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Interdependence of US and Korea

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Abstract

With rapid globalization and capital market liberalization, it has been argued that the global financial markets show convergence. However, it has also been argued that the strong growth performance of emerging markets appears to be decoupling among industrial and emerging market economies. This paper examines financial linkages between the US and the Republic of Korea to find out whether two financial markets show converging or decoupling. We study the effects of turbulences in the US stock and short-term debt markets on the Korean financial markets by examining the relationships of the prices in those markets. When we compare the interdependence of financial variables before-and-after the subprime mortgage crisis, we found that the effect of U.S stock price on Korean stock price and Korean stock price on exchange rate have been increased to a larger degree even though a long run relationships between U.S and Korea financial market are similar qualitatively. We also found that the movement of the exchange rate has been affected by Korean stock price rather than interest rate differential between two countries when the subprime mortgage crisis began.

Keywords: Financial market integration, Relationship of financial markets

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I. Introduction

As financial markets become increasingly integrated, financial market linkages are also believed to be an increasingly important mechanism for the transmission of shocks across countries. Starting from the 1990s, there has been a tremendous increase in financial liberalization in developing countries and a substantial increase in financial interdependencies between emerging market economies and the United States. In this regard, it has been questioned whether increased financial liberalization and interdependence tend to magnify the spillovers of financial shocks from the United States to emerging market economies.

Incidents of financial market turbulence originating in the United States are often thought to have a major impact on emerging market economies. In general, the mechanisms through which shocks influence various markets operate through different channels in the midst of an episode of financial stress compared to the normal times. During tranquil periods, market illiquidity shocks are typically short-lived, as they create opportunities for arbitrage. Traders provide liquidity and contribute to stability of markets.

However, during periods of crisis, several mechanisms amplify and propagate the shocks across financial markets, creating systemic risks. Typically asset price is impacted directly and indirectly, and financial institutions face marked-to-market price declines. As a consequence, positions are deleveraged, and the creditworthiness of the respective institutions deteriorates due to rising risk of default when the value of the corresponding assets is significantly affected.

The recent subprime mortgage crisis, that at began in August 2007, has been called the worst financial crisis since the Great Depression. The unexpected large amount of loss in the financial institutions has been announced, and concerns of the global credit squeeze sparked and the global stock market lost their values.

With this financial crisis, widespread credit risk resulted in a sharp reduction in the supply of loans and tight credit rationing. It does not only raised interest rates, but also made borrowing more difficult. This credit crunch increased the liquidity risk of the economy and cut down asset prices. Especially, in the stock markets, the crisis has not only caused sporadic panics, but also long-lasting unrest that makes investors hesitant to invest in equities.

For this reason, stock prices in the major markets showed downward trends and even some sharp drops at moments when sub-prime related shocks hit the markets. The monthly averages of the US Dow Jones Industrial Average(DJIA) fell greatly and Korean financial markets have been also hit significantly as impact of the subprime mortgage turmoil has been transmitted. In the first half of 2007, the Korean won had been strong against the US dollar, reaching the exchange rate around the level of 950 won per dollar. With the subprime mortgage crisis of the US, however, the won-dollar exchange rates soared to the level of 1,400 as of 9 October 2008.

Every time subprime mortgage shocks arrived, concerns of the global credit squeeze intensified the investors' preference for safe assets so that there happened an increased outflow of foreign portfolio investment from Korean stock market that weakened the Korean won. In line with this, we will analyze in the paper how the subprime mortgage problem affected Korean financial markets. Specifically, we focus on the effects of frequent turbulences in the US stock and short-term debt markets on the Korean financial markets by examining changes in the relationships of the prices in those markets.

The paper also investigates the recent debate about ‘decoupling’ between developing and developed markets. Before the subprime mortgage turmoil began, there was a debate about whether the financial markets between developing countries and developed countries were decoupled.

Since the US economy was such a dominant one in the world, its demand for goods and services drove much of the world’s industrial development. Most of developing countries’ growth performance depended on the US' demand to sustain their economic expansion. As China, India, Brazil, Central Europe and other regions of the world have emerged as sizable markets for goods and service, the dependence of developing countries on the US economy start changing.

Instead of the thinking that the US and other world economy are coupled, the ‘decoupling’ argument is appeared. In this argument, it is claimed that, even though the US economy slips into recession and its demand for the world’s products falls, these new economies can pick up.

