

次貸風暴對亞太國家股票市場之影響： PLS- SEM 之運用

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摘 要

本文探討美國次貸危機對下列太平洋國家的股票市場之影響，包括：大陸、香港、韓國、新加坡和臺灣。經實施 Partial Least Squarer (PLS) SEM 分析後，主要發現如下：

一、實證結果顯示：美國與全體樣本各國間存在顯著正向之金融連結關係。二、本研究證實次貸危機之蔓延效果係同時透過金融及貿易連結所構成之中介功能予以傳遞。三、本文證實：就日本與台灣而言，金融連結對貿易連結產生一顯著正向影響。四、本研究顯示：金融與貿易連結分別對香港及新加坡產生一負向及正向顯著影響。

關鍵字：次貸風暴、Partial Least Square SEM

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The Impacts of Sub-Prime Crisis on Asia-Pacific Stock Markets: PLS-SEM Approach

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Abstract

This study investigates the impact of the US subprime crisis on the stock markets of the Asia-Pacific countries in terms of the data from China, Hong Kong, Korea, Singapore, and Taiwan. After completing the Partial Least Square Structural Equation Modeling (SEM) analyses, the main findings are obtained. First, the empirical results show significant positive financial linkages between the US and all sample countries. Second, the study demonstrates the contagion effect simultaneously with the mediate function via financial linkage and trade linkage. Third, the study shows that the financial linkage will generate one significantly positive influence on trade linkage in Japan and Taiwan. Fourth, the study shows that the financial and trade linkages generate one significantly negative and positive influence on the stock markets of Hong Kong and Singapore respectively.

Key words: Partial Least Square SEM, Sub-prime crisis

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I. Introduction

Usually, a crisis has a number of simultaneous reasons for its origin that are hard to separate. Of the different forms of a crisis, the most harmful comes from the banking sector. Banks are naturally exposed to crises as they may come from within the system, rather than from outside. The banks are exposed to the risks in their ongoing activity more than other financial institutions. The sub-prime crisis of 2007–2009 is a good example of a deep banking crisis and its implications (Kaganov, 2019).

The credit and global financial crisis of 2008 subprime crunch (Chang & Kuo, 2010) mainly derived from the rapid growth of mid-2007 U.S. low-quality subprime mortgages, which eventually turn out to be hard-control complex loan contracts. The global financial system was destroyed by the investors' stream for asset mortgage securities, structured credit products and high yield-high risk targets. This invest stream leads to the crash of housing price and the rapid growth of default rate, associated with the loss of confidence and the decrease of consumption and investment bring out the global economic crisis (Xue, He & Shao, 2012).

Dooley and Hutchison (2009) found that the emerging markets, from January 2007 to August 2008, seems insulated from the development of the US financial markets. But from mid-September 2008 on, the emerging markets (China and Korea) reflect strongly to the deteriorating real economic situation derived from the subprime crisis. Hwang (2012) found that during 2008 US financial crisis period, most Asian stock markets return losses exceed 20% (Taiwan and Malaysia excluded). However, the US, Japan and Taiwan exhibit negative weekly average return, from -0.118% (Japan), to 0.101% (Korea). Relatively, from risk-return trade to examine, the Sharpe ratio highest is Malaysia, next are Australia and China.

Dooley and Hutchison (2009) found that the linkage of US Standard and Poor's 500 indexes with the national stock indices of selected emerging markets generally increased substantially after mid-September 2008. The daily credit-default spreads (CDS) of US and selected emerging markets was almost no movement in CDS spreads until the Lehman failures. Lehman bankruptcy spread to other countries in remarkably similar ways. Emerging markets initially seems to absorb the influence from U.S. subprime crisis, afterwards their currencies experienced one magnitude far exceed the appreciation span from 2007 to mid-2008.

The objective of this study is twofold. First, I propose and demonstrate one hypothetical subprime crisis model, which considers the relationships among the subprime crisis, financial linkage, trade linkage and stock market performance. Second, to test the generalizability of the evidence results, the current study focuses on China, Hong Kong, Taiwan, Korea and Singapore.

The remainder of this paper is structured as follows. I begin by reviewing the literature on the subprime crisis and related topics. Next, I based on the theoretical context and related empirical evidence plus logic reasoning to establish one hypothesized subprime crisis mediator Structural Equation Modeling (SEM) model and one competing mediator-moderator SEM model. I then empirically illustrate this hypothesized causal model through five sample countries' related monthly

data and find one more fit SEM model. In the discussion section, I compare the finding of this study to the findings in the literature. In the concluding section, I use the evidence derived from the discussion section to describe how the findings of the study can contribute to the literature on the subprime crisis.

II. Literature review

Knowing the level of market integration helps policymakers to plan policies for internal capital markets in the event of a global economic and financial crisis. Therefore, market integration or contagion has been an important issue in international finance.

Kaoa, Zhaob, Kuc and Niehd (2019) employed Enders and Siklos asymmetric co-integration frameworks, including the momentum threshold autoregressive (M-TAR) and logistic smooth transition co-integration (LSTC) models, to investigate whether contagion effects had existed in international stock markets. They found the subprime crisis determined the degree of contagion, depending on the financial linkage to the U.S. market, which further demonstrates the differences in the causes and influence between the subprime crisis and other financial crises in emerging markets.

Rose and Spiegel (2010) use a cross-country multiple indicator multiple cause model and consider international linkages between countries and potential crisis 'epicenters,' including the United States. They, however, fail to find strong evidence associating international linkages with crisis incidence. In particular, exposure to the United States in either form has little impact.

Xue et al. (2012) adopted principal components and average method to construct a comprehensive measure, which consists of S&P Case-Shiller composite-10 housing price index, S&P 500 index and M2 money multiplier, to investigate the evolution of the subprime crisis in the United States. They found that the Asian equity markets were not affected by the crisis; rather, trade contagion is the dominant channel for the transmission of the crisis to Asia. Their empirical evidence suggests that monetary policy, not fiscal policy, is a better policy for assisting Asian economies during this crisis. Bagliano and Morana (2010) applied the common trends model and found long-run house price effects on consumption only for France, Germany and the US. However, interactions between house prices and consumption are detected in all sample countries at shorter horizons.

