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Financial Transmission Mechanism between Financial Centers and Peripheries

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The causes of contagion effects during periods of crisis are still unable to be fully explained by fundamental factors. This paper focuses on non-fundamental explanatory factors such as financial centers' shock amplification effects induced by global portfolio investors and extends Kaminsky and Reinhart (2003)'s center-periphery framework by introducing three time zones for the analysis of conditional distribution of 37 countries' daily stock returns from 1994 to 2003, and accessibility of stock markets to investigate if financial centers stabilize or amplify shocks. Centers such as U.S. and Germany played a vital role in propagating turmoil in G7 countries and spreading shocks to countries in other regions during periods of crisis, whereas Japan amplified turmoil in Asian peripheries only within the same region. In contrast, an emerging center, Hong Kong, appears to have much stronger shock-amplification effects on developing countries than the three centers.

Keywords: *financial center, stock markets, and contagion.*

Introduction

The propagation of Latin American financial crises of the 1980s, in which U.S. banks played an important role in transmitting shocks, was limited within Latin American countries. Financial crises of 1990s, however, more strongly affected other countries' economy and traversed their regional border. Consequently, "contagion" of financial shocks rapidly became an essential word, and was variously defined in different ways (Doukas, 1989; Eichengreen, Rose & Wyplosz, 1996; Valdés, 1997). Thus, one of the most interesting aspects of the contagion debate is the disagreement over a precise definition (Bekaert, Harvey, & Ng, 2005). This paper defines a change in conditional distribution of returns as a method to evaluate contagion effects. Since most of literature except Kaminsky and Reinhart (2003) rarely pays attention to a change in conditional distribution of returns as a method to evaluate contagion effects, this paper contributes to further analysis on contagion effects.

When did financial transmission mechanism begin to work more contagiously? What factor amplified contagion effects from the origin during the Asian, Russian, and Latin American crises? The onset of the Asian crisis

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episode began in Thailand in July 1997. Due to massive speculative attacks as well as to hasty reduction in foreign banks' exposures, especially Japanese banks', Asian emerging countries toppled like dominoes. The Russian crisis of 1998 more broadly dispersed most emerging markets, accompanied by the collapse of the Long-Term Capital Management (LTCM). This engulfed the U.S. financial market, the largest financial center in the world. Because of geographical links with Russia, the German economy was severely damaged by the spillover effects of the Russian crisis. Brazil devalued the Real and eventually floated on February 1, 1999. The Brazilian Real was depreciated by 70 percent, leading to high volatility in some of larger equity markets and as a result Argentine risk premium spreads widened. The causes of contagion effects of these crises were unable to be fully explained by fundamental factors, e.g., trade-link.

This paper, therefore, focuses on non-fundamental explanatory factors such as a financial center's shock amplification effects induced by global portfolio investors and tries to investigate if financial centers stabilize or amplify shocks from developing countries and from themselves. This paper extends Kaminsky and Reinhart (2003)'s center-periphery framework by introducing three time zones for the analysis of conditional distribution of stock returns, three times longer sample periods, and accessibility to stock markets. Although financial centers provide liquidities and thus normally stabilize financial shocks, they could accelerate flight-to-quality effects on peripheries, particularly during financial crises due to the globalization (Kaminsky & Reinhart, 2003; Pavlova & Rigobon, 2008). The results of this paper suggest that the major financial centers could play a vital role in the propagation of turmoil. But the patterns of propagation vary by financial center; the magnitude of propagation is time-variant. Overall, the results are in some points similar to Kaminsky & Reinhart (2003), but the results of this paper are more robust and significant. Furthermore, I find an emerging financial center such as Hong Kong played an important role in scattering financial shocks of periphery over the developing countries.

Literature Review

Contagion effects of shocks are defined in various ways: (1) a rise in the probability of a speculative attack on the domestic currency derived not from domestic fundamentals but from the existence of a speculative attack elsewhere in the world (Eichengreen, et al., 1996); (2) a systematic risk element enters into the default risk perceptions of lenders (Doukas, 1989); and (3) excess co-movement in asset returns across countries (Valdés, 1997). This paper investigates the existence of contagion as a change in conditional distribution of stock index returns.

This research focus on two views on contagion effects: contagion between center and peripheries and contagion due to more globalized stock markets. This paper considers the three types of contagion paths between a center and peripheries, namely, (1) a periphery to another periphery through a center; (2) a center to peripheral countries; and (3) a periphery to another periphery. A center is the largest economy in a region, which has the financial center such as U.S., Japan, and Germany. Other countries, especially developing countries, are regarded as peripheries.

Shocks from one periphery country to another can be propagated through a center or amplified by a center. Asymmetric information and liquidity problems in the financial center, indicates that frequent margin calls results in an increase in the shortage of the liquidity (Calvo, Bour, Heymann, & Navajas, 2004). For instance, Mexican Net Asset Values (mostly operated by Mexican investors) declined more rapidly than the prices of Mexican funds (mostly operated by international investors). This implies the causality between the Mexico City investors (a periphery) to the Wall Street investors (a center) (Frankel & Schmukler, 1996). Furthermore, a financial turbulence in Brazil, Russia, and Thailand only spreads universally when it affects asset markets in at least one financial center (Kaminsky & Reinhart, 2003). When financial shocks are propagated through a banking channel, spillovers through bank lending, so-called a common lender effects, can also contribute to the explanation for contagion effects (Van Rijckeghem & Weder, 1999). Common creditors, U.S., Japan, and Germany, played a prominent role in spreading the Mexican, Asian, and Russian Crises, respectively (Caramazza, Ricci, & Salgado, 2004). The above empirical results are supported by theoretical work that uses dynamic equilibrium model in which the center's agents face portfolio constraints (Pavlova & Rigobon, 2008).