Therefore, most emerging countries may not need to be dependent on only United States any more and can sustain their economic growth by their own market. It

this sense, the emerging market financial market may not also need to be moved by the same direction with the US.

However, after the subprime mortgage turmoil began, it seems to be that some financial markets like the stock markets in emerging countries are more likely to move in the same direction as the US market. Thus, it will be worthy to examine whether the Korean financial market was coupled with the US financial markets. This paper investigates the effects of subprime mortgage crisis on the Korean financial markets to find out the degree of 'interdependence' between the US and Korean financial markets.

Many empirical studies have been conducted about convergence of the stock markets across countries. The works of the stock market interdependence across the borders include Campbell and Hamao(1992), Arshanapalli and Doukas(1993), Lin et al.(1994) and so on. However, it seems that there is no general consensus on the issue.

Campbell and Hamao(1992) and Lin et al.(1994) argue that there exists a bi-directional interdependence between the stock markets in the US and Japan. According to Masih and Masih(1997) and Janakiramanan(1998), the influences of the US markets on other developed and emerging countries are significant. On the other hand Arshanapalli and Doukas(1993) shows the US stock markets have a considerable impact on the French, German and UK markets after October 1987 but the performance of the Japanese equity market has no links with the US stock markets or the others during the pre and post-October crash period.

There are also previous studies that examine the stock market interdependence between US and Korea. Their results are somewhat mixed. Moon and Hong(2003) shows that there is no cointegration relationship between them. However, Yoo and Kim(1997) and Park and Jung(2003) support cointegration relationship between them before and after the currency crisis. On the other hand, Yoon and Sul(2005) shows that the cointegration relationship between them becomes weaker when a GARCH model is introduced in addition to a cointegration method. Yoon(2007) shows that there is short term Granger causalities between two markets but no long term cointegration.

In this paper we try to figure out most recent features in the US and Korean financial markets with respect to the 'coupling' issue. In doing so, we analyses the stock markets and short-term debt markets of both countries together as well as the Korean foreign exchange market, contrast to the previous works pay attentions only on the

stock markets.

Using four variables in the Error Correction model –the U.S and Korean Stock price indices, interest rate differential between two countries and exchange rate-, we found that (i) there is one cointegration relationship among those variables in the both before and after periods of subprime mortgage crisis and that (ii) there is a long run positive relationship between DJIA and KOSPI, between DJIA and IRD, between KOSPI and USD/KRW and between IRD and USD/KRW in both periods, while there is a long run negative relationship between DJIA and USD/KRW.

The rest of the paper is organized as follows. Section 2 explains the data and methodological framework; Section 3 provides estimates with discussion; and Section 4 concludes.

. Data and Methodology

The interdependence of stock markets can be classified as two types; long term and short term ones. As time series data can be decomposed by a trend and cycles, we consider a trend as long term interdependence and cycles as short term one.

We can also classify the interdependence of stock markets as the interdependence of the rates of return and that of variability. Generally, cointegration and error correction models are used to study the convergence of the rates of return, while GARCH models are used to study variability. This paper focuses on the rates of return.

1. Data

In this paper we examine long and short term interdependence of daily stock index returns between the US and Korean financial markets. For the stock price indices, we use the DJIA for the US and the KOSPI200 for Korea.

For the short term debt markets, we use 3 months USD LIBOR for the US and 90 days CD rates for Korea, taking the interest rate differential(IRD) between two. The 5 year Treasury bond rates in the US(USTB) and Korean(KOTB) capital markets are added to the system but exogenously.

The Won/Dollar exchange rate(USD/KRW) is taken as an endogenous variable. All of these variables are logged in our analysis.

Daily closing data of them have been collected from the Bloomberg and the Bank of Korea. As the main purpose of our study is compared the interdependence before and after the subprime mortgage turmoil, we take two sample periods; 2002.1.2 2006.12.29 and 2007.7.2 2008.5.2. Meanwhile, we only take account of days when the financial markets are open in both countries, and these common business days are newly indexed. The first and second sample consists of 1179(= n_1) and 197(= n_2) observations, respectively.