Chang and Kuo (2010) using the cointegration test, found no effect on the long-term equilibrium and no cointegration between the stock and foreign exchange markets in Taiwan during the American subprime mortgage crisis. They did, however, find a feedback relationship between the stock and foreign exchange markets in Taiwan. Dooley and Hutchison (2009) using event study, found that a range of financial and real economic news emanating from the US had statistically and large impacts on 14 emerging markets and several news events (such as the Lehman bankruptcy and swap arrangements) uniformly moved markets. In addition, they found that from the summer 2008 on, emerging markets responded strongly to the deteriorating situation in the US financial system and in the real economy. Hwang (2012) employing the dynamic conditional correlation GARCH

model examines the stock market linkages within the Asia-Pacific region and between Asia markets and the US market from January 2000 to June 2010. Hwang (2012) found that the linkage between Asian and the US market are significant in all cases except for China. Further, their results show that the US market significantly affects the stock markets in the Asia-Pacific region.

Chen, Huang and Cheng (2010) employed event study approach and found that the subprime crisis affects the stock markets of Asia-Pacific countries, especially in Hong Kong and Taiwan. In addition, the Asia-Pacific countries have greater market reactions through financial linkages, but not through trade linkages. They recognized that although trade linkages do not have a transmitted function in a short period, they might play a role in transmitting the information effect of the subprime crisis in a longer period. The literature review leads me to believe that to untangle the relationships of the subprime crisis, financial and trade linkages and their subsequent impacts, a structural perspective will shed new light on policy considerations. The partial least squares structural equation modeling (PLS-SEM) is a method for structural equation modeling that allows estimation of complex cause-effect relationships in path models with latent variables. Because this study includes complex cause-effect relationship between latent variables of financial, trade and stock performance, also moderate effect is investigated. Thus, I use Partial Least Square SEM (PLS-SEM) to investigate the relationships among these macro variables.

III. Proposed model and hypotheses

Before an empirical investigation is conducted, the financial, trade links with the subprime crisis must be defined first. The financial links represented the cross country, cross-economy, or cross-market linkages occurring in the international financial market system (Wong, 2000; Forbes & Rigobon 2002). Forbes and Rigobon (2002) expounded the transmission mechanism by using three points, namely, the coordination on trade and policy, the re-evaluations of the regimes of the countries, and the stochastic aggregate shocks, including shocks on finance markets. A crisis contagion theory explains that if there was co-movement or a common trend between different markets, then a shock in one market would transmit to another market (Kaoa et al., 2019).

As the financial crisis evolved and prices of most risky assets have declined due to the contagion effect, investors began to rebalance their portfolios from risky to risk-free assets. This financial behavior can cause sudden increase in correlations between international stock market returns. Further, Hwang (2012) show evidence in favor of contagion effects due to herding behavior in Asian financial markets during the financial crisis of 2008.

1. Mediate role of contagion effect (financial and trade linkages)

In epidemiological studies, ‘true contagion’ is then a larger-than-expected effect of foreign shocks. Therefore, contagion is defined as an exceptional increase in the magnitude of international linkages, such as the 50% fall in the Brazilian stock market subsequent to the collapse of the Russian ruble in 1998. The contagious response to an individual foreign shock seems to be intrinsically bilateral (e.g. countries with more exposure to US assets might respond more to a

decline in US asset prices) (Rose & Spiegel 2010).

Prior literature has demonstrated the contagion effect of crisis, through investigating a series of crises including the Mexican crisis of 1994-1995, the Asian crisis of 1997, the Russian crisis of 1998 and the subprime mortgage crisis of 2008 (Chen et al., 2010; Eichengreen, Rose, & Wyplosz, 1996; Forbes & Rigobon 2001; Haile & Pozo 2008; Masson, 2004). There are different channels through which countries can be linked. Two are of particular interest: a real channel that focuses on international trade, and a financial channel that is concerned with assets cross-holdings (Rose & Spiegel 2010).

2. Subprime crisis, financial linkages and equity performance

Reinhart and Rogoff (2008) argued that the 2007 subprime crisis shared many similarities with prior financial crises. Kaminsky and Reinhart (1999) had employed many fundamental and financial indicators to describe past crises. Xue et al. (2012) deemed a financial crisis as one series of negative random shocks and claimed that it can be measured through economic indicators. Therefore, this study assumes the subprime crisis as one unobservable random variable and it can be measured with multiple economic indicators.

One country's response to the common impact appears to be multi-sides (for instance, more financially developed countries probably consistently raise their risk-aversion level). Alternatively, for those individual foreign shocks, countries will reflect with bilateral character (for U.S. trade partners will facilitate the price of American assets to decrease).

Exposure to contagion through international cross-holding of assets might have been exacerbated in 2008 crisis because of the prevalence of holding of exotic financial instruments; these were particularly vulnerable to capital loss in the wake of a general downturn. For instance, when the market price of the United States asset-backed securities fell, European banks holding that paper, as well as related conduits and structured investment vehicles, experienced losses. These losses then spread to the asset-backed commercial paper market, as the instruments holding these money-losing instruments turned to that market for funds (Davis, 2008). Therefore the subprime crisis will lead to the real house price decline and countries with exposure to US assets will reduce their cross-holding assets in the US (financial linkage). Hence, the hypothesis is established as follows.

H1: The subprime crisis (real house price declines) will reduce the financial linkage (cross-holding assets) with other countries.

Rose and Spiegel (2010) argue that there is little strong evidence of an international financial linkage that might have allowed a crisis centered initially in the United States to spread to other countries. However, Hwang (2012) found that during the subprime crisis period, the US market brought negative influences on most Asian stock markets (Taiwan and Malaysia excluded). However, Chen et al. (2010) found that stock markets and companies in Hong Kong and Taiwan

had the strongest reactions to news of the subprime crisis, perhaps because both countries have more globalized economies and hence a more significant connection with the US economy. Hence, I establish the following hypothesis. It implies that when the subprime crisis occurs, the Case-Shiller index or S&P 500 will decline, thus deteriorate the stock market. Hence, there is one positive association between the subprime crisis and equity performance.

H2: As the subprime crisis occurs will deteriorate the equity performance.