Shocks from a center to a periphery country may have catastrophic impacts on the periphery if they lead to a systemic risk. The definition of systemic risk is also actively debated (Bartholomew, 1998). The simultaneous occurrence of currency crises might be derived from a common shock from a financial center. In the early 1980s, for instance, an increase in U.S. interest rates was an important factor in the Latin American debt crisis. A rally in U.S. interest rates in 1994 may similarly have played a role in the Mexican crisis. Also, the rapid appreciation of the U.S. dollar during the mid of the 1990s and Japan's weak growth and turbulence may have contributed to the weakening of the external sectors in several Asian countries (Calvo, Leiderman, & Reinhart, 1996).

In the case of the transmission of shocks from one periphery to another, a speculative attack against one currency may accelerate the warranted collapse of a second party (Gerlach & Smets, 1995). Moreover, a financial crisis will negatively affect all trading partners with strong connections of bilateral trade. Thus, the patterns of international trade are imperative to examine how currency crises spread beyond any macroeconomic factors (Glick & Rose, 1998). However, these trade linkages only partially explain the reaction of stock markets to crises (Forbes, 2002).

Contagion effects of stock market returns might be time-variant due to the rapid development of globalization and market integration. As the proportion of volatility of stock returns is driven by global, regional, and local factors, contagion effects in Europe, Southeast Asia, and Latin America and in a crisis period and non-crisis period are different (Bekaert, et al., 2005). Therefore, I examined the three center-periphery paths not only during the crisis but before and after the period to see if contagion effects were time-variant.

The cause of propagation of extreme stock returns could be different between developed and developing world. Asymmetric market frictions such as wealth constraints lead to crises propagation in emerging markets, whereas asset re-allocation of globalized investors could act as a channel for crises to spread for developed markets (Boyer, Kumagai, & Yuan, 2006). For example, macroeconomic announcements and other public information do not affect co-movements of Japanese and American stock markets (Connolly & Wang, 2003; Karolyi & Stulz, 1996). Observable economic variables explain only a small fraction of international stock market co-movements (King, Sentana, & Wadhwani, 1994). When investors suffer a large loss in investment in the crisis country, they may have to liquidate their positions in other countries and thus cause equity prices to depreciate in these other countries (Kyle & Xiong, 2001).

The magnitude of propagation might depend on openness of domestic stock markets among developing countries. During high volatility periods, greater co-movement with crisis country index returns was observed for the returns of stocks that can be purchased by foreigners than the returns of stocks that cannot be purchased by foreigners. Thus, crises spread through the asset holdings of international investors rather than through changes in fundamentals (Boyer, et al., 2006).

Data Specification

A whole sample period is from September 1, 1994 to December 31, 2003.