We first check out the order of integration of each series before examining cointegration or Granger causality. For this procedure, the augmented Dickey-Fuller (ADF) unit root tests are performed. The null hypothesis for each series is that it has a unit root. The results for the levels and first differences are presented in Table 1. The reported results indicate that none of the null hypotheses on the levels can be rejected at the 10% level, while for the first differences we can reject all of them at the 1% level. Thus, it can be said that in the sample periods all variables were integrated of order one; $I(1)$.

<Table 1> ADF tests for unit roots

		Panel A: 1st Period		Panel B: 2nd Period	
		Level	1st different	Level	1st different
t-Statistic	DJIA	-1.017	-36.244	-2.019	-16.249
	KOSPI	-0.397	-33.160	-1.868	-13.892
	IRD	0.198	-14.990	0.064	-8.872
	USD/KRW	-0.719	-35.612	0.064	-7.025
	USTB	-1.6166	-35.7622	-1.4680	-16.6451
	KOTB	-2.2279	-30.4269	-1.1429	-14.3028
Test critical values		10%: 2.568, 1%: 3.436		10%:2.575, 1%: 3.464	

2. Cointegration

For our analysis we employ a vector autoregression (*VAR*) model that consists of the first differences, or the rates of return to the underlying assets. In order to avoid

model misspecification, we check first whether a group of these $I(1)$ series are cointegrated or not, based on a vector error correction model (*VECM*).

The VECM for our analysis can be written as

$$\Delta X_t = \alpha(\beta^T X_{t-1} + c_1) + \alpha_\perp c_2 + \sum_{j=1}^{l} \Gamma_j \Delta X_{t-j} + \Phi Z_t + \varepsilon_t \quad , \quad t = 1, \ldots, n. \tag{1}$$

where $X_t = [DJIA_t,\ KOSPI_t,\ IRD_t,\ USD/KRW_t]^T$ and $Z_t = [\Delta USTB_t,\ \Delta KOTB_t]^T$ are the endogenous and exogenous variable vector respectively, and $\varepsilon_1, \ldots, \varepsilon_n$ are independent 4-dimensional Gaussian variables with mean 0, while $\alpha_\perp$ is the null space of α such that $\alpha^T \alpha_\perp = 0$. We estimate the adjustment coefficient vector α, the cointegrating vector β with intercept c_1, the short-run effect vector $\Gamma_1, \cdots, \Gamma_l$, the linear trend in VAR $\alpha_\perp c_2$, and the coefficient vector Φ associated with the exogenous variables. The lag length l has been chosen through *SBC*[1] and other information criteria like *AIC*[2].

In order to conduct the cointegration tests, we employ Johansen's method that uses the maximum likelihood estimator (*MLE*) for the reduced rank of $\Pi = \alpha\beta^T$. A number of cointegration is tested by testing significance of the restrictions implied by the reduced rank of Π. Since the number of eigenvalues of a matrix determines its rank, significance of r highest eigenvalues (trace test) or the $(5-r)$th highest eigenvalue (maximum eigenvalue test) implies that the rank of Π is at least $4-r$ and hence that there exist at most r conintegrations.

3. Fractional cointegration and non error-correction

Since the cointegrating vector β is not identified, it is possible to impose some identifying restrictions on the cointegrating coefficients (elements of the β) and/or on the adjustment coefficients (elements of the α). Imposing such restrictions is associated with following two important issues in VECM analysis.

First, we need to consider the possibility of fractional cointegration. Since it is

[1] *Schwartz Bayesian Criterion*.
[2] *Akaike Information Criterion*.

possible some of the cointegrating coefficients are 0, the tests for identification could be necessary. For this matter, various methods provide ways to test the null hypothesis that specific elements of β are jointly 0 against no restriction. However, theory says little about selection between two competing restrictions.

Second, we can think of the case that some of the adjustment coefficients are positive. In this case, effects of a shock on X are not disappeared and it has a balanced path rather than long-run equilibrium level, while $\beta^T X_t$ is stationary and $\alpha(\beta^T X_t + c_1)$ goes back to 0 in the long run. Actually, this kind of model is a cointegrated VAR model rather than a VECM. Thus, it is natural to impose the restriction of $\alpha_j \geq 0$ for j in our model.

4. Granger Causality

In order to check the short-term interdependence, we use Granger causality test; ΔX_{1t} Granger-causes if the later can be predicted by using past values of ΔX_{2t} with accuracy better than by not doing so.

