The Role of Financial Market Development on Financial Contagion: Evidence from Selected Asian Economies

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By: Iman Badrudin[1]

Abstract

This paper seeks to examine the role of financial sector development in cushioning the extent of financial contagion in Asian economies since the 2008 Global Financial Crisis. This study looks at Thailand, Indonesia, Malaysia and Korea, countries that were severely affected during the 1997 Asian Financial Crisis. This paper also attempts to distinguish the ability of current Asian financial systems in dealing with global and regional shocks. The empirical results broadly suggest that financial market development has played significant roles in the management of financial contagion for these Asian economies. The effects on equity contagion are comparatively stronger than for currency contagion. In particular, the size of the banking system and the degree of financial openness matters to reduce stock market contagion, while higher levels of adequate reserves does have some offsetting effects during currency shocks. Present market conditions also appear to show signs of greater resilience against a regional equity shock similar to what was experienced in 1997.

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[1] Author can be reached at imanbadrudin@bnm.gov.my

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1. Introduction

1.1 Background and motivation

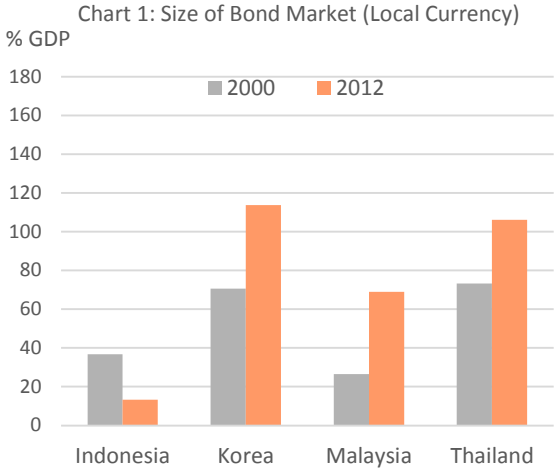
Financial market development has always been an important agenda for Asian economies. This is due to the recognition that market development can facilitate long-run economic growth, enable easier government borrowing and enhance general welfare; all while simultaneously acting as a conduit for domestic monetary policy (Obstfeld, 2009). Nevertheless, the Asian Financial Crisis (AFC) in 1997 had highlighted inherent weaknesses in both the economy and financial systems of the countries at the epicentre of the crisis, i.e. Thailand, Indonesia, Malaysia and Korea. In the period leading to the crisis, domestic investments were mostly funded through foreign borrowings, while prudential regulation and supervision failed to keep up with financial liberalisation (Lindgren et al, 1999). Following the crisis, these economies underwent various macroeconomic, corporate and financial sector reforms aimed at strengthening fundamentals, improving resilience towards unfavourable shocks and promoting regional financial integration (Park, 2011).

Post Asian crisis financial sector reforms had focused on restructuring the banking system's balance sheets, mostly through deleveraging processes and recapitalization. These efforts worked to reduce external vulnerability, as evidenced by the resilience of Asian economies during the 2008 Global Financial Crisis (GFC)[2]. These reforms were also accompanied by carefully sequenced financial market development that was supported by better regulation. In this respect, market development was intended to

[2] While Asian economies were not spared from the economic and financial shocks of the 2008 GFC, by 2010 most countries had experienced economic recovery that prompted the withdrawal of monetary stimulus that was implemented during the crisis.

enable more efficient intermediation of funds, facilitate risk management through funding diversification (Fornari and Stracca, 2013) and to increase investment opportunities. Consequently, all four economies have since exhibited deeper financial markets (Charts 1 and 2).

Chart 1: Size of Bond Market (Local Currency)



Source: Asian Development Bank, Asian Bonds Online

*Size of Indonesian bond market contracted in 2012 due to unusually high maturity of total outstanding bonds during the year.

Chart 2: Market Capitalisation of Listed Companies

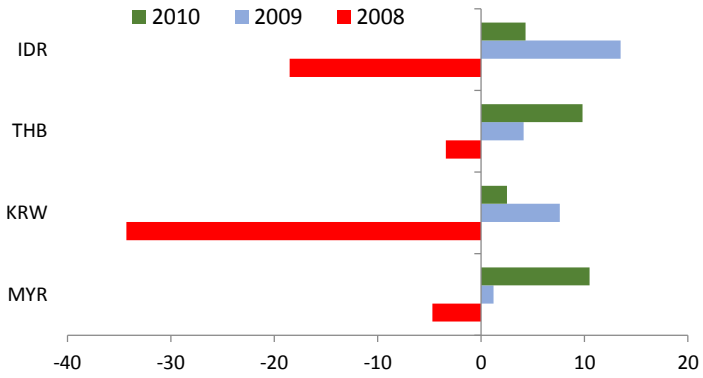
Source: World Development Indicators

With the development of bond and equity markets, the process of financial intermediation is no longer concentrated within the banking system (Park, 2011). A survey of the economic literature related to this topic suggests that the relative importance of the banking system and capital markets evolves throughout the process of economic development. In order to better insulate economies and financial systems from adverse external financial shocks, Obstfeld (2009) notes that the expansion of local currency bond markets can address the problem of currency mismatch, and facilitate a more efficient distribution of financial resources to the economy that is compatible with domestic monetary stances. Demirgüç-Kunt, Feyen and Levine (2012) show that the development of banking systems and securities markets is linked to economic growth and prosperity. During this process, however, the relationship

between traditional banking and economic activity tends to weaken amid strengthening links between capital markets and economic growth. Boot and Thakor (1997) and Weinstein and Yafeh (1998) also suggest that while the financial services offered by banks and capital markets are different but complementary, financing via the capital market tends to become more relevant as the economy grows and the number of projects or investments that require customized financing needs increases. As such, capital markets that are not constrained by standardized contracts and easily collateralised capital inputs would best meet these requirements. Thus it is not surprising that greater development of capital markets is likely to play a relatively stronger role in supporting economic activity (Demirgüç-Kunt, Feyen and Levine, 2012).

Nevertheless, Fornari and Stracca (2013) also highlight that while greater financial diversification serves to insulate domestic economic agents from local shocks, it simultaneously increases their exposure to global financial shocks via open debt and equity markets. Devereux and Yetman (2010) stress that there exists a fundamental trade-off between the benefits of financial integration and the contagion effects of global financial interdependence. Notwithstanding the quick rebound in Asian economies following the 2008 GFC, portfolio linkages through interdependent financial institutions across economies lead to contagion effects and negative business cycle transmissions (Charts 3,4 and 5).