3. Subprime crisis and trade linkages

Countries linked through international trade might experience contagion if their partners devalue their currencies. That is, strong trade linkages might encourage devaluation in response to foreign currency shocks, because countries wish to maintain external competitiveness. Crisis contagion can also hit economies through declines in merchandise trade (Reisen, 2008). Eichengreen and Rose (1998) find that although both macroeconomic and trade channels play a role in conveying shocks internationally, trade linkages dominate. However, Lahiri and Vegh (2003) find that central banks often actively resist devaluations during financial crises, shedding doubt on the ‘contagion through competitive devaluation’ hypothesis.

In general, a permanent change in house price will have a positive wealth effect on landlords and a negative income effect on tenants and on prospective first-time buyers, so that an aggregate non-zero effect on consumption is detectable if a change in house prices entails a redistribution between agents with different marginal propensity to spend.

Bagliano and Morana (2010) found that the percentage change in consumption associated with a 1% increase in real house prices due to the output-neutral shock. Further, based on Case-Shiller index, US real house prices have contracted by about 24% in the subprime crisis. They use this figure as an estimate of the expected contraction in house prices for the European countries (0.01%-0.18% over the 1-year horizon) and the resulting decline in consumption expenditures calculated (-0.2%- -4.3% for 1-year). In addition, in France, Germany and the US, the house price variable enters the cointegration relationship along with consumption and output, pointing to a long-term housing wealth effect.

Further, unemployment and loss of confidence (expectation behavior effect) may have led to a reduction in consumer consumption. As one of the biggest consumers in the world, decreases in demand in the US would reduce exports in many countries. Countries that depend on external consumption would suffer if most of their exports were intended for partners affected by the subprime crisis (Xue et al., 2012).

Another consequence of the subprime crisis was that the economic growth in the US steadily deteriorated, causing a decline in consumer wealth and hence in spending. Because the countries in Asian emerging markets adopted an exported-oriented strategy, they developed intensive economic dependence on US market conditions. Therefore, declining demand in the US during the crisis led

to reduced supply in Asian emerging markets. This is the income effect through trade linkages (Chen et al., 2010). Additionally, Xue et al. (2012) find that the Asia equity markets are not contagious by the subprime crisis; rather trade is the dominant transmission channel for the crisis to be transmitted to Asia. This seemingly surprising finding reveals the unique property of Asian banks: the relative conservative banking philosophy in Asian countries.

Rose and Spiegel (2010) found that greater export dependence on the United States leads to less intense financial disruptions. By the same token, countries that traded more with the USA in 2006 seemed to experience a less intense crisis in 2008. They also considered two financial channels: the fraction of external assets in US securities and the fraction of PPG debt in dollars, and considered two real channels: export to both the US and to small crisis countries. However, almost none of the channels for contagion seem to have had a statistically discernible effects on crisis intensity. The only exception is the real channel to the US; countries that proportionately either export more to or trade more with the US in 2006 experienced a less severe crisis in 2008. However, there is little evidence of contagion spreading via a financial channel.

H3: Subprime crisis will lead to those countries' exports depending on the US external consumption (trade linkage) experience severe downturns.

4. Financial linkages and equity market performance

Rose and Spiegel (2010) argue that the most direct source of contagion on the financial side is the deterioration in a country's balance sheet because of capital loss on assets with international exposure. Xue et al. (2012) argue that the most direct channel is the mutually dependent and highly correlated financial systems of the countries. For example, banks in Japan invested in high-yield bonds that provided were backed by low-quality mortgages. Thus, when the sub-prime crisis struck the US, these banks lost their investments. This is known as the chain effect. Exposure to contagion through this financial channel might have been exacerbated in the 2008 crisis because of the prevalence of holdings of exotic financial instruments; these were particularly vulnerable to capital losses in the wake of a general downturn.

Vulnerability to adverse external shocks might be exacerbated by poor balance sheet positions. For instance, Davis (2008) argues that leveraged investors might have to sell in illiquid situations, feeding a 'fire-sale' dynamic that depresses prices and results in the need for even more selling. Thus, Adrian and Shin (2008) argue that market-to-market practices exacerbate the severity of the impact of changes in prices and perceived risks on market liquidity. Empirical evidence supports the 'shift-contagion' in financial markets. For example, Baig and Goldfajn (1999) find evidence of increased correlation in asset returns in emerging markets in the wake of the 1997 Asian financial crisis.

Rose and Spiegel (2010) found countries with more exposure to US financial assets (i.e. external financial assets held in US) seem to have experienced a less intense crisis. For example,

countries that had larger shares of their 2006 foreign wealth in the United States seem to have experienced small stock declines in 2008. They also found that countries with higher fractions of dollar debt had less intense crises. Alternatively, the higher the debt denominated in yen, the more intense the crisis appeared. Empirical evidence confirms the ‘shift-contagion’ in financial markets. For example, Calvo and Reinhart (1996) find an increase in the correlation on returns in Asian and Latin American equity and bond markets following the Mexican peso crisis. Similarly, Baig and Goldfajn (1999) find evidence of increased correlation in assets in emerging markets following the 1997 Asian financial crisis.

H4: Countries with more exposure to US financial assets will experience stock decline in the wake of the subprime crisis.

5. Trade linkage and stock market performance

Rose and Spiegel (2010) found countries that proportionately either exported more to or traded more with the United States in 2006 experienced less severe 2008 crises. They also found that countries depended heavily on exports to the US seem, if anything, to have experienced smaller crisis, holding other factors constant. However, they also argued that there is no systematic strong evidence that export dependence on any except the small crisis countries matters. Further, Asian countries’ central banks have improved their management of capital flows, mitigating the risk of exchange rate overvaluation, credit booms, and assets bubbles (Ee & Xiong, 2008). It implies that growth in one counterparty country’s export share to the US will lead to better stock market performance (less severe crisis); hence, it is predicted there is one positive association between the trade linkage with US and the stock market performance of its counterparty country.

H5: Growth in one country’s trade linkage with US will lead to less intense financial disruption (higher equity market performance).

6. Bilateral influences of Trade linkages and financial linkages

Peek and Rosengren's (1997) study of the banking crisis in Japan concluded that disruption to the banking ‘parent’ had an adverse impact on lending through subsidiaries in the United States. Peek and Rosengren (1997) found that when the stock market value of Japan declines will result in the lending operation of Japan’s bank branch in U.S. declined. Further, the loss of Japan’s real estate and the fluctuation of Japan’s stock value will generate continuous impacts on the bank branch of Japan in U.S. However, Kaminsky and Reinhart (2000) found that some of the contagion that they had attributed to trade linkages might actually have stemmed from financial linkages, as the two are highly correlated in the data. In practice, however it has proven difficult to disentangle contagion due to trade linkages from that attributable to financial linkages, as countries that are closely linked in one dimension also tend to be linked in the other. Hence, I postulate that the

decline of the US real estate market or stock value will lead to the decrease of lending operation of counterpart countries and generate one negative impact on the export to US (H₆). Alternatively, I assume H₆₋₁ that the trade linkage will generate one positive impact on the financial linkage.

