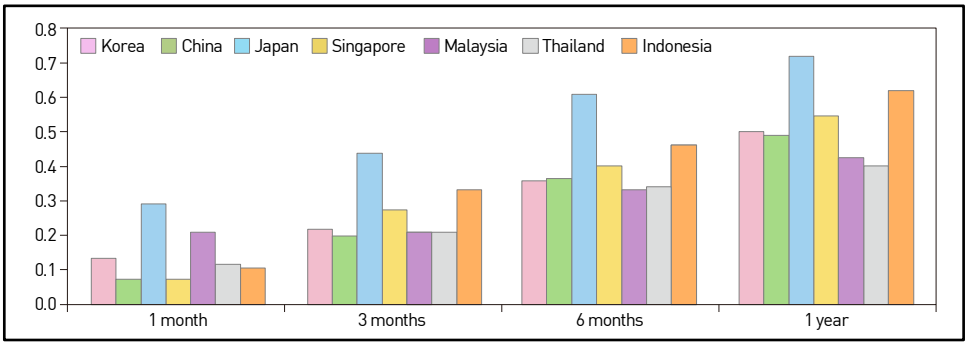
Notes: These tables show the results of the foreign exposure analysis obtained from Formula (5).

(5) $\Delta_n \mathbf{S_{it}} = \boldsymbol{\alpha} + \boldsymbol{\beta_1}\Delta_n \mathbf{FX_t} + \boldsymbol{\beta_2}\Delta_n \mathbf{IV_t} + \boldsymbol{\beta_3}\Delta_n \mathbf{M_t} + \boldsymbol{\epsilon_t}$

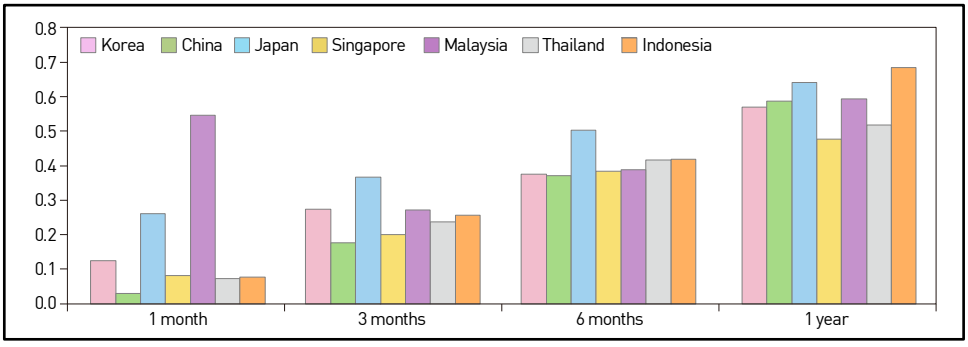
In Formula (5) , Δ_n represents the rate of change with respect to the value at the previous n months, $\mathbf{S_{it}}$ is the stock price of a firm i at time t, FX_t the exchange rate at time t, IV_t is the implied volatility in the currency option price at time t, and M_t is the market index at time t, $\boldsymbol{\beta_2}$ indicates the effect of exchange rate volatility on the change in firm's stock price. Thus, the number samples for which $\boldsymbol{\beta_2}$ is significant at a 5% significance level can be interpreted as the number of firms that have a statistically significant exposure.

Graph 1. The Ratio of Firms with a Significant Foreign Exchange Rate Exposure According to the Return Horizon

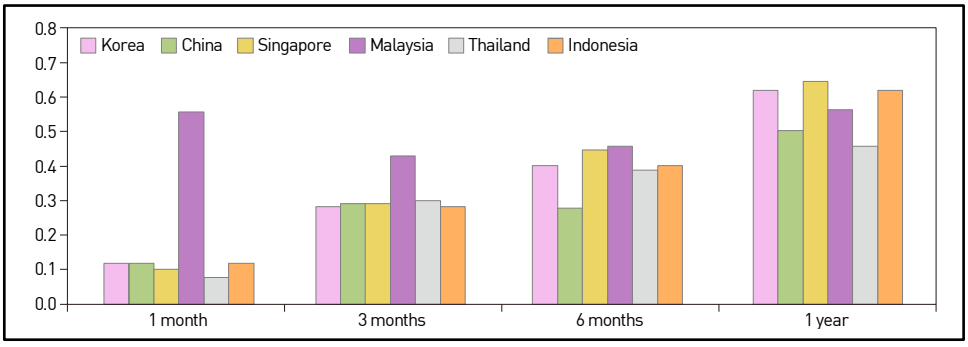
Graph 1-1. In Case of a Nominal Effective Exchange Rate as an Exchange Rate Variable