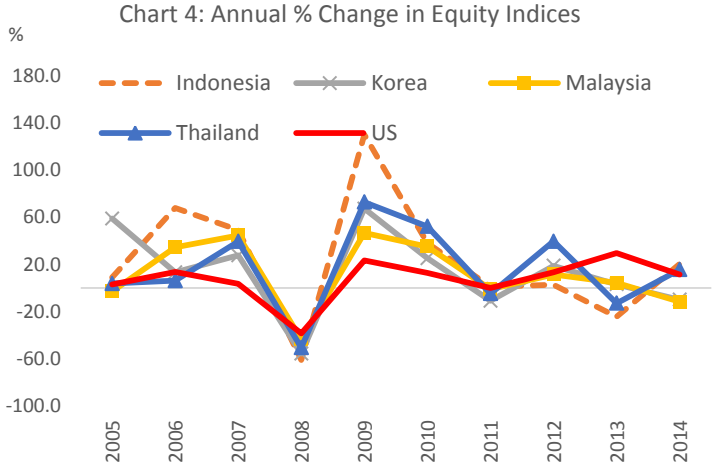
Chart 3: Exchange Rate Movement (% change)



Source: Bloomberg

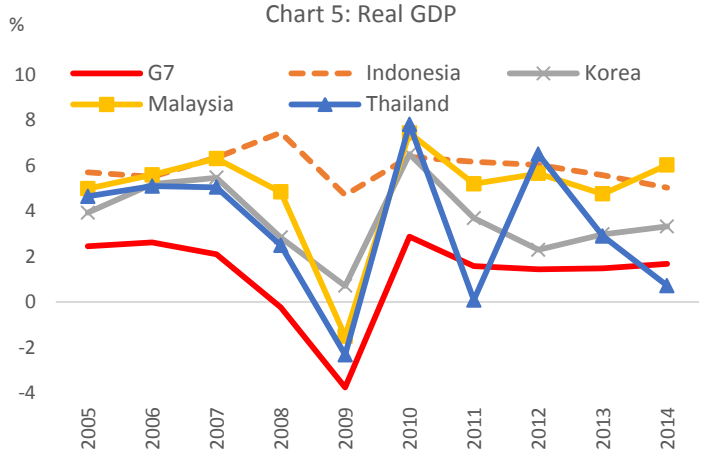
*IDR: Indonesian Rupiah; THB: Thai Baht; KRW: Korean Won; MYR: Malaysian Ringgit

Chart 4: Annual % Change in Equity Indices



Source: Bloomberg

Chart 5: Real GDP



Source: IMF World Economic Outlook

The impact of the 2008 GFC was different from the AFC in 1997 not only because the sharp reversal in capital flows was due to the crisis in advanced economies, but also because the Asian economies studied in this paper could not rely on exports to drive their recovery despite the depreciation of their currencies (Ozkan and Unsal, 2012). Given the quick turnaround of Asian economies in a weak external environment, this strongly suggests that the existing domestic economic and financial structures, which are a product of the post-AFC reforms, have had a positive impact on their ability to withstand adverse shocks. Since the 2008 GFC, these financial systems have also been subjected to further external shocks due to heightened uncertainty and volatility in global financial markets. These include the implementation and withdrawal of the United States (US) Federal Reserve's Quantitative Easing (QE) programmes, as well as investors' concerns over the relative strength of macroeconomic fundamentals within the region.

1.2 Research objective

Given that the financial markets of the economies that were severely affected during the 1997 AFC are now much more developed, it is likely that these factors have had some influence during the recent episodes of financial contagion. Therefore, this paper will seek to answer 2 key questions:

i. Has financial sector development helped Asian economies cushion the extent of financial contagion since the 2008 Global Financial Crisis? If so, which aspect of financial sector development matters most for this purpose?

ii. Are there differences in the ability of current Asian financial systems to withstand global and regional shocks?

This research differs from other studies of financial contagion, as it will examine the role of financial market development in totality rather than focus on one aspect, i.e. financial integration, as most studies have done. Chami, Fullenkamp and Sharma (2009) suggest a framework for financial market development that relies upon the existence and actions of participants (liquidity providers, regulators, international and domestic borrowers and lenders) whose presence is essential for the efficient functioning of markets. Following the recommendations in the International Monetary Fund's (IMF) 2005 'Financial Sector Assessment: A Handbook', financial structure and development should capture the size, breadth and composition of the financial system. Therefore, the impact of other aspects of market development in managing financial contagion, particularly those recommended by the IMF, will also be considered. These may include the adequacy of foreign reserves, size of the domestic banking system, equity and bond markets, as well as the degree of financial openness.

The analysis in this paper is divided into three main stages. In the first stage, global and regional financial shocks are tested via a structural vector autoregression (SVAR) to ensure that they have had significant impact across all four economies studied in this paper. Next, a two sample or heteroskedastic t-test is carried out to determine whether financial contagion occurred in stock and currency markets during these identified shocks. Finally, we estimate the effects of various aspects of market development for each economy during separate periods of financial contagion using Ordinary Least Squares (OLS) regressions. In this section, we also attempt to simulate stronger regional shocks by replicating the magnitude of stock and currency contagion

during the AFC, and testing the performance of present levels of market development against these financial shocks.

The key findings of this paper suggests that while on average, financial market development has had significant effects in the management of financial contagion for these Asian economies, the impact appears to be more constraining for contagion in the stock market. In particular, the size of the banking system and the degree of financial openness matters to minimize stock market contagion, while higher levels of adequate international reserves does have some offsetting effects during currency shocks. Nevertheless, present market conditions appear to show signs of greater resilience against a major regional shock similar to that during the AFC.

The rest of the paper is organized as follows. Section 2 provides detailed information on the empirical strategy and data used in this study to examine the impact of market development on several types of financial contagions. Section 3 then provides a comprehensive discussion of the results, while Section 4 concludes and offers some policy recommendations and potential areas for further research on the topic.

2. Empirical strategy and data

The empirical strategy of this study will be broadly based on the methodology used by Baig and Goldfajn (1999), albeit with some modifications to ensure that the key research questions outlined in Section 1 are addressed. As such, the sequence of methods is divided into three main stages.

2.1 Stage 1: SVAR analysis to identify common global and regional shocks

A SVAR model is used to identify global and regional shocks that have had comparable effects across the Asian financial markets being studied. A SVAR approach is chosen over the vector autoregression (VAR) method used in Baign and Goldfajn (1999) to differentiate the movements in indicators that reflect financial contagion caused by a shock in either global or regional financial markets by imposing restrictions on the long-run characteristics of the variables (Dungey et al, 2003). These restrictions enable the impulse response functions to be interpreted as the impact of an increase in the shock variable to the structural innovation of the dependent variables.