H₆: When the financial linkage declines will lead to the trade linkage decrease in the wake of the subprime crisis.

H₆₋₁: When the trade linkage declines will lead to the financial linkage decrease in the wake of the subprime crisis.

Based on the above hypotheses (H₁-H₆) I establish one subprime crisis model, depicted in Figure 1(PLS-SEM₁). In this causal model there is one structural latent variable, the subprime crisis, with multiple indicators; the other three structural variables are single indicator variable, it will be referred as a nonstandard model.

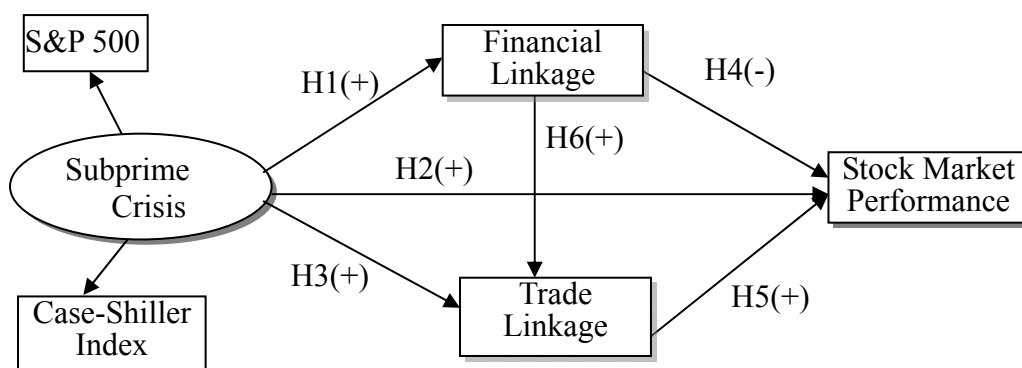


Figure 1. The hypothesized subprime crisis model (PLS-SEM₁)

Chen et al. (2010) argued that Asia-Pacific countries' stock markets react remarkable to the subprime crisis (especially for Hong Kong and Taiwan). Perhaps because Taiwan and Hong Kong have been more globalized and generates one close connection with the US. The shift-contagion effect in financial markets and the increased correlation in assets in emerging markets, after the 1997 Asia financial crisis are also demonstrated (Calvo & Reinhart, 1996). Hence, I establish the moderate effect (subprime crisis*financial linkage, SC*FL) hypothesis H₇ that the subprime crisis associated with financial linkage will exacerbate (moderate) the impact on the stock markets of the sample countries. Moreover, I integrate the moderate effect hypothesis (H₇) into the PLS-SEM₁ (H₁-H₆) and constitute the competing moderate model (PLS-SEM₂, H₁-H₇) in Figure 2. Further, the fitness of PLS-SEM₁ and PLS-SEM₂ will be compared in order to choose one more fit model. Lastly, I will use H₆₋₁ to replace H₆, thus H₁-H₆₋₁ and H₇ will constitute PLS-SEM₃ (Figure 3) to investigate the bilateral influences between the financial and trade linkages.

H₇: The subprime crisis will associate with financial linkage to generate one reinforcement

moderate effect on the stock market performance.

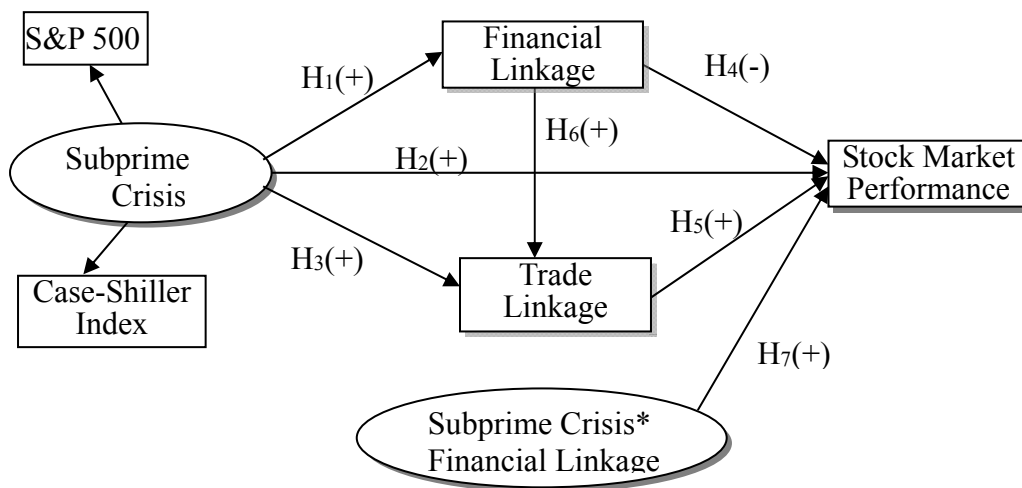


Figure 2. The hypothesized subprime crisis moderate model (PLS-SEM₂)

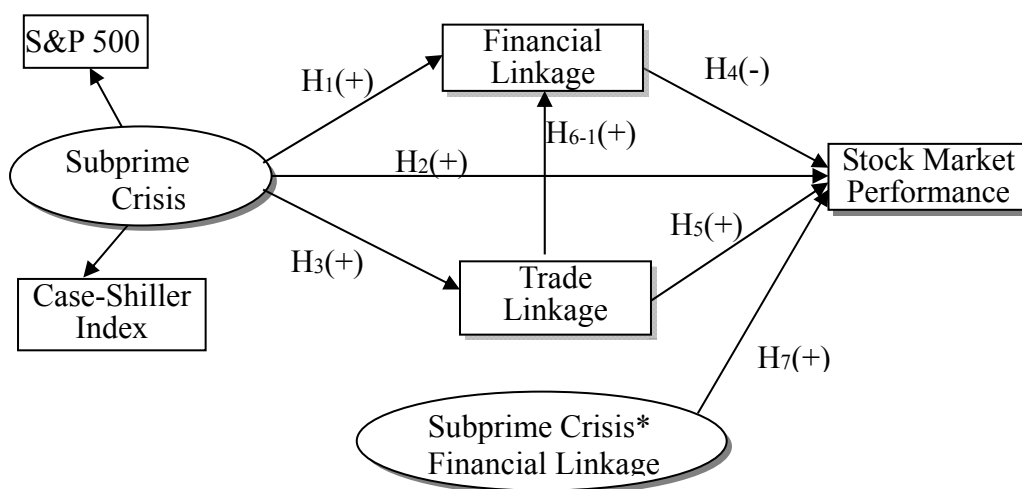


Figure 3. The hypothesized subprime crisis moderate model (PLS-SEM₃)