Table 1. Descriptive Statistics

	Counrty	Index	Market Capitalization (billion USD)	Accessibility		Stock Index Returns					
				Accessible Percentage	Inaccessible Percentage	Full sample			Crisis Period		
						Mean	5th	95th	Mean	5th	95th
ASIA OCEANIA	HONG KONG	Hang Seng	413.3	100.0%	0.0%	1.2%	-2.6%	2.6%	1.6%	-3.7%	3.7%
	INDONESIA	Jakarta SE Composite	29.1	97.7%	2.3%	1.1%	-2.5%	2.6%	1.6%	-3.9%	4.4%
	MALAYSIA	Kuala Lumpur Composite	93.6	93.6%	6.4%	1.0%	-2.4%	2.3%	1.7%	-3.6%	3.6%
	PHILIPPINES	Philippines SE Composite	31.4	48.3%	51.7%	1.0%	-2.3%	2.3%	1.4%	-3.3%	3.2%
	SINGAPORE	Singapore Straits Times	106.3	100.0%	0.0%	1.0%	-2.1%	2.1%	1.3%	-2.9%	2.9%
	SOUTH KOREA	Korea SE Composite (KOSPI)	46.1	54.5%	45.5%	1.5%	-3.5%	3.6%	2.0%	-4.4%	5.3%
	TAIWAN	Taiwan SE Weighted	287.8	39.5%	60.5%	1.2%	-2.6%	2.8%	1.2%	-2.6%	2.7%
	THAILAND	Bangkok S.E.T.	23.5	47.0%	53.0%	1.3%	-2.7%	2.9%	1.8%	-3.5%	4.6%
	AUSTRALIA	ASX All Ordinaries	295.8	100.0%	0.0%	0.6%	-1.2%	1.3%	0.7%	-1.4%	1.4%
LATIN AMERICA	ARGENTINA	MERVAL	59.3	99.6%	0.4%	1.6%	-3.9%	3.8%	1.6%	-4.3%	3.5%
	BRAZIL	BOVESPA	255.5	86.8%	13.2%	1.7%	-3.8%	3.5%	2.1%	-4.8%	4.3%
	CHILE	Santiago Selective (IPSA)	72.0	98.9%	1.1%	0.8%	-1.7%	1.9%	1.0%	-2.3%	2.4%
	COLOMBIA*	Colombia SE Index	19.5	79.5%	20.5%	0.7%	-1.6%	1.8%	0.8%	-2.0%	2.2%
	MEXICO	Mexico IPC (BOLSA)	156.6	94.8%	5.2%	1.2%	-2.5%	2.8%	1.3%	-2.8%	3.1%
	PERU	Lima SE General (IGBL)	17.6	93.6%	6.4%	0.8%	-1.6%	1.8%	0.9%	-2.0%	1.9%
	VENEZUELA	Caracas SE General	14.6	91.2%	8.8%	1.2%	-2.4%	2.9%	1.5%	-4.0%	3.3%
EASTERN EUROPE (TRANSITION)	CZECH	PX 50	12.8	37.7%	62.3%	0.9%	-2.0%	2.0%	0.9%	-2.3%	2.0%
	HUNGARY	BUX	15.0	99.5%	0.5%	1.2%	-2.4%	2.7%	1.6%	-3.6%	3.5%
	POLAND	Warsaw General Index	12.1	100.0%	0.0%	1.2%	-2.7%	2.9%	1.3%	-3.0%	3.0%
	RUSSIA	Moscow Times Index (RUR)	128.2	63.3%	36.7%	2.0%	-4.4%	5.1%	3.0%	-6.7%	7.9%
	SLOVAKIA	SAX 16	1.8	86.2%	13.8%	0.9%	-2.2%	2.0%	1.0%	-2.5%	2.2%
EUROPE	AUSTRIA	Austrian Traded Index	35.7	100.0%	0.0%	0.7%	-1.5%	1.5%	0.9%	-2.2%	1.9%
	BELGIUM	BEL 20	137.0	100.0%	0.0%	0.8%	-1.9%	1.7%	0.8%	-1.9%	1.8%
	DENMARK	KFX	93.8	100.0%	0.0%	0.8%	-1.7%	1.8%	0.9%	-1.9%	1.8%
	FINLAND	HEX General	73.3	100.0%	0.0%	1.5%	-3.4%	3.5%	1.3%	-2.9%	2.8%
	NETHERLANDS	Amsterdam SE AEX	468.7	100.0%	0.0%	1.0%	-2.4%	2.4%	1.2%	-2.4%	2.5%
	SPAIN	Madrid SE General	290.4	100.0%	0.0%	0.9%	-2.0%	2.1%	1.0%	-2.1%	2.3%
	SWEDEN	Stockholmsborsen All Share	272.7	100.0%	0.0%	1.0%	-2.2%	2.2%	1.0%	-2.1%	1.9%
	SWITZERLAND	Swiss Market	575.3	100.0%	0.0%	0.9%	-2.0%	1.9%	1.0%	-2.2%	2.1%
	TURKEY	ISE National 100	61.1	100.0%	0.0%	2.2%	-4.5%	4.9%	2.4%	-5.3%	5.4%
G7	CANADA	S&P/TSX Composite index	567.6	100.0%	0.0%	0.7%	-1.5%	1.5%	0.7%	-1.6%	1.5%
	FRANCE	CAC 40	674.4	100.0%	0.0%	1.1%	-2.4%	2.3%	1.1%	-2.4%	2.3%
	GERMANY	DAX 30	825.2	100.0%	0.0%	1.2%	-2.6%	2.5%	1.2%	-2.5%	2.2%
	ITALY	MIBTEL	344.7	100.0%	0.0%	1.0%	-2.2%	2.2%	1.2%	-2.4%	2.5%
	JAPAN	Tokyo SE (TOPIX)	2216.7	100.0%	0.0%	0.9%	-2.0%	2.0%	0.9%	-2.0%	2.2%
	U.K.	FTSE 100	1996.2	100.0%	0.0%	0.8%	-1.8%	1.8%	0.9%	-1.9%	1.9%
	U.S.	S&P 500 Composite	11308.8	100.0%	0.0%	0.8%	-1.8%	1.8%	0.9%	-1.8%	1.9%

Souces: Boyer, Kumagai, and Yuan (2008), Datastream, and World Bank Development Indicator
Note: Mean is the average daily percent returns of absolute values. 5th and 95th are the 5th and 95th percentiles of daily percent returns, respectively. Market capitalization is Market capitalization of listed companies as of the end of 1997. Full sample is from September 1, 1994 to December 31, 2003. A crisis period is January 1, 1997 - August 31, 1999

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Table 2. Trading Hour of Stock Market