The following global and regional financial shocks will be tested:

i. The 2008 collapse of Lehman Brothers[3], which effectively triggered the Global Financial Crisis. The Chicago Board Options Exchange's (CBOE) Market Volatility Index (VIX) will be used to proxy this shock. The VIX index is largely an asymmetric measure of investor confidence; much stronger when stock markets plunge due to adverse financial shocks compared to when measuring

[3] The collapse of Lehman Brothers on 15 September 2008 is widely viewed as the key trigger event for the Global Financial Crisis as it lead to a severe loss of confidence in the global financial system (International Organization of Supreme Audit Institutions, 2010).

investor confidence during a market rally (Whaley, 2008). As such, the asymmetric nature of the VIX index would provide a more robust reflection of global market turbulence during the Lehman collapse.

ii. The implementation and scaleback of quantitative easing (QE) in the United States. These events were unlike anything that had occurred in global financial markets previously in terms of magnitude and impact to global monetary conditions. To proxy for these shocks, the US 5 year sovereign yields are used to reflect the impact of the programme announcements and implementation. In particular, only the implementation of the first QE programme (QE1) will be tested, whereas for the programme withdrawal, the shocks will cover the period of market tantrum due to misinterpretation of hints by the then Federal Reserve Chairman, Ben Bernanke, over the timing of a scaleback in the QE programme, as well as the actual tapering of the Federal Reserve's asset purchases.

iii. In terms of regional financial shocks, the case of twin deficit concerns originating from Indonesia in 2013 will be tested as it was considered a trigger for investor fears over weakening fiscal and current account fundamentals within the region. To represent this shock, the 5 year Indonesian sovereign yield will be used to reflect the corresponding outlook downgrade by Standard and Poor (S&P) due to concerns over its twin deficits.

The impact of the shocks listed above will be analysed on three main market indicators that are likely to reflect any immediate financial contagion driven by shifts in investors' portfolio funds. These indicators include daily changes in domestic stock market

indices, nominal exchange rate and sovereign yields, from January 2005 to July 2015[4]. For each of these contagion indicators, a nine variable SVAR is repeated using the lag length identified through pre-estimation lag-order selection statistics. The full sets of variables for each SVAR are as follows:

$$Z_{yt} = \{\Delta \text{ Contagion indicator}_{xt}, \Delta \text{ VIX index}_t, \Delta \text{ US Sovereign Yield}_t * QE1, \Delta \text{ US Sovereign Yield}_t * \text{QE tantrum}, \Delta \text{ US Sovereign Yield}_t * \text{QE scaleback}, \Delta \text{ Indonesian 5 year Sovereign Yield}_t\} \quad (1)$$

Whereby Z_{yt} refers to the respective SVAR for each type of market indicator, Δ *Contagion indicator* is the relevant market indicator for each country, Δ *VIX index*$_{tt}$ as a proxy for global market turbulence, while Δ *Indonesian Sovereign Yield*$_t$ captures investors' twin deficit concerns. The interaction terms Δ *US Sovereign Yield*$_t$ * *QE1*, Δ *US Sovereign Yield*$_t$ * *QE tantrum,* and Δ *US Sovereign Yield*$_t$ * *QE scaleback,* reflect the three distinct aspects of US QE activity that will be tested. These variables are interacted with time dummies to control for the periods in which QE1 was implemented, the misinterpretation of QE scaleback, and the subsequent official announcement[5].

[4] The interbank market is excluded from testing in this paper as conditions are more likely to be affected by domestic monetary policy rather than external financial shocks.

[5] Shock durations are as follows:

- Lehman Brothers collapse: 15 September 2008 to 15 September 2009
- QE1: 25 November 2008 – 30 June 2009 (to capture announcement effects when the programme was introduced and expanded in March 2009)
- QE tantrum: 22 May 2013 to 17 December 2013 (period of uncertainty following Bernanke's first mention of the possibility of a scaleback in asset purchases)
- QE scaleback: 18 December 2013 to 31 October 2014 (official announcement until end of programme scaleback)
- Twin deficit concerns in Indonesia: 2 May 2013 to 21 May 2014 (period of S&P's negative outlook for Indonesia

Each of the SVARs are fitted with diagonal matrix restrictions on the contemporaneous correlations between each variable, and the respective impulse response functions for the impact of the various shocks on each country's contagion indicator market is generated. The impulse response functions should reflect the direction, magnitude, lagged impacts and size of the confidence intervals of the shocks in question. Going forward, only shocks with distinguishable and comparable effects indicated by the impulse response functions will be examined for the rest of the study.

2.2 Stage 2: Determining the presence of financial contagion

Upon identifying the relevant shocks in Stage 1, it is essential to ensure that there was financial contagion during the identified shock periods. This paper will follow Dornbusch, Park and Claessens (2000) by defining contagion as 'a significant increase in cross-market linkages after a shock to an individual or group of countries, as measured by the degree of co-movement in asset prices and financial flows across markets, relative to tranquil times.'

The empirical strategy employed by Baig and Goldfajn (1999) for this stage is similar to the methodology used by Forbes and Rigobon (1998), and features a two sample or heteroskedastic t-test to determine whether the cross correlation of contagion indicators has changed significantly following a financial shock, compared to tranquil or pre-crisis times. This method, however, requires having to use a Fisher transformation to convert the correlation coefficients to a normal distribution with mean μ_t and variance σ^2_t. In their review of empirical models of contagion, Dungey et al (2005) highlight that the Forbes and Rigobon (1998) method involves the use of a non-linear

function of changes in asset return volatility from the contagion source over the relevant sample periods. They propose an alternative formulation of implementing the heteroskedastic t-test by scaling both the asset returns during the tranquil and crisis period by the standard deviations during tranquil times (Appendix A1). In this paper, we follow Baign and Goldfajn (1999) by arbitrarily identifying the tranquil period as one year prior to the shock, to account for any prior sequential changes in the relationship of the asset returns being studied[6].

Dungey et al (2005)'s alternative formulation simplifies the Forbes and Rigobon (1998) heteroskedatic t- test to a Chow test for a structural break in the regression slope. To do so, the following pooled OLS regression over the entire sample, is estimated:

$$\frac{\Delta Z_{2,t}}{\sigma_{x,2}} = \beta_1 \left(\frac{\Delta Z_{1,t}}{\sigma_{x,1}}\right) + \gamma_1 \left(\frac{\Delta Z_{1,t}}{\sigma_{x,1}}\right) d_t + \eta_t \qquad (2)$$

Where $Z_{2,t}$ refers to the series of domestic asset returns during both tranquil and crisis periods, and scaled by their respective pre-crisis standard deviations. $Z_{1,t}$ is the asset return shock proxies, also scaled by their tranquil period standard errors. For the second term in this regression, the scaled $Z_{1,t}$ is interacted with a time dummy variable defined as *d=1* during the crisis period and d=0 otherwise. The estimated coefficient γ_1 reflects any change in impact arising from the shock during the crisis. Performing a one-sided t-test of

$$H_0 : \gamma_1 = 0 \qquad (3)$$

[6] Due to the close gap between the Lehman collapse shock on 15 September 2008 and the implementation of QE1 on 25 November 2008, an exception is made for the tranquil period prior to the implementation of QE1. For this shock, the tranquil period will follow the identified pre-crisis interval for the Lehman shock.

will indicate whether or not the time dummy contributes any additional information on the relationship between the shock variable and the domestic indicator of financial contagion. A significant change in the relationship of the variables will suggest the presence financial contagion during the period.