In test practice, the null hypothesis 'ΔX_{1t} does not Granger-cause ΔX_{2t}' is not accepted if in partial regression for ΔX_{2t}, $\cdot_1, \cdots, \cdot_l$ are significantly different from zero individually as well as jointly, based on the standard tests (e.g., t-test and joint F-test for the significance of each and all, respectively).

. Results and Discussion

1. Interdependence before the crisis

1.1. Cointegration and Long-term interdependence

Given the common integrational properties of the variables, we then proceeded to test for the presence of cointegration by using Johansen and Juselius's multivariate MLE procedure. Schwarz Criterion (SC) suggests an optimal lag length of one for the entire Vector Error Correction Model system.

Results of Johansen and Juselius's LR tests are presented in Table 2 for the first sample period. They indicate quite consistently the presence of at most a single cointegrating vector among the set of the variables. This is concluded due to the evidence that the null hypothesis of r =0 is rejected at the 95% critical values by both tests. However, a similar finding is not observed for the null hypothesis of $r < 1$.

<Table 2> **Cointegration test**

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Prob.**	Max-Eigen Statistic	Prob.**
None*	0.0350	55.1268	0.0089	41.4377	0.0005
At most 1	0.0077	13.6891	0.8576	8.9707	0.8348
At most 2	0.0038	4.7184	0.8380	4.4773	0.8058
At most 3	0.0002	0.2411	0.6234	0.2411	0.6234

Imposing restriction $\alpha_{\perp}$=0, we found that in cointegration there is a long run positive relationship between DJIA and KOSPI. In other words, Korean stock market is positively related to the U.S stock market in the long run. There is also a long run positive relationship between DJIA and IRD which may be economically unreasonable because, usually, both stock price and short term interest rate go up in the economy boom.

Even though there is a long run negative relationship between DJIA and USD/KRW, there is a long run positive relationship between KOSPI and USD/KRW and between IRD and USD/KRW. It hardly finds exact direction of relationship between each stock price and exchange rate because usually the relative economic growth is an important factor to determine the exchange rate instead of economic growth in each country when we consider that the stock price is a proxy for economic growth.

On the other hand, the negative long run relationship between IRD and USD/KRW is possible in this sample period mainly because the USD/KRW decreased rapidly during the period when the FRB raised rapidly their target rate.

1.2. Granger causality and short-run interdependence

Meanwhile, in short term interdependences, there exist several statistically significant ones. Since the optimal lag is only one in this analysis, if the coefficient of

short-run effect is statistically significant, this indicates that there is a granger-cause relationship between two variables in a short run.

It is shown that the increase of DJIA leads (or granger cause) to the increase in KOSPI and the decrease in USD/KRW. While the increases of IRD and KOSPI lead to the decrease in USD/KRW, the increase of IRD leads to the increase in DJIA. Among them, the relationships between DJIA and KOSPI and between KOSPI and USD/KRW can be reasonable economically.

It is needless to say that there is positive interdependence between DJIA and KOSPI. On the other hand, if the KOSPI increases as the increase of the foreign investors' investments, the increase in KOSPI could decrease USD/KRW. Notice that there is not only a long run negative relationship between DJIA and USD/KRW, but also the increase of DJIA leads to the decrease of USD/KRW in a short run. This is possible that, in this period, while the U.S stock market was continued to be boom, USD/KRW was continued to decrease as the Korean economy recovered its strength.

1.3. Alternative models with pair-wise cointegration

As mentioned in the methodology, it is possible that we give some more restrictions in order to find more efficient model. We found that, when we make a model such that there is only pairwise cointegration relationship among 4 variables, the model efficiency is increased.

When we compare the results of pairwise relationships and the ones in the 4 variable- model, two pairwise relationships are reversed. Unlike benchmark model, there is a long run negative relationship between DJIA and IRD, and between KOSPI and USD/KRW (See Table 3).