	Time Zone	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21 (GMT)
HONG KONG	1						■	■	■	■	■	■														
INDONESIA	1						▐	■	■	■	■	■	■													
MALAYSIA	1					■	■	■	■	■	■	■	■													
PHILIPPINES	1					▐	■	■																		
SINGAPORE	1					■	■	■	■	■	■	■	■													
SOUTH KOREA	1				■	■	■	■	■	■																
TAIWAN	1					■	■	■	■	▌																
THAILAND	1							■	■	■	■	■	■	■												
AUSTRALIA*	1				■	■	■	■	■	■																
ARGENTINA	3																	■	■	■	■	■				
BRAZIL*	3																			■	■	■	■	■	■	
CHILE *	3																	▐	■	■	■	■	▌			
COLOMBIA	3																			■	■	▌				
MEXICO*	3																			▐	■	■	■	■	■	
PERU	3																		■	■	■	■	■	■	■	
VENEZUELA	3																		▐	■	■	■	■			
CZECH*	2												▐	■	■	■	■	■	■							
HUNGARY*	2												■	■	■	■	■	■	■	▌						
POLAND*	2													■	■	■	■	■	■							
RUSSIA*	2												■	■	■	■	■	■	■							
SLOVAKIA*	2												■	■	■	■	■	■	■	■						
AUSTRIA*	2												▐	■	■	■	■	■	■	■	▌					
BELGIUM*	2												■	■	■	■	■	■	■	■	▌					
DENMARK*	2												■	■	■	■	■	■	■	■	▌					
FINLAND*	2												■	■	■	■	■	■	■	■						
NETHERLANDS*	2												■	■	■	■	■	■	■	■	▌					
SPAIN*	2												■	■	■	■	■	■	■	▌						
SWEDEN*	2												▐	■	■	■	■	■	■	■	▌					
SWITZERLAND*	2												■	■	■	■	■	■	■	■	▌					
TURKEY*	2											▐	■	■	■	■	■	■	▌							
CANADA*	3																		▐	■	■	■	■	■	■	■
FRANCE *	2												▐	■	■	■	■	■	■	■	▌					
GERMANY*	2												▐	■	■	■	■	■	■	■	▌					
ITALY*	2												▐	■	■	■	■	■	■	■	▌					
JAPAN	1				■	■	■	■	■	■																
U.K.*	2												■	■	■	■	■	■	■	■	▌					
U.S.*	3																		▐	■	■	■	■	■	■	

Source: Bloomberg, Reuters, and Time and Date.com (http://www.timeanddate.com/)
* Countries which advance the clocks by one hour during the summer owing to introducing Daylight Saving Time
(i.e. Their markets are opened and closed earlier by an hour during the summer than during the winter described above)

The daily returns of thirty-seven countries' stock indices in local currency were collected from Datastream (Table 1). The total number of one economy's samples is 2435. The sample period is divided into three periods: pre-crisis (September 1, 1994 - December 31, 1996), crisis (January 1, 1997 - August, 31 1999), post-crisis (September 1, 1999 to December 31, 2003).

Samples are categorized into five groups. The first group is the G7 countries, composed of Canada, France, Germany, Italy, Japan, United Kingdom, and the United States; another group is transition economies, which include Czech Republic, Hungary, Poland, Russia, and Slovakia. The other three groups are divided by region. The Asia-Oceania group consists of the larger economies in the region, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Australia; The Latin American team includes Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela; the European party contains Austria, Belgium, Denmark, Finland, Netherlands, Spain, Sweden, Switzerland, and Turkey.

Market capitalization is year 1997's

data in nominal U.S. dollar from the World Development Indicators. The market capitalization was the largest in U.S. (11.3 trillion) and the smallest in Slovakia (1.8 billion). Hong Kong's market capitalization was the largest of non-OECD countries (413.3 billion). This is approximately a half of Germany's (825.2 billion) and a quarter of Japan's (2216.7 billion). The accessible stock share (accessibility) was the value of stocks that foreign investors could invest in divided by market capitalization in 1997, cited from Boyer, et al. (2006). Colombia had the lowest accessible stock share in Latin American countries, but it was still 79.5 percent. In contrast, the accessible stock share was clearly separated between high groups (from 86.2 to 100 percent) and low groups (from 37.7 to 63.3 percent) in Asian and Transition.

Methodology

This paper examines whether or not turmoil in one country prompts other countries to take anomalous action, which is defined as a change in distribution of the returns of a stock index. Turmoil is defined as the fact that the daily stock indices of a country record the extreme returns, which is less than the 5th or more than the 95th percentile of the distribution, following Kaminsky and Reinhart (2003). Smirnov Test (Kolmogorov-Smirnov Two Samples Goodness of Fit Test) was implemented to test whether one distribution was identical to the other distribution (Conover, 1980). Since Smirnov Test is a nonparametric method, there is no assumption of any specific sample distribution. I defined the test as follows: Let $S_1(x)$ be the empirical cumulative distribution function of the stock index returns of country j on the days of turmoil in country i; let $S_2(x)$ be the empirical cumulative distribution function of the stock index returns of country j on the days without turmoil in country i.

Test Statistics:

$$T = \max_{-\infty < x < \infty} \left| S_1(x) - S_2(x) \right|$$

H_0 : $S_1(x)=S_2(x)$ for all x from $-\infty$ to $+\infty$
H_1 : $S_1(x) \neq S_2(x)$ for at least one value of x

The null hypothesis *Ho(x)* will be rejected if the p-value of the Smirnov Test Statistics was five or below five percent. Through the above test, the distribution of stock return in country j on the days turnmoil in country i will be compared with the distribution of stock returns in country j on the days of no turnmoil in country i. If there was a significant difference between the two distributions, then can be stated that turnmoil in country i resulted into anomalous returns in country j.