2.3 Stage 3: Estimating the impact of financial market development

This stage of the empirical strategy should ultimately provide answers to the key research objectives of this paper. Here, we follow a similar regression by Baig and Goldfajn (1999) to quantify the role of financial market development on contagion. In their paper, Baig and Goldfajn examine the effects of own-country and cross-border news on markets. This study, however, will replace the 'news' variables with the set of indicators that reflect the level of development of the financial system. In addition, to quantify the effects of the level of market development during financial contagion (as identified in Stage 2), a set of interaction terms are included to control for the periods that the shock occurs. The equations for each country, and each type of contagion indicator will be as follows:

$$\Delta Contagion_{x,t} =$$
$$\Delta\, Financial\ Market\ Indicators_{\,x,t} * d_{y,t} + \Delta\, Financial\ Market\ Indicators_{x,t} +$$
$$\Delta\, Ln\ US\ stock\ index_t + \Delta\, Ln \frac{Yen}{Dollar_t} \qquad (4)$$

where x refers to a given country within the sample of selected Asian economies and $d_{y,t}$ is a time dummy that is equivalent to 1 during a *y* shock, and 0 otherwise. Separate regressions will be run for various contagion indicators for each country, including changes in the nominal exchange rate and domestic stock market index. Estimations

will also account for on-going global financial conditions[7], which is proxied for by the US S&P500 stock index and the Yen-Dollar[8] exchange rate. Financial market development indicators will be based on the IMF sectoral indicators of financial development that are publicly available. Specifically, this study will take into account the following aspects of market development:

i. Adequacy of foreign exchange reserves to mitigate excessive volatility in the domestic currency. This is measured by international reserves as a percentage of money supply (M2).

ii. Bank deposits as a percentage of GDP, which serves as an indicator of the banking system's available sources of funds. A higher ratio suggests greater size and depth of the banking system. While a banking system that is largely reliant on stable long-term deposits as its main source of funds could mean that there is a lack of financial innovation, lessons from the GFC have highlighted the need for financial institutions to fund their business activity via prudent channels to avoid contagion effects in the event of a liquidity squeeze in financial markets (OECD, 2012).

[7] These regressions do not control for country specific macroeconomic variables (e.g. nominal GDP, inflation, current account balance and the Government's fiscal balance) due to concerns surrounding potential multicollinearity between these variables and financial market development indicators. As mentioned in Section 1, there may be causality among these factors.

[8] The Yen-Dollar exchange rate is used as a measure of global risk aversion. Botman, de Carvalho Filho and Lam (2013) provide support for the yen's safe heaven currency status during periods of global risk aversion. The yen's appreciation in response to global risk aversion is mainly driven by portfolio rebalancing through offshore derivative transactions.

iii. External debt[9] as a percentage of GDP to measure the degree of financial openness, given that it reflects the level of foreign participation in the domestic financial system.

iv. Liquidity of domestic stock markets, where depending on the type of data available for each country, is proxied for by either monthly traded volume, turnover, or new issuances in share units[10]. A liquid stock market should in theory be less susceptible to contagion effects due to the greater presence of participants to offset any sell-off pressure.

v. Total outstanding bonds as a percentage of GDP as a measure of bond market size. A higher ratio would reflect a more liquid market that should be capable of absorbing contagion shocks.

As per IMF recommendation, the variables for each country (except for stock market liquidity) have been scaled by their respective nominal GDP or broad money[11]. This is done to enable valid cross-country comparisons. While fluctuations in these ratios may be due to changes in the denominator, given that these economies have exhibited similar business cycle patterns during the period of study, these ratios can be considered reliable measures of market development.

[9] Gross external debt is defined as the outstanding amount of those actual current (and not contingent) liabilities that require payments of interest and /or principal by the debtor at some point in the future. These debts are owed by residents of an economy to non-residents.

[10] Stock market liquidity for Malaysian equity is reflected by monthly stock turnover in million units. For Korea and Indonesia, the same indicator is represented by the monthly volume of shares traded, while the number of new stock issuances in Thailand for each month is used as a proxy for market liquidity.

[11] All scaled variables are expressed as a percentages, not ratios. E.g. 70% is entered as 70 and not 0.7.

The hypothesis is that greater financial market development should help to cushion the impact of shocks on contagion. As such, the coefficients on these variables are expected to have constraining effects on contagion.

2.4 Data

Data coverage in this empirical study ranges from January 2005 to July 2015. Stages 1 and 2 rely on daily financial data extracted from Bloomberg. For Stage 3, these data were converted to monthly frequency by taking their end-month values. Country specific macroeconomic fundamentals were obtained from Bloomberg, IMF International Financial Statistics and World Economic Outlook databases, while indicators of financial market development were sourced from Bloomberg and national central bank databases.

Where necessary in all stages, the log-linear functional form is used to reduce the skewness of distribution and seasonality effects were removed for the relevant data. In most cases, the estimations are run on the data's first difference to ensure stationarity in the data. Throughout this research, exchange rate data is quoted as local currency per US dollar. Therefore an increase in the exchange rate reflects a depreciation in the currency, and vice versa. (Appendix B1 for summary statistics)

3.0 Empirical Results

3.1 Stage 1: SVAR impulse response analysis

In total, three systems of SVARs were estimated to identify the impact of financial shocks on daily changes in the stock, currency and sovereign markets of Malaysia, Thailand, Indonesia and Korea. Each SVAR was run over a sample period from January 2005 to July 2015 using daily data. A lag of one day was used, as suggested by pre-estimation lag-order selection statistic, which is consistent with the lag structure used by Baig and Goldfajn (1999). The estimations yielded a total of 15 impulse response function graphs that illustrate the impact of a one standard deviation change in the impulse or shock variable for each financial market (Appendix B2). For each graph, the ordering of variables was inconsequential. Nevertheless, in generating the impulse response functions, the response variables i.e. the financial market indicators that reflect contagion for the countries being studied, were ordered according to the relative size of their financial markets (i.e. Korea, Malaysia, Thailand, Indonesia).

For the stock market SVAR, the impulse response charts in Figures B2.1, B2.2 and B2.3 show that the collapse of Lehman Brothers, implementation of QE1 and the QE tantrum did lead to significant and similar directional responses in the Korean, Malaysian, Thai and Indonesian equity markets. Nevertheless, while the impulse response charts for the QE1 and QE tantrum shocks exhibited relatively wider 95% confidence interval bands, the impact appears to be confined to mostly one-sided effects. The impulse response charts for the QE scaleback and Indonesian twin deficit shocks (Figures B2.4 and B2.5), however, reveal insignificant responses towards the

shocks given that the confidence intervals are wide and include both positive and negative values. Therefore, these shocks will be excluded from Stage 2 onwards.