7. Measure variables

(1) The measure variable for subprime crisis

Reinhart and Rogoff (2008) argued that the 2007 subprime crisis shared many similarities with prior financial crises. Kaminsky and Reinhart (1999) had employed many fundamental and financial indicators to describe past crises. Xue et al. (2012) deemed a financial crisis as one series of negative random shocks and claimed that it can be measured through economic indicators. Therefore, this study assumes the subprime crisis as one unobservable variable and it can be measured with multiple economic indicators.

Bagliano and Morana (2010) based on Case-Shiller index and find that US real house prices

have contracted in subprime crisis. In addition, they use this fact to predict the expected contraction in house prices for the European countries and the resulting decline in consumption expenditures. In addition, the housing price index can also characterize the real estate market. In addition, the S&P 500 was used to identify common shocks in the financial markets in the United States (Xue et al., 2012). Thus above both indices were adopted in this study of the subprime crisis.

(2)The measure variable for financial linkages

I follow Chen et al. (2010) who use the asset allocation percentage of MSCI (Morgan Stanley Capital International) Asia-Pacific Ex-Japan Index as a proxy for financial linkages. MSCI Asia-Pacific Ex-Japan Index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of Asia, excluding Japan (MSCI Barra 2008, www.msclub.com). This index is among the most widely followed benchmarks in the world as a better reflection of real investment opportunities, particularly in the US and the Asia-Pacific region (Pavabutr, 2003; Sokulsky, Brooks & Davidson, 2008). Thus, I use the asset allocation percentage of the index to determine the investing activities of institutional investors and their wealth connection with Asia-Pacific countries and to examine the impact of their behaviors on the Asia-Pacific stocks.

(3)The measure variable for trade linkages

By virtue of the income effect, I adopt the import-export relation to capture the extent of economic dependence between these Asia-Pacific countries and the US. To do so, as a proxy for the trade linkages, I use the percentage of Asia-Pacific countries' exports on US total imported inputs (Chen et al., 2010).

(4)The measure variable of stock market performance

I follow Hwang (2012) and consider the monthly return data to alleviate problems associated with non-synchronous trading resulting from the fact not all markets are open during the same hours of the day. The specific markets are China (Shanghai Composite), Hong Kong (Hang Seng), Korea (KOSPI), Singapore (Straits Times), Taiwan (SE weighted). The monthly stock returns, obtained by taking the logarithmic difference of the monthly stock index ($r_t = \log P_t - \log P_{t-1}$) are used to measure the stock market performance.

8. Data and methodology

The subprime crisis period is defined from failure of Fannie Mae and Freddie Mac (September 7, 2008) through the first repayment of Troubled Asset Relief Program (March 31, 2009). I follow Xue *et al.* (2012) by using the monthly data of China, Hong Kong, Korea, Singapore and Taiwan from 2007 January to 2010 December. The data are collected from Yahoo finance and MSCI Barra, www.msclub.com.

The current hypothesized subprime model includes latent variables and consists of one nested structure. After considering the following advantages of Partial Least Square Structural Equation Modeling (PLS-SEM): (1) It can deal with multiple dependent and independent variables. (2) It can overcome the problem of multicollinearity. (3) It can robustly deal with moderate data and missing values. (4) The input reflective variables can strongly predict latent variables. (5) It can simultaneously deal with reflective and formative indicators. (6) It is appropriate for small-size sample. (7) It is not restrict to the distribution of the sample data (Pirouz, 2006). Hence, I adopt PLS-SEM, through bootstrapping procedure on 1000 samples, to estimate the path coefficients in the hypothesized subprime crisis model of Figure 1, 2 and 3.

IV. Empirical results

1. PLS-SEM₁ evidence analyses

(1) Reliability and validity

The SmartPLS 2.0, through bootstrapping and PLS Algorithm, is used to perform PLS-SEM analysis. Table 1 shows that all the average variance extracted (AVE) are greater than 0.9, hence, far exceeds the threshold value 0.5. All composite reliability and Cronbach Alpha are bigger than 0.9, thus exceeds the threshold value 0.7 (Rigdon, Ringle, Sarstedt & Gudergan, 2010). Thus, the measurement reliability of the reflective constructs is demonstrated. Further, the square root of AVE of each latent variable is calculated and exceeds the correlation between other variables. Therefore, the discriminant validity of constructs is demonstrated also.

Table 1. PLS-SEM₁ quality criteria (China)

Variables	AVE	Composite Reliability	R ²	Cronbach Alpha	Index for Latent Variables
MSCI ExJapan	1.00	1.00	.54	1.00	402.46
Subprime Crisis	.93	.96	0	0.93	277.60
TChina	1.00	1.00	.24	1.00	.14
rShanghai	1.00	1.00	.03	1.00	-.00

Notes: TChina represents the percentage of China's exports on US total imported inputs (trade linkage). The variable rShanghai represents the monthly returns of China's stock market performance.

Table 1. PLS-SEM₁ quality criteria (continued) (Hong Kong)

Variables	AVE	Composite Reliability	R ²	Cronbach Alpha	Index for Latent Variables
MSCI ExJapan	1.00	1	.54	1.00	402.46
Subprime Crisis	.93	.96	.00	0.93	277.85
THong Kong	1.00	1.00	.66	1.00	.00
rHangSeng	1.00	1.00	.10	1.00	-.00

Notes: THong Kong represents the percentage of Hong Kong's exports on US total imported inputs (trade linkage). The variable rHengSeng represents the monthly returns of Hong Kong's stock market performance.