This paper examines whether turmoil in a peripheral country affects another country through a financial center as follows. To see the impact of anomalous Thai stock returns on U.S. through Japan, the U.S. samples were divided into (1) days of no turmoil in Thailand and Japan (2) days of turmoil in Thailand and in Japan (3) days of turmoil in Thailand but no turmoil in Japan. Smirnov test for the two distributions of stock returns during (1) and (2) indicated whether turmoil in Thailand affected the distribution of the U.S. stock returns when the Japan's stock index returns were anomalous; Smirnov test for the two distributions of stock returns during (1) and (3) exhibited whether turmoil in Thailand affected the distribution of the U.S. stock returns when the Japan's stock index returns were relatively stable. The comparison of the two test statistics checked if turmoil in Japan amplified turmoil in Thailand.

Since a country's stock market is not open for 24 hours, we need to consider trading hours of the stock markets (Table 2). For example, turmoil in Japan affects the U.S. stock price on the same day, whereas turmoil in U.S. has an impact on the Japan's stock return on the next day, not on the same day. Thus, we must adjust a date to test the U.S. contagion effect on Japan. To solve this problem, I divided a day into three time zones. This modification minimized overlapped trading hours across stock markets that belonged to different time zones. If a country *i*'s time zone was later than a country *j*'s, the distribution of stock returns in country *j* on the next days of turmoil in country *i* was compared with the distribution of stock returns in country *j* on the next days of no turmoil in country *i*.

Based on the above test statistics, this paper examines three types of hypotheses. First, the validity of wealth constraint effects will be considered, which works during the downturn of the market. The percentage of countries the stock return distribution of which turnmoil in a country A changes (β) also will be estimated.

Test Hypothesis 1A (Wealth Constraint vs. Portfolio Rebalancing): *Turmoil in a periphery A more severely propagates another periphery during a crisis than during a non-crisis period due to wealth constraints.*

Test Hypothesis 1B (Wealth Constraint vs. Portfolio Rebalancing): *Turmoil in a center A more severely propagates another country during a crisis than during a non-crisis period due to wealth constraints*.

$$H_0 : \beta_{\text{A, crisis}} - \beta_{\text{A, non-crisis}} \leq 0$$
$$H_1 : \beta_{\text{A, crisis}} - \beta_{\text{A, non-crisis}} > 0$$

If Hypothesis 1A is true and 1B is false, my result follows Boyer, et al. (2006). If both hypotheses are rejected despite high significance of test statistics for contagion effects, cross-market portfolio holding effects dominates wealth constraint effects.

Second, examining centers' amplification effects predicted by Pavlova and Rigobon (2008).

Test Hypothesis 2 (Center-Amplification Effects) *During days of turmoil in a center, a periphery A's turmoil have more significant contagion effects on other peripheral countries than during days of no turmoil in the center*.

$$H_0 : \beta_{\text{A, turmoil in center}} - \beta_{\text{A, no turmoil in center}} \leq 0$$
$$H_1 : \beta_{\text{A, turmoil in center}} - \beta_{\text{A, no turmoil in center}} > 0$$

Third, This research also considered if shock propagation was fundamental-based or international investor -induced contagion effects, following the concept of Boyer, et al. (2006). If high accessibility of foreign investors to stock market led to high influence on the distribution of stock returns, i.e., correlation (ρ) between accessible stock share and (1 - T) was positive, this could imply the existence of investor-induced contagion effects. If, despite low accessibility of foreign investors to stock market, there was high influence on the distribution of stock returns, i.e., correlation (ρ) between accessible stock share and (1 - T) was negative, this could imply the existence of other types of contagion effects such as fundamental-induced contagion effects.

Test Hypothesis 3 (Investor-Induced Hypothesis) *Turmoil in a center more strongly affects a periphery A that has the high share of accessible stocks than another periphery that has the low share of accessible stocks*.

$$H_0 : \rho_A \leq 0$$
$$H_1 : \rho_A > 0$$

Result and Discussion

First, shock from a center to a periphery will be examined. Table 3 shows the percentage of countries a financial center's turmoil had significant contagion effects on. Developed countries consisted of G7, Australia, and European countries except Turkey; developing countries comprises the rest of the countries. In the table, The

Table 3. Propagation of Center's Turmoil

	JAPAN				GERMANY				U.S.			
	All	Before	Crisis	After	All	Before	Crisis	After	All	Before	Crisis	After
ASIA, OCEANIA	100	22	56	78	44	0	33	22	89	33	33	44
LATIN AMERICA	14	0	0	0	57	0	57	29	57	0	71	43
TRANSITION	60	0	40	20	80	0	80	60	80	20	60	60
EUROPE	100	0	89	22	89	89	100	89	100	22	67	56
G7	83	29	71	29	100	33	67	100	100	67	33	83
TOTAL	75	11	54	33	73	28	67	60	86	29	52	56
Financial Center	G	-	G	-	J, U	-	-	J, U	J, G	-	G	J
Developed Country	93	19	81	31	100	60	80	100	100	47	53	73
Developing Country	62	5	33	33	52	5	57	29	76	14	52	43

Note: The values are the percentage of countries, which are affected by turmoil in a financial center, divided by the number of group members except itself. J, G, and U means Japan, Germany, and U.S., respectively. Sample periods for "All", "Before", "Crisis", and "After" are September 1994 - December 2003, September 1994 - December 1996, January 1997 - August 1999, September 1999 - December 2003, respectively.