In terms of currency effects, the impulse response charts for the Lehman Brothers shock (Figure B2.6) shows that all four currencies experienced significant depreciation. For the impact of QE1, Figure B2.7 suggests that the rupiah, won and ringgit underwent some appreciation, whereas the baht depreciated in response to this shock. While the confidence band for the rupiah and ringgit may suggest some uncertainty in the impact, this could be a reflection of exchange rate intervention during the period as the region as a whole did experience strong capital inflows that are likely to have exerted pressures on the exchange rate. The QE tantrum event did cause significant appreciation in the rupiah, and depreciation in the won and ringgit. The baht did not experience much discernible impact during this period, which may also have been a consequence of exchange rate intervention to manage volatility at that time. Figure B2.9 shows that the QE scaleback did have broadly significant depreciation effects on all four currencies. Lastly, the Indonesian twin deficit shock appears to have lead to appreciation in the rupiah, won and ringgit, and depreciation in the baht. The 95% confidence bands for Indonesia, Malaysia and Thailand, are mostly one-sided, despite being relatively wide. For Korea, however, the width of the confidence band covers both positive and negative values. The effects for Korea may not be surprising as investors may view Korea[12] as different from the other three economies given that it has experienced greater levels of economic development compared to the other three

[12] The IMF presently categorizes Korea as an advanced economy, and Malaysia, Thailand and Indonesia as emerging and developing economies.

economies. Nevertheless, the next two stages will continue to consider these shocks as the currency effects may be a reflection of central bank intervention to manage volatility.

The sovereign yield SVAR strongly suggests that most of the global and regional financial shocks that were tested did not have much visible impact to Asian sovereign markets. Given these results, the next stage of estimations will focus only on contagion effects in equity and currency markets. While the directional impact in the currency market and the twin deficit concerns on stock markets may not be similar across countries, the following empirical tests will continue to consider these shocks as the trends may be due to differences in economic fundamentals and exchange rate intervention. In any case, the next two stages of estimations will provide further information on the factors driving these differences. The following tables (Tables 1a to 1c) summarize the directional impact of the shocks from the impulse response functions.

Table 1a: Stock Market Impulse Response Summary

	Stock Market SVAR			
Impulse/Shock	Korea	Malaysia	Indonesia	Thailand
Lehman Brothers Collapse	–	–	–	–
QE1	+	+	+	+
QE Tantrum	–	–	–	–
QE Scaleback (not significant)	–	–	–	–
Twin Deficit in Indonesia (not significant)	+	–	-	NE*

Notes:
'+' denotes an increase in stock indices, while '-' refers to a decline in stock indices
*NE indicates no discernable impact from shock to exchange rates.

Table 1b: Exchange Rate Impulse Response Summary

	Exchange Rate SVAR			
Impulse/Shock	Korea	Malaysia	Indonesia	Thailand
Lehman Brothers Collapse	–	–	–	–
QE1	+	+	+	–
QE Tantrum	–	–	+	NE*
QE Scaleback	–	–	–	–
Twin Deficit in Indonesia	+	+	+	–

Notes:
'+' denotes a currency appreciation while '-' refers to a currency depreciation
*NE indicates no discernable impact from shock to exchange rates

Table 1c: Sovereign Yield Impulse Response Summary

	Sovereign Yield SVAR			
Impulse/Shock	Korea	Malaysia	Indonesia	Thailand
Lehman Brothers Collapse	–	NE*	+	NE
QE1	NE	NE	NE	NE
QE Tantrum	+	+	+	+
QE Scaleback	NE	NE	NE	NE
Twin Deficit in Indonesia	NE	NE	NE	NE

Notes:
'+' denotes a rise in sovereign yields, while '-' refers to a decline in sovereign yields
*NE indicates no discernable impact from shock to sovereign yields

3.2 Stage 2: Identifying presence of financial contagion

Equation 2 was regressed to test for the presence of financial contagion for each country's daily change in stock indices and exchange rates during the identified shocks. Should the t-test on the γ_1 coefficient for the regressions be significant, this would indicate the presence of contagion during the shock for the market in question.

Each equation was regressed using Newey-West standard errors to ensure robustness against arbitrary autocorrelation and heteroskedasticity (Wooldrige, 2006). While daily data is used for these estimations, the maximum lag for autocovariances to be computed is set to three days to allow for any shocks that occur on the last trading day

of the week, i.e. Friday, to be immediately transmitted on the first trading day of the following work week, i.e. Monday.

Tables 2a and 2b summarize the estimation results. There is evidence of significant financial contagion for all four equity markets during the collapse of Lehman Brothers, and implementation of QE1. With the exception of Korea, stock markets in Malaysia, Indonesia and Thailand did not experience financial contagion during QE tantrum.

For currency markets, however, there appears to be no consistent impact of financial contagion for all markets given the same shocks. For instance, during the Lehman Brothers collapse and twin deficit concerns, all currencies showed signs of contagion except for the rupiah. Given the noticeably strong contagion effects in the stock market during these shocks, these results come as a surprise and strongly allude to the presence of active currency intervention to mitigate the contagion effects. During the implementation of QE1, only the rupiah and won can be categorized as having experienced contagion. Contagion effects in the ringgit, rupiah and won were present during the QE tantrum, and had disappeared by the time the scaleback was actually implemented. One plausible reason for these developments is that market participants had already priced in the effects of a scaleback during the tantrum period, resulting in no change in the relationship between asset returns in the US and most Asian markets when the QE scaleback was actually implemented.

Table 2a: Significance of γ_1 for the Presence of Stock Market Contagion

	Stock			
	Malaysia	Indonesia	Thailand	Korea
Lehman	Yes**	Yes**	Yes***	Yes***
QE1	Yes***	Yes***	Yes***	Yes***
QE Tantrum	No	No	No	Yes**

Notes:
'Yes' indicates the presence of financial contagion and 'No' otherwise
*denotes significance of 10% for the presence of financial contagion
**denotes significance of 5% for the presence of financial contagion
***denotes significance of 1% for the presence of financial contagion

Table 2b: Significance of γ_1 for the Presence of Currency Contagion

	Currency			
	Malaysia	Indonesia	Thailand	Korea
Lehman	Yes***	No	Yes***	Yes**
QE1	No	Yes***	No	Yes***
QE Tantrum	Yes***	Yes***	No	Yes**
QE Scaleback	No	No	Yes***	No
Twin Deficit	Yes***	No	Yes***	Yes***

Notes:
'Yes' indicates the presence of financial contagion and 'No' otherwise
*denotes significance of 10% for the presence of financial contagion
**denotes significance of 5% for the presence of financial contagion
***denotes significance of 1% for the presence of financial contagion

3.3 Stage 3: Assessing the impact of financial market development on contagion

Equation 4 tests the role of various aspects of market development in Malaysia, Indonesia, Thailand and Korea during the periods where financial contagion was present in stock and currency markets.