<Table 3> Long run relationship in the VECM Estimation

	Model Ⅰ		Model Ⅱ		Model Ⅲ		Model Ⅳ	
	β	α	β	α	β	α	β	α
DJIA	20.4266	-0.0003	7.3062	-0.0009	8.2429	-0.0009	0	0
KOSPI	-8.1661	0	0	0	0	0	0.1660	-0.0059
IRD	-1.1575	-0.0012	0.8939	-0.0015	0	0	0	0
USD/KRW	2.0881	-0.0003	0	0	7.0779	-0.0006	0.4091	-0.0126
CONSTANT	-146.5546	-	-67.8561	-	-125.5601	-	-3.9977	-
x^2( )	14.7355(1)		29.7927(4)		28.9492(4)		35.6619(4)	

Those results are more economically reasonable. As already mentioned, DJIA increases with increasing U.S short term interest rate which can lead to the decrease of IRD. Since KOSPI goes up as the Korean economy is recovered, USD/KRW could decrease as KOSPI increases.

On the other hand, in short term interdependence, when we use pairwise restrictions, most results are similar. Only two more statistically significant relationships are added. The increase of DJIA could lead to the decrease of IRD and the increase of IRD could lead to the decrease of KOSPI (See Table 4).

<Table 4> Granger causality and short-run interdependence

	Model Ⅰ				Model Ⅱ			
	DJIA	KOSPI	IRD	USD/KRW	DJIA	KOSPI	IRD	USD/KRW
DJIA	-0.0666 (-2.4019)	0.4657*** (11.2792)	-0.0395 (-1.4264)	-0.0389*** (-3.0425)	-0.0655 (-2.3839)	0.4841*** (11.7509)	-0.0514* (-1.8589)	-0.0414*** (-3.2579)
KOSPI	0.0256 (1.3883)	-0.0232 (-0.8466)	0.0227 (1.2345)	-0.0321*** (-3.7751)	0.0269 (1.4638)	-0.0219 (-0.7943)	0.0227* (1.2345)	-0.0317*** (-3.7261)
IRD	0.0116 (0.3968)	-0.0652 (-1.4889)	0.0900 (3.0673)	-0.0260* (-1.9205)	0.0111 (0.3845)	-0.0873** (-2.0048)	0.1051 (3.5998)	-0.0260 (-1.9205)
USD/KRW	0.1179 (1.8704)	-0.0836 (-0.8907)	0.0289 (0.4602)	-0.0533 (-1.8341)	0.1134* (1.8014)	-0.0969 (-1.0261)	0.0338 (0.5341)	-0.0530 (-1.8216)
CONSTANT	0.0002 (0.7411)	0.0004 (1.0659)	-0.0008 (-2.8762)	-0.0003 (-2.2407)	0.0002 (0.7331)	0.0004 (0.9958)	-0.0008 (-2.8017)	-0.0003 (-2.213)
DLNUSR5YR	0.1965 (13.9217)	0.0400 (1.9038)	-0.0346 (-2.4526)	0.0033 (0.5049)	0.1970 (13.9706)	0.0401 (1.9000)	-0.0342 (-2.4099)	0.0034 (0.5320)
DLNKOR5YR	0.0099 (0.4179)	0.2417 (6.8749)	0.0366 (1.5526)	0.0371 (3.4103)	0.0102 (0.4349)	0.2453 (6.9474)	0.0344 (1.4514)	0.0366 (3.3691)

	Model Ⅲ				Model Ⅳ			
	DJIA	KOSPI	IRD	USD/ KRW	DJIA	KOSPI	IRD	USD/ KRW
DJIA	-0.0661 (-2.4040)	0.4817*** (11.7077)	-0.0526* (-1.9039)	-0.0405*** (-3.1955)	-0.0709 (-2.5861)	0.4865** (11.8474)	-0.0574** (-2.0766)	-0.0444*** (-3.0425)
KOSPI	0.0273 (1.4809)	-0.0237 (-0.8585)	0.0235 (1.2647)	-0.0309*** (-3.6334)	0.0272 (1.4762)	-0.0195 (-0.7060)	0.0195 (1.0449)	-0.0311*** (-3.6504)
IRD	0.0113 (0.3912)	-0.0844* (-1.9398)	0.1059 (3.6232)	-0.0239* (-1.7839)	-0.0167 (-0.5757)	-0.0896 (-2.0645)	0.1111 (3.8026)	-0.0196 (-1.4652)
USD/KRW	0.1160* (1.8441)	-0.0952 (-1.0113)	0.0383 (0.6045)	-0.0531 (-1.8309)	0.1203* (1.9134)	-0.1020 (-1.0831)	0.0449 (0.7080)	-0.0495 (-1.7065)
CONSTANT	0.0002 (0.7331)	0.0004 (1.0073)	-0.0008 (-2.7926)	-0.0003 (-2.2321)	0.0002 (0.7598)	0.0004 (0.9835)	-0.0008 (-2.7536)	-0.0003 (-2.1849)
DLNUSR5YR	0.1966 (13.9399)	0.0403 (1.9118)	-0.0348 (-2.4559)	0.0033 (0.5049)	0.1964 (13.9225)	0.0405 (1.9177)	-0.0350 (-2.4621)	0.0031 (0.4818)
DLNKOR5YR	0.0099 (0.4232)	0.2449 (6.9431)	0.0339 (1.4290)	0.0368 (3.3868)	0.0093 (0.3963)	0.2462 (6.9716)	0.0327 (1.3765)	0.0362 (3.3325)