research find the strong relationships between financial center and peripheral countries in the same region. Turmoil in Japan affected all the Asian and Oceanic countries. Turmoil in Germany had a large impact on transition economies (80%) and European countries (89%) than on those in other regions. Of the three financial centers, turmoil in U.S. most strongly affected the Latin American countries. In fact, U.S. more powerfully affected the Asian countries than the Latin American ones. Turmoil in financial centers affected developed countries well. To the extent of contagion effects among centers, turmoil in Japan did not significantly affect that in U.S. (p-value 0.06), while turmoil in U.S. caused Japan's stock markets to behave anomalously. Although the developed countries' stock markets are well-integrated and open to foreign investors, my results show the Japan's stock market was slightly isolated. The total percentage of countries affected by turmoil in Japan, Germany, and U.S. were 75, 73, and 86 percent, respectively. The magnitude of shock may have corresponded with the market capitalization.

Since contagion effects appeared to be stronger during a crisis period than during non-crisis periods, centers (especially Japan) had wealth constraint effects (Hypothesis 1B is true). However, if we compare a crisis period with a post-crisis period for Germany and U.S., the difference is very small. Thus, cross-market portfolio holding effects might dominate wealth constraint effects for the two countries than for Japan.

Second, This research also investigated how turmoil in a peripheral country affected turmoil in other countries in the unconditional or conditional cases of turmoil in a financial center of the same region (Table 4). The "All days" column shows the percentage of countries on which a periphery's turmoil has significant contagion effects, in the whole sample period. The "Turmoil" column reflects the results of Smirnov test for the two distributions of stock returns during days of no turmoil in a periphery and a center and during days of turmoil in a periphery and a center. Similarly, the "No turmoil" column reflects the results of Smirnov test for the two distributions of stock returns during days of no turmoil in a periphery and a center and during days of turmoil in a periphery but no turmoil in a financial center. For instance, the percentage of transition countries on which turmoil in Thailand has significant contagion effects during days of turmoil in Japan was 40 percent.

Table 4. Propagation of Periphery's Turmoil via Center

ASIA, OCEANIA	THAILAND All Days	THAILAND Turmoil in Japan	THAILAND No Turmoil in Japan	HONG KONG All Days	HONG KONG Turmoil in Japan	HONG KONG No Turmoil in Japan	INDONESIA All Days	INDONESIA Turmoil in Japan	INDONESIA No Turmoil in Japan
ASIA, OCEANIA	88	88	50	100	100	100	88	88	88
LATIN AMERICA	43	29	29	86	0	100	47	14	47
TRANSITION	100	40	60	80	60	80	40	40	40
EUROPE	22	67	33	100	67	89	67	56	44
G7	43	29	14	86	57	57	29	14	0
TOTAL	56	53	36	92	58	86	57	45	45
Financial Center	J	J	G	J, G	J	G	G	J	-
Developed Country	38	56	19	94	63	81	50	44	31
Developing Country	70	50	50	90	55	90	60	45	55

TRANSITION	CZECH All Days	CZECH Turmoil in Germany	CZECH No Turmoil in Germany	RUSSIA All Days	RUSSIA Turmoil in Germany	RUSSIA No Turmoil in Germany	TURKEY All Days	TURKEY Turmoil in Germany	TURKEY No Turmoil in Germany
ASIA, OCEANIA	22	67	22	78	67	78	22	44	0
LATIN AMERICA	71	29	43	100	57	57	0	71	0
TRANSITION	100	60	60	80	60	80	80	60	20
EUROPE	100	100	11	89	100	11	100	100	11
G7	86	100	0	29	71	29	71	86	0
TOTAL	72	74	23	76	73	48	53	72	5
Financial Center	G, U	J, G, U	-	-	G	-	G	G, U	-
Developed Country	94	94	6	56	81	13	81	88	0
Developing Country	57	57	38	90	67	76	33	62	10

LATIN AMERICA	MEXICO All Days	MEXICO Turmoil in U.S.	MEXICO No Turmoil in U.S	ARGENTINA All Days	ARGENTINA Turmoil in U.S.	ARGENTINA No Turmoil in U.S	BRAZIL All Days	BRAZIL Turmoil in U.S.	BRAZIL No Turmoil in U.S
ASIA, OCEANIA	67	67	33	89	56	22	89	44	22
LATIN AMERICA	100	43	86	100	43	86	100	57	100
TRANSITION	100	40	60	60	40	20	60	20	20
EUROPE	44	100	0	67	67	0	33	78	0
G7	57	71	29	43	71	0	57	43	29
TOTAL	69	68	37	72	57	23	67	51	31
Financial Center	J, U	J, G, U	J	U	J, G, U	-	G, U	J, U	G
Developed Country	50	88	19	57	69	0	50	57	13
Developing Country	86	52	52	86	48	43	81	48	48

Note: A sample period is from September 1, 1994 to December 31, 2003. Values are the percentage of countries, which are affected by turmoil in a peripheral country, divided by the number of group members except itself. J, G, and U means Japan, Germany, and U.S., respectively.

Germany and U.S. appeared to have center-amplification effects, particularly on developed countries. During days of turmoil in Germany, in Turkey affected 72 percent, while during days of no turmoil in Germany it affected only 5 percent of them. Germany's amplification effects on developed countries were more obvious. During days of turmoil in Germany, in Turkey affected 88 percent of developed countries, while during days of no turmoil in Germany it had no contagion effect. Results of Czech, Russia, Mexico, Argentina, and Brazil were similar. But German and U.S. amplification effects on developing countries were ambiguous. Thus, in the case of Germany and U.S., Hypothesis 2 was valid for developed countries.