Similar to the equations in Stage 2, equation 4 was also regressed using Newey-West standard errors to properly account for any heteroskedasticity and autocorrelation. Given that the data used in this stage is of monthly frequency, the standard maximum lag of 12 was chosen.

3.3.1. Role of market development during stock market contagion

It appears that for each stock market, various types of market development have had differing impacts on changes in equity prices.

Following the collapse of Lehman Brothers, some aspects of market development did affect the degree of financial contagion experienced in Malaysia, Indonesia and Thailand. In particular, the size of banking system deposits had a contractionary impact on changes in domestic stock market indices. For each of these countries, a 1 percentage point increase in bank deposits causes stock prices to fall by 0.003%, 0.01% and 0.002% respectively. These results are consistent with the view that contagion effects to these Asian economies were relatively contained as banking activity were largely funded through stable deposits with limited exposure to toxic financial assets from advanced economies (Park, 2011). While higher levels of external debt in Malaysia led to more contagion impact in the Malaysian stock market, the relationship for these two variables are the opposite for Indonesia and Thailand. In these markets, a 1 percentage point increase in external debt reduces changes to stock price by 2.19% and 5.84% respectively. At first glance, this may seem counter-intuitive. Nevertheless, this observation may be due to the maturity profiles of external debt for these countries. In general, a longer maturity profile reduces the frequency of having to refinance external funding positions and having to liquidate other financial assets such as equity during times of financial duress (OECD 2012). For both Malaysia and Indonesia, higher liquidity in both domestic stock and bond markets lead to higher contagion effects to equity prices. While this is a likely reflection of momentum stock trading behaviour during the financial shock (Barberis, Shleifer and Vishny, 1998), the

small coefficients on these variables may be due to negative feedback trading, where domestic market participants take the opportunity from an equity sell-off to purchase stock at cheaper prices, thus reducing any one-sided pressure in stock markets. It is interesting to note that during this shock, market development indicators had no significant impact on stock price changes in Korea. (Appendix B3, Table B3.1)

During the implementation and scaleback of QE[13], the level of central bank reserves, in particular, had significant impact on stock market contagion across all four economies. A 1 percentage point rise in international reserves has the ability to reduce changes in stock prices by 0.04%, 0.03% and 0.05% for Malaysia, Indonesia and Korea respectively. Central bank intervention to manage exchange rate volatility (indirectly) works to reduce the risk of currency mismatches for foreign investors, and domestic traders with international portfolios, thereby reducing equity sell-off pressures. For Thailand, however, the impact of higher reserve levels contributes to stronger changes in stock prices. The impacts of other aspects of market development for Malaysia were significant and of similar signs as during the Lehman shock. During the QE related financial shock, external debt was a contributing factor to stock market contagion in Korea. A 1 percentage point increase in external debt increases stock price changes by 1.76%. Similar to the estimations during the Lehman shock, higher capital market liquidity led to significant but small changes in stock prices across all four economies. (Appendix B3, Table B3.2)

[13] To ensure consistency with Stage 2 results for the QE related shocks, the time dummy on the interaction terms only account for the period in which QE1 was introduced, except for Korea, whose time dummy also captures the impact of QE tantrum.

For all estimations on stock market contagion, changes in US stock prices have had significant and amplifying effects to financial contagion in these Asian economies. The impact of developments in Japanese yen was, however, not significant in all instances.

3.3.2 Role of market development during currency contagion

During the Lehman shock, all four currencies underwent initial depreciation due to capital flight in an environment of heightened global risk aversion. Overall, only international reserves in Korea had the effect of offsetting depreciating pressure during this period; depreciation pressure in the Korean won was reduced by 0.03% for every 1 percentage point increase in reserves. The stock of external debt contributed to depreciation pressure across all four currencies. In particular, a 1 percentage point increase in external debt resulted in currency depreciations of 0.0001%, 1.82%, 0.62% and 0.95% for the Malaysian ringgit, Indonesian rupiah, Thai baht and Korean won respectively. Bond market size and liquidity, while significant for Malaysia and Korea, had muted effects in amplifying currency depreciation during the Lehman shock. (Appendix B3, Table B3.3)

Throughout the implementation and scaleback of QE[14], the impact of external debt and banking system deposits were significant across all currencies. A 1 percentage point increase in external debt resulted in 1.36%, 0.55% and 1.20% additional depreciation in the rupiah, baht and won, while the impact on the ringgit was offset by a 0.002% appreciation. Stronger levels of banking system deposits had the effect of adding some

[14] Analysis of the impact of QE on currency contagion will be kept general as the implementation of QE mostly resulted in appreciation pressure, while the scaleback in QE had on average resulted in depreciation in Asian currencies.

appreciation pressure on the currencies, except for Indonesia. From this perspective and owing to the fact that the region experienced strong capital inflows throughout the implementation of QE[15], the impact of deposit levels may differ among countries and depend largely upon holder and type of deposit composition and central bank liquidity management strategies. In addition, the level of adequate international reserves was also effective in reducing currency contagion in the baht and won during the period; a 1 percentage point increase in reserves during the period led to a 0.01% and 0.03% reduction in changes to the exchange rate. In terms of capital market liquidity, larger bond markets in Thailand and Korea likely contributed to further depreciation pressure to their respective local currencies, while the opposite is true for Indonesia. For Malaysia, the level of stock market liquidity mattered more for offsetting any appreciation pressure on the ringgit. The coefficients on these variables are very small, rendering only significant but small effects on currency contagion. (Appendix B3, Table B3.4)

During the occurrence of the Indonesian twin deficit[16], the level of banking system deposits had significant but small effects on currency contagion. The role of external debt, i.e. the extent of financial openness, however, did contribute to further depreciation in the rupiah and baht during the period. Alternatively, for Malaysia, the level of external debt had an offsetting effect on the changes in the ringgit. Capital

[15] The impact of the scaleback in QE on the currency should be influenced by the extent of capital inflows experienced during the prior implementation of QE. Also, to ensure consistency with Stage 2 results for the QE related shocks, the time dummy in the interaction terms for each country only reflects their respective significant contagion events; i.e. QE1, QE tantrum, QE scaleback, or the relevant combinations.

[16] Indonesia continues to remain in twin deficit but efforts by the Government and monetary authorities have thus far eased investor concerns, as evidenced by the upgrade in S&P's rating outlook for Indonesia from negative to stable in May 2014.

market liquidity appears to only matter for Thailand and Malaysia; a 1 percentage point increase in stock market activity resulted in a 0.003% depreciation in the baht while a 1 percentage point rise in the size of local currency bond market in Malaysia would have resulted in a 0.002% appreciation in the ringgit. The coefficients on these variables are very small, rendering only significant but small effects on currency contagion. Similar to previous shocks, the sizes of the coefficients suggest minimal impact. (Appendix B3, Table B3.5)

Throughout these estimations, the impact of changes in the US stock market on the currency was significant and negative; implying that any increase in the US stock prices would have led to appreciation pressure in the exchange rates. The impact of shifts in the value of the Japanese yen however, is significant and positive on most Asian currencies during each shock tested.