Table 1. PLS-SEM₁ quality criteria (continued) (Taiwan)

Variables	AVE	Composite Reliability	R ²	Cronbach Alpha	Index for Latent Variables
MSCI ExJapan	1.00	1	.55	1.00	402.46
Subprime Crisis	.93	.97	.00	0.93	278.22
TTaiwan	1.00	1.00	.18	1.00	.02
rTaiwan	1.00	1.00	.06	1.00	-.00

Notes: TTaiwan represents the percentage of Taiwan's exports on US total imported inputs (trade linkage). The variable rTaiwan represents the monthly returns of Taiwan's stock market performance.

Table 1. PLS-SEM₁ quality criteria (continued) (Singapore)

Variables	AVE	Composite Reliability	R ²	Cronbach Alpha	Index for Latent Variables
MSCI ExJapan	1.00	1	.55	1.00	402.46
Subprime Crisis	.93	.97	.00	0.93	278.22
TSingapore	1.00	1.00	.18	1.00	.02
rSingapore	1.00	1.00	.06	1.00	-.00

Notes: TSingapore represents the percentage of Singapore's exports on US total imported inputs (trade linkage). The variable rSingapore represents the monthly returns of Singapore's stock market performance.

Table 1. PLS-SEM₁ quality criteria (continued) (Korea)

Variables	AVE	Composite Reliability	R ²	Cronbach Alpha	Index for Latent Variables
MSCI ExJapan	1.00	1	.55	1.00	402.46
Subprime Crisis	.93	.97	.00	0.93	278.22
TKorea	1.00	1.00	.18	1.00	.02
rKorea	1.00	1.00	.06	1.00	-.00

Notes: TKorea represents the percentage of Korea's exports on US total imported inputs (trade linkage). The variable rKorea represents the monthly returns of Korea's stock market performance.

(2)PLS- SEM₁ path analyses

Next, the path evidence of PLS-SEM₁ are indicated in table 2.

Table 2. Path coefficients of the hypothesized structured model (PLS-SEM₁)

Hypotheses	Standardized β (t):China	Standardized β (t):Hong Kong	Standardized β (t):Taiwan	Standardized β (t):Singapore	Standardized β (t):Korea
H1(+):SC→FL	.73***(31.37)	.74***(33.36)	.74***(35.64)	.74***(34.43)	.77***(39.61)
H2(+): SC→SM	-.23*(2.12)	-.00(.01)	.31***(4.97)	-.29***(5.20)	-.23**(2.81)
H3(+):SC→TL	-.68***(12.16)	1.02***(22.58)	.40***(5.24)	-.09(.97)	.00(.01)
H4(-): FL→SM	.16(1.48)	-.32***(3.73)	-.32***(3.41)	.31***(3.78)	.35**(3.20)
H5(+):TL→SM	-.17*(2.17)	.26*(2.00)	.04(.66)	.37***(8.38)	.24***(5.08)
H6(+): FL→TL	.36***(4.43)	-.32***(4.21)	.03(.387)	.19*(1.96)	-.10(.95)

Notes: SC= subprime crisis; FL= financial linkage; TL= trade linkage; SM= stock performance (hereafter).The path coefficients and t-values in the parenthesis are obtained through the procedure of bootstrapping Algorithm on 1000 samples. *p< .05; **p< .01; ***p< .001

2. PLS-SEM₂ evidence analyses

Since Henseler, Wilson, and Dijkstra (2007) suggest that the product indicator approach is the best choice for hypothesis testing, therefore, I adopt this approach to calculate the moderate effect item of PLS-SEM₂ and PLS-SEM₃.

(1) Reliability and validity

Based on the sample countries, the AVE of subprime crisis and the moderate term (subprime crisis*financial linkage, SC*FL) is 0.93 and .53-.94 respectively, both far exceed the threshold value 0.5. Next, the composite reliability and Cronbach Alpha of SC*FL and subprime crisis are .93-.97 and .96-.97 greater than the threshold value .70; except the composite reliability of SC*FL is .68 for Singapore (Ridgon et al., 2010). Hence, the measure reliability of the reflective construct of the subprime crisis and the moderate term are demonstrated. In addition, according to Fornell and Larcker's (1981) criteria that the square-root of each latent variable all above the correlation of other variables. Therefore, the discriminant validity of the subprime crisis and the moderate term are proved.

(2) PLS-SEM₂ path analyses

The empirical evidences of the subprime crisis moderate model are shown in table 3. After comparing the path coefficients, I find that the empirical results of PLS-SEM₁ and PLS-SEM₂ are

equivalent. Moreover, I compare the R^2 of the endogenous variables (FL, TL and SM) and find that the R^2 of FL and TL are very similar, but the R^2 of SM in PLS-SEM₂ is improved (Table 4). Therefore, the PLS-SEM₂ is selected for the subsequent empirical analyses.

Table 3. Path coefficients of the hypothesized subprime crisis moderate model (PLS-SEM₂)

Hypotheses	Standardized β (t):China	Standardized β (t):Hong Kong	Standardized β (t):Taiwan	Standardized β (t):Singapore	Standardized β (t):Korea
H1(+):SC→FL	.73***(31.35)	.74***(33.30)	.74***(35.55)	.74***(36.80)	.77***(38.84)
H2(+): SC→SM	-.16(1.35)	-.18(1.55)	.37***(5.00)	-.29***(4.44)	-.32***(3.58)
H3(+):SC→TL	-.68***(11.92)	1.02***(22.83)	.40***(5.13)	-.09(.97)	.00(.01)
H4(-): FL→SM	.08(.65)	-.41***(4.40)	-.40***(4.12)	.30***(3.51)	.42***(3.90)
H5(+):TL→SM	-.17*(2.23)	.63***(5.35)	.06(1.02)	.37***(8.20)	.27***(5.46)
H6(+): FL→TL	.36***(4.30)	-.32***(4.02)	.03(.39)	.19*(2.00)	-.10(1.03)
H7(+): SC*FL→SM	-.20*(2.23)	-.47***(5.27)	-.19**(2.66)	-.00(.05)	.19(1.65)

Notes: SC= subprime crisis; FL= financial linkage; TL= trade linkage; SM= stock performance (hereafter); SC*FL= the moderate term of SC and FL. The path coefficients and t-values in the parenthesis are through partial least square through the bootstrapping Algorithm on 1000 samples. * $p < .05$; ** $p < .01$; *** $p < .001$

Table 4. R^2 of endogenous variables for PLS-SEM₁ and PLS-SEM₂

Model	Endogenous Variables	China	Hong Kong	Taiwan	Singapore	Korea
PLS-SEM ₁	FL	.54	.54	.55	.55	.58
	TL	.24	.66	.18	.02	.01
	SM	.03	.10	.06	.20	.10
PLS-SEM ₂	FL	.54	.54	.54	.55	.59
	TL	.24	.66	.17	.02	.01
	SM	.06	.26	.09	.20	.14

Notes: The PLS-SEM₁ includes the mediator variables (FL and TL), however, the PLS-SEM₂ contains the mediator and moderator variables (SC*FL) also.