In contrast, Japan's center-amplification effects were weak. Turmoil in Thailand on the days of turmoil in Japan fomented more anomalous stock returns of other countries except that of transition economies. In other Asian countries, the percentages of countries affected by the extreme stock returns of Indonesia were 45 percent, regardless of the Japan's stock returns. Thus, this implies Hypothesis 2 cannot be applied for Japan. Results of Hong Kong are puzzling. Hong Kong's turmoil had more significant contagion effects on other countries when Japan did not encounter turbulence in the domestic stock market. In fact, Hong Kong's contagion effects dominated all of Japan's, U.S., and Germany's in the whole sample period (the column of "All days"). Turmoil in Hong Kong changed the distribution of stock returns for 92 percent of all the countries.

So far, this research considered how turnmoil in a center or a periphery affected other countries. If a center was easily affected by turmoil in other countries, dynamic effects between a center and peripheries might accelerate contagion. Thus, it is better to consider centers' vulnerability to external financial shocks to the extent of center-amplification effects.

Table 5 shows the percentage of countries in which turmoil affects the centers. Since Hong Kong appeared to have strong contagion effects, Hong Kong was also included for comparison. Groups in columns are the sources of turmoil; countries in rows are destinations of shocks. Turmoil in developing countries appeared to have a small impact on centers such as Japan (29 percent), U.S. (38 percent) and Germany (52 percent). This implies that these financial centers could absorb shocks from the emerging stock markets, while financial centers could amplify shocks from G7 countries. In contrast, Hong Kong was vulnerable to shocks from developing countries as well as G7 countries. For instance, 100 percent of Asian and 86 percent of Latin American countries had contagion effects on Hong Kong. Thus, if the origin of crisis was a periphery, Hong Kong's amplification effects could be much stronger than that of the three financial centers'.

The contagion effect of turnmoil in the origin of crisis were time variant will be analyzed. Sample periods were divided into pre-crisis, crisis, and post-crisis periods (Table 6). Thailand, Russia, and Brazil were the origins of contagious crisis during periods of crisis.

A Japan's center-amplification effect of turmoil in Thailand is high in Asia and Oceania during crisis periods (63 percent during days of Japan's turmoil and 0 percent during days of no turmoil) although contagion effects of turmoil in Thailand did not appear to change dramatically overtime. Actually, contagion effects of turmoil in Thailand to the world are slightly higher during periods of post-crisis (36 percent) than during periods of crisis (22 percent). Thus, wealth constraint effects were observed during the period of crisis in Asia and Oceania. Hypothesis 1A worked only in the same region of Thailand. Contagion effects of turmoil in Russia and Brazil were clearly high during periods of crisis. Unconditional results of all pre-crisis, crisis, and all post-crisis in Russia's cases were 8, 64, 22 percent, respectively; unconditional results in Brazil's were 19, 56, and 34 percent, respectively. This implies that Hypothesis 1A is true for Russia and Brazil. Turmoil in Russia affected 72 percent of all the countries, during days of turmoil in Germany of crisis periods, while affecting 30 percent of them during days of no turmoil in Germany. Similarly, turmoil in Brazil affected 64 percent of

Table 5. Vulnerability to External Shocks: Hong Kong as Emerging Center

	Asia, Oceania	Latin America	Transition	Europe	G7	Total	Financial Center	Developed Countries	Developing Countries
HONG KONG	100	86	40	55	100	78	J, G, U	81	75
JAPAN	67	14	0	78	86	53	G, U	87	29
GERMANY	78	29	40	100	100	72	J, U	100	52
USA	22	57	40	89	86	59	G	87	38

Note: A sample period is from September 1, 1994 to December 31, 2003. Values are the percentage of countries, which are affected by turmoil in a peripheral country, divided by the number of group members except itself. J, G, and U means Japan, Germany, and U.S., respectively.

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Table 6. Propagation of Periphery's Turmoil during Periods of Crisis and non-Crisis