Graph 1-2. In Case of the Exchange Rate against the U.S. Dollar as an Exchange Rate

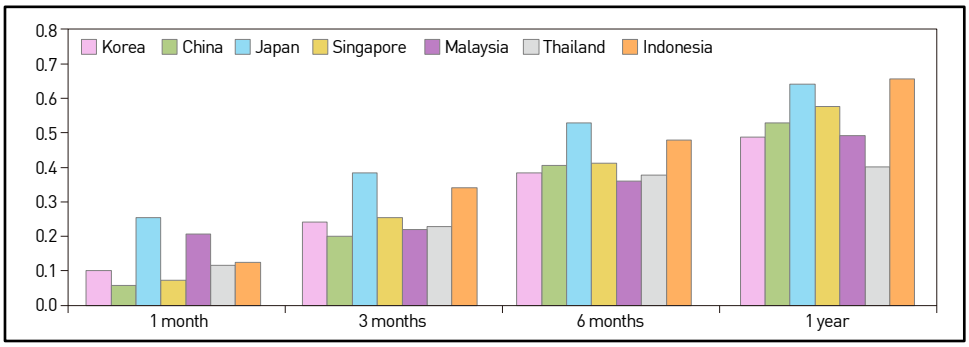


Graph 1-3. In Case of the Exchange Rate against the Japanese Yen as an Exchange Rate

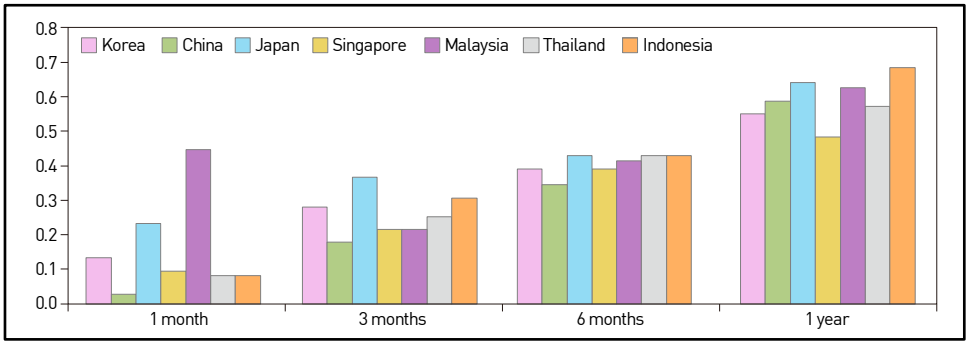


Graph 2. The Ratio of the Firms with a Significant Foreign Exchange Rate Exposure According to the Return Horizon When the Exchange Rate Volatility is Included

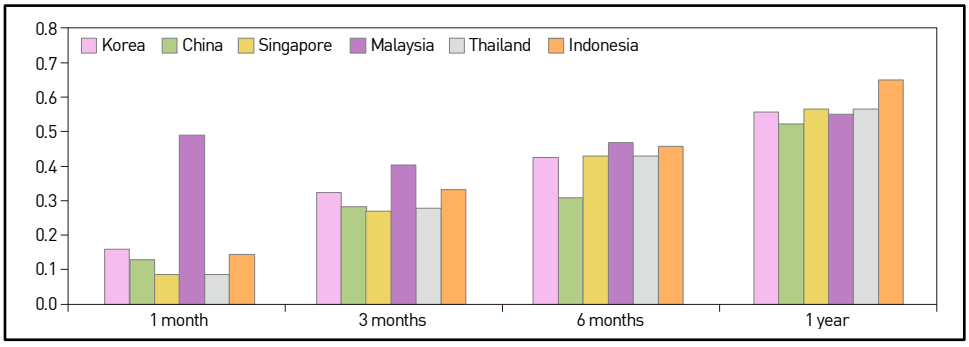
Graph 2-1. In Case of a Nominal Effective Exchange Rate as an Exchange Rate



Graph 2-2. In Case of the Exchange Rate against the U.S. Dollar as an Exchange Rate