Table 5. Path coefficients of the hypothesized subprime crisis moderate model (PLS-SEM₃)

Hypotheses	Standardized β (t):China	Standardized β (t):Hong Kong	Standardized β (t):Taiwan	Standardized β (t):Singapore	Standardized β (t):Korea
H1(+):SC→FL	.82***(35.0)	1.03***(19.56)	.73***(27.82)	.74***(34.46)	.76***(39.03)
H2(+): SC→SM	-.16(1.44)	-.18(1.52)	.37***(5.07)	-.29***(4.20)	-.32***(3.43)
H3(+):SC→TL	-.42***(9.37)	.78***(30.32)	.42***(8.64)	.05(.84)	-.07(1.19)
H4(-): FL→SM	.08(.67)	-.41***(4.35)	-.40***(4.32)	.30***(3.37)	.42***(3.89)
H5(+):TL→SM	-.17*(2.19)	.63***(5.02)	.06(0.97)	.37***(8.20)	.27***(5.41)
H ₆₋₁ (+): FL→TL	.20***(4.84)	-.38***(5.51)	.02(.38)	.08*(2.10)	-.04(0.96)
H7(+): SC*FL→SM	-.20****(3.53)	-.47****(5.33)	-.19***(2.58)	-.00(.05)	.19(1.71)

Notes: SC= subprime crisis; FL= financial linkage; TL= trade linkage; SM= stock performance (hereafter); SC*FL= the moderate term of SC and FL. The path coefficients and t-values in the parenthesis are through partial least square through the bootstrapping Algorithm on 1000 samples. * $p < .05$; ** $p < .01$; *** $p < .001$

Based on the PLS-SEM₂ empirical evidence shown in table 3, First, I infer that when the US subprime crisis struck, measured by S&P 500 and Case-Shiller composite-10CSXR, as both indexes decline will lead to investors to hold less securities and real estates, thus, reducing the financial linkage between the US and sample countries. Therefore, the following sample countries (China, $\beta = .73***$, Hong Kong, $\beta = .74***$, Taiwan, $\beta = .74***$, Singapore, $\beta = .74$, Korea, $\beta = .77***$, $p < .001$) are demonstrated respond strongly to the deteriorating situation derived from the subprime crisis via financial linkage. Hence, the hypothesis 1 (H₁) is demonstrated. This finding echoes the findings of Dooley and Hutchison (2009) that from 2008 on, emerging markets responded strongly to the deteriorating situation in the US financial system and real economy. It is also consistent with Davis' (2008) claim that countries with more exposure to US assets might respond more to a decline in US asset prices.

Second, the PLS-SEM₂ results show that the subprime crisis will significantly deteriorate the stock market performance of Taiwan ($\beta = .37***$, $P < .001$), for its more globalized degree, hence lead to its close connection with the US economy. However, the evidences are insignificant for China ($\beta = -.16$) and Hong Kong ($\beta = -.18$). The potential reason for the insignificance of China, might due to its insulation character which echoes the finding of Dooley and Hutchison (2009) and Hwang (2012). However, the insignificant evidence for Hong Kong might due to its more financially developed character, thus results in its investors will raise their risk-aversion level. However, the stock market of Singapore ($\beta = -.29***$, $P < .001$) and Korea ($\beta = -.32***$, $P < .001$) are not deteriorated by the subprime crisis, might due to their macroeconomic fundamentals are much healthier (including cut back domestic spending, reduced fiscal deficits, and reform their

economies). Central banks have also improved their management of capital flows, mitigating the risk of exchange rate overvaluation, credit booms, and assets bubbles (Ee & Xiong, 2008).

Third, the PLS-SEM₂ results show that the US subprime crisis will significantly lead to those countries' exports depending on the US external consumption experience severe downturns (H₃). One possible reason is that the subprime crisis will devalue the US currency; thus reduce imports from its counterparty countries (Hong Kong, $\beta = 1.02^{***}$, Taiwan, $\beta = .40^{***}$, $p < .001$). This PLS-SEM₂ supports Reisen's (2008) finding that crisis contagion can also hit economies through declines in merchandise trade. Countries that depend on external consumption would be particularly vulnerable if most of their exports were intended for partners affected by the subprime crisis (Xue et al., 2012). However, the contrary evidence for China might due to its exchange rate depreciation policy, associates mild fiscal expansion with strong monetary expansion (Dooley & Hutchison 2009; Xue et al., 2012). Moreover, they are running current account surpluses, maintaining large foreign reserves, and diversifying exports (Ee & Xiong, 2008). By performing above policies, China not only buffered the negative shock from the subprime crisis, but also brings positive contributions on its export for US. The insignificant evidence of Singapore and Korea might due to their adoption of exchange rate depreciation sharply after summer 2008, and the conduct of diversifying export policy (Dooley & Hutchison, 2009).

Fourth, the PLS-SEM₂ analysis demonstrates H₄ that when countries increased their foreign assets exposure to the US will lead to a significant negative impact to their stock market performances (Hong Kong, $\beta = -.41^{***}$, Taiwan, $\beta = -.40^{***}$, $p < .001$). However, the potential reason for the significant positive evidence of Singapore and Korea ($\beta = .30^{***}$, $\beta = .42^{***}$, $p < .001$) might due to their holding relatively less foreign assets exposure to the US and the reduction of leverage for the class of borrowers whose problems were painfully exposed by the crisis. Central banks have also improved their management of capital flows, mitigating the risk of exchange rate overvaluation, credit booms, and bubbles. As for the insignificant results of China might due to its diversification policy shifts its investments to other countries.