The Origin	Pre-Crisis			Crisis			Post-Crisis		
THAILAND	All Pre-Crisis	Turmoil in Japan	No Turmoil in Japan	All Crisis Periods	Turmoil in Japan	No Turmoil in Japan	All Post-Crisis	Turmoil in Japan	No Turmoil in Japan
ASIA, OCEANIA	38	0	13	63	63	0	75	38	0
LATIN AMERICA	0	0	14	29	0	14	0	14	0
TRANSITION	20	20	0	0	20	20	80	20	20
EUROPE	0	0	0	0	33	11	11	33	0
G7	29	0	43	14	14	14	29	43	0
TOTAL	17	3	14	22	28	11	36	31	3
Financial Center	G	-	G, U	-	-	J	J	J	-
Developed Country	13	0	19	13	25	13	25	31	0
Developing Country	20	5	10	30	30	10	45	30	5
RUSSIA	All Pre-Crisis	Turmoil in Germany	No Turmoil in Germany	All Crisis Periods	Turmoil in Germany	No Turmoil in Germany	All Post-Crisis	Turmoil in Germany	No Turmoil in Germany
ASIA, OCEANIA	0	0	0	11	33	22	33	0	11
LATIN AMERICA	43	29	14	71	86	0	29	0	14
TRANSITION	0	0	25	75	75	75	25	0	25
EUROPE	0	0	0	100	100	44	11	11	11
G7	0	0	0	71	71	29	14	0	14
TOTAL	8	6	6	64	72	30	22	3	14
Financial Center	-	-	-	G	G	J	-	-	-
Developed Country	0	0	0	81	81	31	13	6	13
Developing Country	15	10	10	50	65	30	30	0	15
BRAZIL	All Pre-Crisis	Turmoil in U.S.	No Turmoil in U.S	All Crisis Periods	Turmoil in U.S.	No Turmoil in U.S	All Post-Crisis	Turmoil in U.S.	No Turmoil in U.S
ASIA, OCEANIA	11	0	11	11	67	0	0	0	0
LATIN AMERICA	67	0	50	100	83	83	50	33	17
TRANSITION	20	20	20	60	80	0	0	0	0
EUROPE	11	0	11	67	56	0	11	11	22
G7	0	0	0	57	43	0	14	29	43
TOTAL	19	3	17	56	64	14	14	14	17
Financial Center	-	-	-	G	G	-	U	U	-
Developed Country	0	0	0	63	50	0	13	19	31
Developing Country	35	5	30	50	75	25	15	10	5

Note: Values are the percentage of countries, which are affected by turmoil in a financial center, divided by the number of group members except itself. J, G, and U means Japan, Germany, and U.S., respectively. Sample periods for "Pre-Crisis", "Crisis", and "Post-Crisis" are September 1994 - December 1996, January 1997 - August 1999, September 1999 - December 2003, respectively. "All Pre-Crisis," "All Pre-Crisis," "All Crisis," and "All Post-Crisis" are results of unconditional tests for each period.

all the countries during days of turmoil in U.S. of crisis periods, while affecting 14 percent of all during days of no turmoil in U.S.. However, turmoil in Russia during days of turmoil in Germany affected the same percentage (75 percent) of transition countries as during days of no turmoil in Germany in crisis period; turmoil in Brazil during days of turmoil in U.S. also affected the same percentage (83 percent) of Latin American countries as during days of no turmoil in U.S. in crisis period. Thus, I did not find evidence that German and U.S. had center-amplification effects on countries in the same region although German and U.S. appeared to have center-amplification effects on countries in other regions.

Finally, the correlation between accessible stock market share and test statistics of Smirnov test will be conducted to examine Hypothesis 3 (Table 7). Positive correlation means a center has investor-induced effects on peripheries; negative correlation or no correlation means turmoil in a center could have fundamental-based effects or other factors (e.g., trade and bank lending). Results indicate that turmoil in Japan had investor-induced effects on Asian countries (0.43); turmoil in Germany had investor-induced effects on Asian countries

Table 7. Correlation between Accessible Stock Share

	JAPAN	GERMANY	U.S.
ASIA	0.62	0.43	-0.21
LATIN AMERICA	-0.12	0.78	0.47
TRANSITION	-0.15	-0.20	-0.06
DEVELOPING TOTAL	-0.25	0.24	-0.13

Note: correlation is calculated between accessible stock share and (1 - p-value of test statistics). Asia does not include Australia. Transition includes Turkey. A sample period is from September 1, 1994 to December 31, 2003.

(0.78) and Latin American countries (0.47); turmoil in U.S. had investor-induced effects on Latin American countries (0.47). Thus, since high accessibility to foreign investors could lead to high contagion effects on Asian and Latin American countries, Hypothesis 3 is true in Asian and Latin American countries, but not in transition countries.

Conclusion

This paper sheds light on center's shock amplification effects, portfolio rebalancing effects, and wealth constraint effects to answer when financial transmission mechanism began to work more contagiously and what factor amplified contagion effects of turmoil in the origins during the Asian, Russian, and Latin American crises. This paper's contribution is to develop debates on contagion effects as a change in the distribution of stock returns by extending Kaminsky and Reinhart (2003)'s center-periphery framework, namely, (1) introducing three time zones for the analysis of conditional distribution of stock returns; (2) comparing contagion effects during crisis periods and non-crisis periods; and (3) adding accessibility to stock markets to test if contagion effects are global investor-induced.

This paper's results suggest that major financial centers such as U.S., Japan, and Germany could play a vital role in amplifying turmoil. In fact, the patterns of propagation paths vary by financial center; the magnitude of contagion effects is time-variant due to wealth constraint effects. In about a half of the cases, contagion effects were well-explained by accessibility of stock markets. More detailed fundamental based approach is needed to explain the causes of contagion effects in all the cases although it is beyond the scope of this paper. Overall, my results are in some points similar to Kaminsky & Reinhart (2003), but the extension of their center-periphery framework leads to more robust and significant results. I find an emerging financial center such as Hong Kong more strongly spread turmoil in peripheries over the developing countries than U.S., Japan, and Germany.

In order to analyze contagion effects, This paper focus only on the global stock market, where hedge funds and mutual funds actively invest. However, global banks, which can provide liquidity to those funds, have also been playing a vital role in propagating financial shocks since the mid-1990s. For further research, therefore, it would be useful to introduce the analysis of international bank lending in a more detailed fundamental-based approach.

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