2. Interdependence after the crisis

2.1 Cointegration and Long-term interdependence

Similar analysis is performed in the second sample period. Like previous analysis, the optimal lag has been chosen as order of one by the SBC criterion.

We found that there is at most a single cointegrating vector among the set of the Variables. Therefore, the cointegration results in the first and second sample periods are different with the recent study where there is no statistically significant long run relationship between U.S and Korean stock market. The results might be different because we consider a couple of more variables in this paper such as IRD and USD/KRW, which are considered to be important in the financial markets, and divide the sample periods into two.

When we do a cointegration test with only two stock market indices, we found that there is a cointegration relationship in the second period but there is none in the first period.

It is shown that the qualitative benchmark results are not much different with the ones in the first sample period. In the CI, the long run interdependence relationships among pairwise variables are qualitatively the same. There is a long run positive relationship between DJIA and KOSPI, between DJIA and IRD, between KOSPI and USD/KRW and between IRD and USD/KRW. But, there is a long run negative relationship between DJIA and USD/KRW.

<Table 5> **Cointegration test**

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Prob.**	Max-Eigen Statistic	Prob.**
None*	0.1590	48.4990	0.0434	33.2517	0.0084
At most 1	0.0542	15.2473	0.7638	10.7062	0.6765
At most 2	0.0233	4.5410	0.8554	4.5335	0.7992
At most 3	3.93E-05	0.0075	0.9303	0.0075	0.9303

<Table 6> Long run relationship in the VECM Estimation

	Model Ⅰ		Model Ⅱ		Model Ⅲ		Model Ⅳ	
	β	α	β	α	β	α	β	α
DJIA	78.9218	-0.0008	18.2646	-0.0043	14.4410	-0.0007	55.7900	0
KOSPI	-0.2752	0	0	0	0	0	-6.6292	0
IRD	14.0469	-0.0006	2.4157	-0.0027	0	0	0	-0.0003
USD/KRW	-63.3633	-0.0001	0	0	-8.5457	-0.0007	0	-0.0003
CONSTANT	-315.4715	-	-173.6767	-	-78.3662	-	-478.9715	-
x^2( )	21.8706(1)		24.4411(4)		-78.3662(4)		27.5832	

However, we can quantitatively evaluate the model fitted to the real data better than the one in the first sample period when we compare R squares between two results. Furthermore, when we compare the degree of coefficients, we evaluate that the effects in the second sample period are mostly much higher than the ones in the first sample period.

In table 7, we report the cointegration coefficients which are normalized so that it can express the relationship in terms of one of the variables as a dependant variable. When we compare the results of benchmark model (Model I), we find that there are several huge difference between two.

<Table 7> Normalized Cointegrating vector

Panel 1: $DJIA = a_0 + a_1 KOSPI + a_2 IRD + a_3 USD/KRW$

	Model Ⅰ		Model Ⅱ		Model Ⅲ		Model Ⅳ	
	1	2	1	2	1	2	1	2
DJIA	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-	1.0000
KOSPI	0.3998	0.0035	0.0000	0.0000	0.0000	0.0000	-	0.1188
IRD	-0.0567	-0.1780	-0.1223	-0.1323	0.0000	0.0000	-	0.0000
USD/KRW	0.1022	0.8029	0.0000	0.0000	-0.8587	0.5918	-	0.0000