3.3.3 Simulating a stronger regional shock

Throughout the sample period of this study, i.e. from 2005 to 2015, there have not been any major financial shocks emanating from within the Asian region that can be compared to the shocks experienced during the Asian Financial Crisis (AFC). It would thus be interesting to test whether present levels of market development would have alleviated the extent of financial contagion back then. To do so, the dependent variables i.e. changes in stock indices and currency from 2005 to 2015 are replaced with the same variables for the period 1990 to 2000 to simulate the same degree of shocks. The same estimation is re-run, and similar to the previous regressions, we

examine the impact of present levels market development on the AFC simulated scale of contagion.

For similar levels of stock market contagion during the AFC, present levels of market development are likely to play a stronger offsetting role in minimizing changes to equity prices when compared to the previously tested shocks in this paper. The most notable impact is the level of external debt, whereby a 1 percentage point increase in this factor will reduce changes to stock prices by 23.3% and 13.5% in Indonesia and Korea, but increase contagion in Thailand by 12.3%. These results strongly suggest that present compositions of external debt, particularly in Indonesia and Korea, are of a sustainable nature and could work in favour of cushioning stock market contagion in the event of a massive financial shock from within the region. The build-up of adequate reserves since the AFC for Malaysia and Thailand will also be able to offset the simulated shock. In addition, a comparatively stronger and more robust banking system in both Malaysia and Indonesia would also work to contain the simulated shocks in the equity market. Given that banking systems in these economies are no longer reliant on external short-term funding to fund their business, the build-up of a stable deposit base has made the financial system more resilient against financial shocks. The increase in stock market liquidity in Thailand and Korea, and size of bond market in Malaysia should also play an offsetting role in managing stock market contagion. (Appendix B3, Table B3.6)

The impact of financial market development on currency contagion appears to be mixed across the four economies. The level of reserves only has a significant impact in

offsetting depreciation pressure in Korea; a 1 percentage point increase in adequate reserves reduces changes in the won by 0.33%. A stronger deposit base, however, only has a significant offsetting impact for the rupiah, while this factor could further aggravate changes in the won. In terms of financial openness, while a 1 percentage point increase in external debt reduces currency contagion by 45.1% for Indonesia, it would amplify changes in the won by 6.0%. Greater stock market liquidity today will help contain currency contagion pressures in the ringgit and baht, but could worsen conditions for the rupiah. The size of current bond markets would also exacerbate depreciation pressures during shocks of similar magnitude during the AFC in Indonesia and Korea. (Appendix B3, Table B3.7)

4.0 Conclusion and policy recommendations

The estimation results broadly suggest that financial market development undertaken post-AFC have played significant roles in the management of financial contagion for the Asian economies in this study.

Since the 2008 GFC, stock market contagion arising from global shocks have been mostly offset by stronger levels of banking system deposits. This comes as no surprise as deposits provide a more stable funding base for banks, creating insulation from adverse external financial shocks. Greater financial openness as reflected by external debt (normalised to GDP) also served to reduce stock market contagion, especially Indonesia and Thailand. This strongly suggests that external debt composition in terms of maturity profiles and debt holders matter in ensuring that financial openness works to contain, rather than exacerbate stock market contagion. Interestingly, greater equity

and bond market liquidity could intensify changes in stock prices. This could, however, be a reflection of momentum stock trading behaviour during financial duress. Nevertheless, the small coefficients on these factors may be driven by traders offsetting massive sell-off pressures by taking the opportunity to purchase certain stocks with the view the shock is likely to be temporary.

In terms of exchange rate markets, the various aspects of financial market contagion do not seem to overwhelmingly offset currency contagion. Higher levels of external debt raise the risk of aggravating contagion, while the impact of stronger capital market liquidity and banking system deposits appear mixed. On balance, however, higher levels of adequate reserves do work to significantly offset currency contagion depending on the type of shock.

To provide a clearer answer to whether there are differences in the ability of current Asian financial systems to withstand global and regional shocks, this study simulates the magnitude of equity and currency shocks experienced by these countries during the AFC and test whether present levels of market development would have been able to offset the adverse impact. Financial market development in this context has on average, stronger offsetting effects on stock market contagion compared to the currency market. This shows that should there be a strong shock from within the region again, the exchange rates are likely to transmit stronger contagion effects to the economy relative to the equity market. This may not necessarily be a surprising result, as these Asian economies have worked towards greater flexibility in their exchange

rate regimes since the AFC, with intervention occurring to manage the volatility rather than the absolute level of the exchange rate.

These results show that while progress has been made in terms of carefully sequenced financial market development, there remains room for improvement. In particular, policy makers may need to re-look at the details of their capital market liquidity. For instance, in some economies there could be disproportionate concentration of either domestic or foreign ownership of certain financial assets, causing varying degrees of effectiveness in managing financial contagion. Nevertheless, it could also be the case that policymakers have sought a more cautious approach to market development. While the creation of certain financial instruments, such as central bank bills, is intended to manage market liquidity more efficiently, it could simultaneously act as a conduit for potentially destabilizing speculative activity via the offshore derivatives market. In terms of market participation, while the presence of a few institutional investors can provide the stability needed during periods of financial contagion, this may not necessarily add to market vibrance during 'normal' conditions.

Going forward, further advancements to this study can be done to examine the impact of other aspects of market development, especially the role of a growing derivatives market and active central bank liquidity management. In quantifying the effectiveness of market development on managing financial contagion, it could also be worthwhile to consider further country-specific details in the empirical analysis.

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Appendix A: Empirical Strategy

A1. Alternative Formulation of the Forbes and Rigobon Test of Contagion

Dungey et al (2005) proposed an alternative formulation of the Forbes and Rigobon test of contagion by scaling the asset returns, and performing the assessment for contagion within a regression framework. In testing for contagion originating from assets markets in Country 1 to Country 2, the pre-crisis asset returns for both countries is scaled by their respective standard deviations. The pre-crisis regression equation will be as follows:

$$\left(\frac{x_{2,t}}{\sigma_{x,2}}\right) = \alpha_1 \left(\frac{x_{1,t}}{\sigma_{x,1}}\right) + \eta_{x,t} \quad (5)$$

where *x* is the pre-crisis asset returns from either country 1 or 2, and σ their respective standard deviations. η represents the disturbance term, and α_1 the regression coefficient equivalent to the pre-crisis correlation coefficient. For the crisis period regression equation, asset returns for both countries during the crisis are scaled by the pre-crisis standard deviations:

$$\left(\frac{y_{2,t}}{\sigma_{x,2}}\right) = \beta_1 \left(\frac{y_{1,t}}{\sigma_{x,1}}\right) + \eta_{y,t} \quad (6)$$