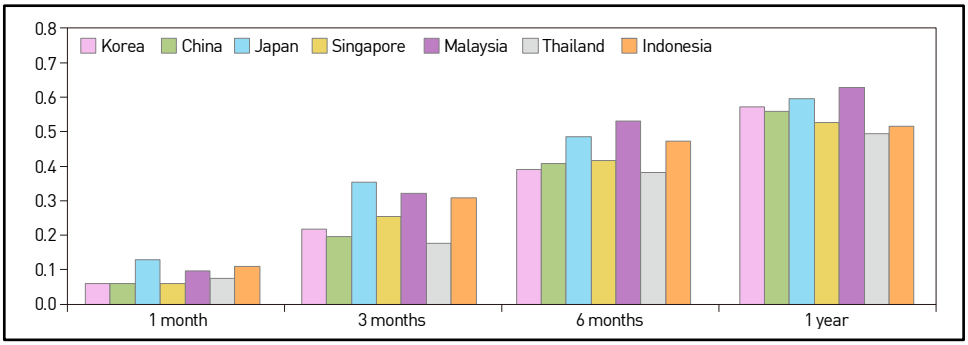


Graph 2-3. In Case of the Exchange Rate against the Japanese Yen as an Exchange Rate

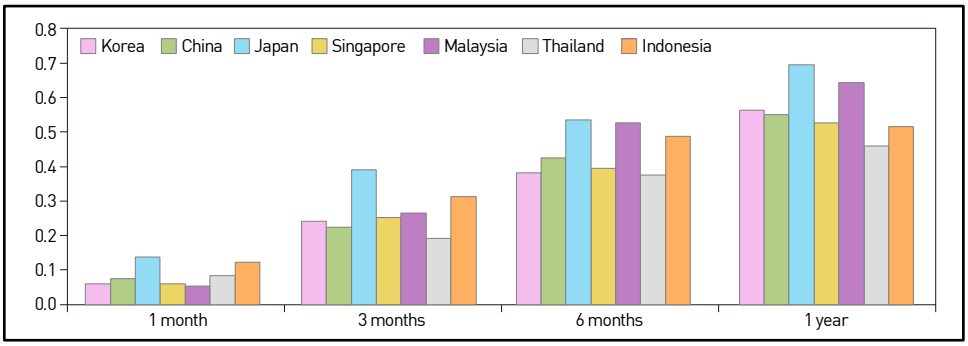


Graph 3. The Ratio of Firms Influenced by the Exchange Rate Volatility According to the Return Horizon

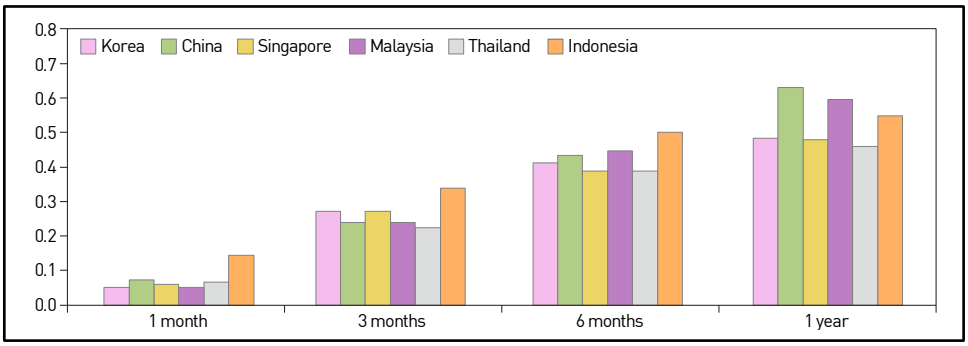
Graph 3-1. In Case of a Nominal Effective Exchange Rate as an Exchange Rate



Graph 3-2. In Case of the Exchange Rate against the U.S. Dollar as an Exchange Rate



Graph 3-3. In Case of the Exchange Rate against the Japanese Yen as an Exchange Rate



IV. CONCLUSION

The proportion of firms with significant exchange rate exposures was lower than generally expected, thus, complementary studies have continued for solving the exposure puzzle. Some empirical studies have proposed that allowing for changes in the return horizons which are used to measure the exposure could be one of the solution. A study by Bodnar and Wong (2000) have shown that exchange rate exposure increases with the increase in the return horizon. Similarly with using lagged variables, it reflects the fact that it takes some time for exchange rate to affect stock prices. However adding lagged variables to the model, while return horizon is fixed, for example, to previous month, can cause multi-collinearity problem.

Thus, in this paper, we show an empirical evidence that significant exposures to exchange rate increases with the return horizons used to measure changes in stock prices and exchange rates, for a sample of 1,400 firms in seven East Asian countries. In other words, the implication that the long-term changes in exchange rate has more impact on firm values than temporary and short-term changes can be derived from the analysis with various return horizons. Interestingly, the exposure to exchange rate volatility increases faster than the exposure to exchange rate itself with the return horizon. From the fact that the increasing exposure to volatility and exchange rate itself as the return horizon increases, it is reconfirmed that the exposure puzzle may be the matter of methodology.

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