Fifth, the PLS-SEM₂ results support H₅ that when the export share of Hong Kong, Singapore and Korea to the US increases will lead to less financial disruption ($\beta = .63^{***}$; $\beta = .37^{***}$; $\beta = .27^{***}$, $p < .001$), relatively, the stock market performance of these countries will grow. These findings are similar to that of Rose and Spiegel (2010) they found that greater export on the US leads to better stock finance performance. However, the export share of Taiwan on the US might relatively low compare to other countries, hence, leads to the insignificant result. China's export to the US declines remarkably during 2008, thus leads to the significant negative result ($\beta = -.17^*$, $p < .05$).

Sixth, the empirical results of PLS-SEM₂ show H₆ that the financial linkage will have one significant positive influence on the trade linkage for China ($\beta = .36^{***}$, $p < .001$) and Singapore ($\beta = .19^*$, $p < .05$). However, the evidence demonstrates that the financial linkage will lead to one significant negative impact on the trade linkage for Hong Kong. This contrary evidence for Hong

Kong might due to its more globalized character which will shift its export to other markets. Further, the insignificant result for Taiwan and Korea might due to their weak dynamic correlations with the US market, therefore, not easily affected by the subprime crisis (Naoui, Liouane & Brahim, 2010). Moreover, these countries have strengthened their external positions by running current account surplus, maintaining large foreign reserves, and diversifying exports (Ee & Xiong, 2008).

Next, after examining the empirical evidences of PLS-SEM₃ (Table 5), I find that all the path coefficients indicate the same significance results. However, the evidence of H₆₋₁ indicates similar significance but reverse direction results compare to H₆ in PLS-SEM₂, namely, the trade linkage will generate one significant positive influence on financial linkage for China ($\beta = .20^{***}$, $p < .001$) and Singapore ($\beta = .08^*$, $p < .05$). Moreover, the trade linkage will lead to one significant negative influence on financial linkage was demonstrated for Hong Kong ($-.38^{***}$, $p < .001$). Thus, the bilateral influences between financial and trade linkages were demonstrated.

The evidences of PLS-SEM₂ indicate H₇ that there is one significant moderate effect of the subprime crisis associated with financial linkage on the stock markets of Hong Kong ($\beta = -.47^{***}$, $p < .001$). This imply that the highly globalization of Hong Kong will through diversification policy to shift the negative impact of the subprime crisis associate with the financial linkage on the stock market performance. On the other hand, the moderate effect of the subprime crisis integrates with the financial linkage will also generate one significant negative impact on Taiwan's stock market ($\beta = -.19^{**}$, $p < .01$). This evidence implies that Taiwan's well-established financial institutes and its conservative loan policy will buffer the negative impact from the subprime crisis. Lastly, there is one significant moderate effect of the subprime crisis associate with the financial linkage on the stock market of China ($\beta = -.20^*$, $p < .05$). The potential reason might due to China's open economic policies performed in recent years.

V. Conclusions, implications and future directions

This study provides some empirical evidence for the mediating role of financial and trade linkages to transmit the subprime crisis to Asian stock markets. The evidence supported that the subprime crisis in the U.S. had a contagion effect on international stock markets. It was more likely that the transmission of massive negative information resulted in higher risk aversion for international investor (Kaoa et al., 2019). On the other hand, there are significant moderate effects of the subprime crisis associated with the financial linkage on the stock markets (China, Hong Kong and Taiwan). The major conclusions are illustrated below. The possible explanation was that the degree of financial linkage with the U.S. market contributed to the strength of the contagion effect (Kaoa et al., 2019).

This study demonstrates the contagion effect along with the mediating function via financial and trade linkages. This evidence is different from prior streams of research. One first stream argues that subprime crisis will influence Asian stock markets only through trade contagion (Reisen, 2008; Xue et al., 2012). A second stream insists that the subprime crisis will only transmit through

financial contagion to generate impacts on Asian stock markets, especially for Hong Kong and Taiwan (Adrian & Shin 2008; Chen et al., 2010; Davis, 2008). The third stream finds an increased correlation following the spread of the subprime crisis through Asian stock markets (Baig & Goldfajn, 1999; Calvo & Reinhart, 1996). The fourth stream of studies insists that the Asian stock markets will respond strongly to the subprime crisis but found no explicit channel through which to transmit it (Dooley & Hutchison, 2009; Hwang, 2012).

Compare to Rose and Spiegel (2010) found no significant evidence of an international linkage to transmit the influence of subprime crisis. However, this study have demonstrated the salience of the mediating function of contagion effect through financial linkage (Hong Kong, Taiwan, Singapore and Korea) and trade linkage (China, Hong Kong) to affect Asian stock markets. In addition, this study shows that the financial linkage will generate positive effect on trade linkage for China and Singapore, and the reverse impact from trade linkage to financial linkage are also demonstrated. Thus the bilateral influences between the trade and financial linkages are proved. In addition, this study demonstrates that the subprime crisis will associated with the financial linkage to generate one negative significant moderate effect on the stock market of Hong Kong and Taiwan, and vice versa.

Lastly, the PLS-SEM₂ empirical evidences have following implications for policymakers. The empirical results show significant financial linkages between the US with Hong Kong, Taiwan, Singapore and Korea. Next, this study shows the significant moderate effect of the subprime associate with the financial linkage on the stock market of Hong Kong and Taiwan. Policymakers and regulators should ensure that sufficient resources are devoted to financial surveillance, supervision, and risk management to mitigate the risks engendered by the increasing complexity and connectivity of financial markets and products.

Central banks and regulators also need to enhance their macroprudential tool kits to understand and address the recurring problems of liquidity, leverage, and contagion in today's globalized financial system. Policymakers and regulators should also be mindful of the classic behavioral problems of principal-agent and moral hazards that are sometimes the unwitting by-products of polices or measures that are well intended.

The empirical results also show strong trade linkages between the US with China and Hong Kong, thus, US currency shocks might have encouraged these countries to run current account surplus, maintaining large foreign reserves, diversification exports to strengthen their external positions (Ee & Xiong 2008).

Since this study only focuses on five Asian countries, therefore, future researches are suggested to expand the scope of sample countries. In addition, more feasible mediate and moderator variables can also be taken into account to investigate their saliencies and functions.

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