Panel 2: $KOSPI = a_0 + a_1 DJIA + a_2 IRD + a_3 USD/KRW$

	Model Ⅰ		Model Ⅱ		Model Ⅲ		Model Ⅳ	
	1	2	1	2	1	2	1	2
DJIA	2.5014	286.7798	-	-	-	-	0.0000	8.4158
KOSPI	1.0000	1.0000	-	-	-	-	1.0000	1.0000
IRD	0.1417	51.0425	-	-	-	-	0.0000	0.0000
USD/KRW	-0.2557	-230.2445	-	-	-	-	-2.4645	0.0000

Panel 3: $IRD = a_0 + a_1 DJIA + a_2 KOSPI + a_3 USD/KRW$

	Model Ⅰ		Model Ⅱ		Model Ⅲ		Model Ⅳ	
	1	2	1	2	1	2	1	2
DJIA	-17.6472	-5.6184	-8.1734	-7.5608	-	-	-	-
KOSPI	7.0549	0.0196	0.0000	0.0000	-	-	-	-
IRD	1.0000	1.0000	1.0000	1.0000	-	-	-	-
USD/KRW	1.8040	4.5108	0.0000	0.0000	-	-	-	-

Panel 4: $USD/KRW = a_0 + a_1 DJIA + a_2 KOSPI + a_3 IRD$

	Model Ⅰ		Model Ⅱ		Model Ⅲ		Model Ⅳ	
	1	2	1	2	1	2	1	2
DJIA	9.7824	1.2455	-	-	-1.1646	1.6899	0.0000	-
KOSPI	-3.9108	-0.0043	-	-	0.0000	0.0000	-0.4058	-
IRD	0.5543	0.2217	-	-	0.0000	0.0000	0.0000	-
USD/KRW	1.0000	1.0000	-	-	1.0000	1.0000	1.0000	-

First, consider that the net effect of KOSPI on DJIA. While in the first sample period, 1% increase of DJIA increase only 2.5% of KOSPI, it increase 286.8% of KOSPI in the second sample period. Therefore, even though the qualitative result is the same, it should be true that the interdependence between two stock markets has been much strengthened since the subprime mortgage crisis began.

In fact, this higher interdependence is appeared because, when the crisis has been realized, foreign investors sell off in the Korean stock market and exchange won to dollar to bring the money to home countries. The proportion of foreign investors' equity ownership, which once hovered above 40% (42% in 2004), fell to around 32.3% as of the end of 2007.

Based on this phenomenon of foreign investors, we expect that the change of KOSPI should more affect exchange rate after subprime mortgage problem than before subprime mortgage problem.

In the Panel 4, it is shown that, when 1% of KOSPI increases, USD/KRW decreased by 3.9% in the first sample period but decreased by only 0.004% in the second sample period. While increasing the net effect of KOSPI on USD/KRW, the net effect of IRD and DJIA on USD/KRW decreased after the second sample period. While 1% of DJIA increases 9.7% and extend the IRD 0.56% in the first sample period, it increases only 1.24% and extend the IRD 0.22% in the second sample period.

2.2. Granger causality and short-run interdependence

The short term interdependences are also qualitatively similar. The only difference is that the increase of USD/KRW does not lead the increase of DJIA statistically significantly any more, but the increase of DJIA and KOSPI leads the decrease of IRD. This result is possible in this sample period because both stock markets collapsed after the subprime mortgage crisis and the U.S short term interest rate decreased as the FRB cut off their target rate.

Similarly, we also gave some restrictions in the analysis of the second sample period, but the long run relationships are much more similar and robust. The short term relationship did not change much.

Meanwhile, the net short term effect is found to be larger in the second sample periods than in the first sample periods when we compare the coefficients of them quantitatively.

. Conclusion

This paper examined whether there is the long and short run interdependence in the U.S and Korean financial Markets. Especially, we have focused on study whether some relationships are changed before and after subprime mortgage turmoil began. For this analysis, we consider the four variables in the Error Correction model; DJIA, KOSPI, IRD, USD/KRW.

We find that, in the both periods, there is one cointegration relationship among those variables. Qualitative long run relationships are mostly similar when we compare the results between two periods. However, qualitatively, the degree of net effect changed significantly.

Most importantly, we found that the net effects of DJIA on KOSPI and KOSPI on USD/KRW have increased. Those results are consistent with what financial analysts' recent claim that the huge size of capital outflows of foreign investors from Korean stock market affect on the stock market collapsed and won/dollar exchange rates soar.

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