where *y* is the crisis period asset returns for either country 1 or 2. The crisis regression coefficient β_1 is equivalent to the Forbes and Rigobon adjusted correlation coefficient. Therefore, an alternative way to implement the Forbes and Rigobon method is by running both equations 5 and 6 by Ordinary Least Squares (OLS) and testing the equality of α_1 and β_1. This is similar to performing a Chow test on a pooled regression equation and testing for structural breaks in the regression coefficient:

$$\left(\frac{z_{2,t}}{\sigma_{x,2}}\right) = \beta_1 \left(\frac{z_{1,t}}{\sigma_{x,1}}\right) + \gamma_1 \left(\frac{z_{1,t}}{\sigma_{x,t}}\right) d_t + \eta_t \quad (7)$$

where *z* includes both *x* and *y,* and d_1 is time dummy variable where crisis period is 1 and 0 otherwise. The parameter γ_1 is equivalent to β_1 minus α_1 and captures any existing contagion effects. Thus, the Forbes and Rigobon test is implemented by performing a one-sided t-test on γ_1:

$$H_0: \gamma_1 = 0$$

A rejection of the null hypothesis would imply the presence of financial contagion during the crisis.

Appendix B: Empirical Results

B1. Summary Statistics

Table B1.1: Summary Statistics for Financial Variables used in Stage 1 and 2

Variable	Obs	Mean	Std. Dev.	Min	Max
VIX (Index)	3,850	19.72	9.81	9.89	80.86
KLCI (Index)	3,850	1,370.94	327.60	829.41	1,892.65
KOSPI (Index)	3,850	1,693.59	335.34	874.18	2,228.96
JCI (Index)	3,850	3,050.16	1,393.45	994.77	5,348.47
SET (Index)	3,850	976.10	343.21	384.15	1,643.43
MYR/USD	3,857	3.37	0.25	2.94	3.80
KRW/USD	3,857	1,083.37	112.15	900.75	1,570.65
IDR/USD	3,857	9,940.10	1,228.72	8,464.00	13,385.00
THB/USD	3,857	33.65	3.10	28.67	42.14
3 year Malaysian Sovereign Yield (%)	3,688	3.34	0.33	2.48	4.50
3 year Korean Sovereign Yield (%)	3,857	3.83	1.05	1.69	6.17
3 year Indonesian Sovereign Yield (%)	3,857	7.20	3.33	4.32	20.10
3 year Thai Sovereign Yield (%)	3,856	3.30	0.95	1.56	5.63
5 yr US Sovereign Yield (%)	3,857	2.46	1.38	0.54	5.23
5 yr Indonesian Sovereign Yield (%)	3,857	8.76	2.61	4.48	20.06

Notes: This table reports the descriptive statistics of all the variables used in Stages 1 and 2 of the empirical tests. The data are reported in their level forms, prior to being log-linearised and converted to first differences where necessary. Measurement units are stated in brackets next to variable names.

Table B1.2: Summary Statistics for Financial Variables used in Stage 3

	Variable	Obs	Mean	Std. Dev.	Min	Max
Global Conditions	S&P500	128	1401.68	326.04	735.09	2107.39
	JPY/USD	128	100.62	14.56	76.27	124.15
Malaysia	Stock Index (KLCI)	123	1361.90	328.14	860.73	1882.71
	MYR/USD	123	3.36	0.25	2.96	3.80
	Reserves (%M2)	123	36.90	6.95	24.68	50.81
	Deposits (%GDP)	123	1595.16	111.91	1402.42	1774.49
	External Debt (%GDP)	123	580.64	170.83	309.70	824.58
	Bond market size (MYR, billion)	126	1025.72	123.40	849.55	1226.65
	KLCI turnover (units)	127	23574.79	12500.37	5037.25	72362.68
Korea	Stock Index (KOSPI)	128	1705.37	339.36	911.30	2192.36
	KRW/USD	128	1082.89	111.98	900.75	1534.35
	Reserves (%M2)	124	19.69	0.76	17.72	21.50
	Deposits (%GDP)	123	1049.91	43.75	960.29	1149.07
	External Debt (%GDP)	123	0.36	0.07	0.20	0.51
	Bond market size (KRW, billion)	123	1203.63	158.46	941.45	1529.27
	KOSPI Volume Traded (Units)	127	7888.93	2439.99	3763.93	16145.46
Indonesia	Stock Index (JCI)	123	2991.58	1364.61	1029.61	5336.52
	IDR/USD	123	9868.94	1138.56	8504.00	13074.00
	Reserves (%M2)	123	32.39	2.84	27.08	40.85
	Deposits (%GDP)	123	391.55	32.38	315.81	441.84
	External Debt (%GDP)	123	0.37	0.08	0.28	0.60
	Bond market size (IDR, billion)	123	184.22	34.82	142.35	253.45
	JCI Volume Traded (Units)	112	96.60	67.25	11.19	531.09
Thailand	Stock Index (SET)	123	962.83	336.21	401.84	1597.86
	THB/USD	123	33.66	3.15	29.27	41.66
	Reserves (%M2)	123	35.38	6.56	25.06	45.81
	Deposits (%GDP)	123	913.92	82.40	787.17	1097.36
	External Debt (%GDP)	123	0.36	0.04	0.29	0.44
	Bond market size (THB, billion)	123	683.34	123.44	437.80	850.81
	SET New Issuance (Units)	123	11.56	15.68	0.01	113.85

Notes: This table reports the descriptive statistics of all the variables used in Stage 3 of the empirical tests. The data are reported in their level forms and measurement units are stated in brackets next to variable names.

B2. Impulse Response Graphs

Figure B2.1: Stock Market SVAR
Shock: Collapse of Lehman Brothers
Impulse: VIX Index

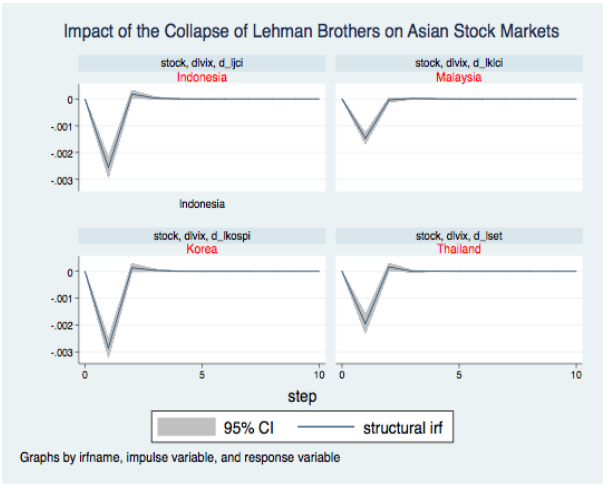


Figure B2.2: Stock Market SVAR
Shock: Implementation of QE1
Impulse: 5 yr US Sovereign Yield * QE1

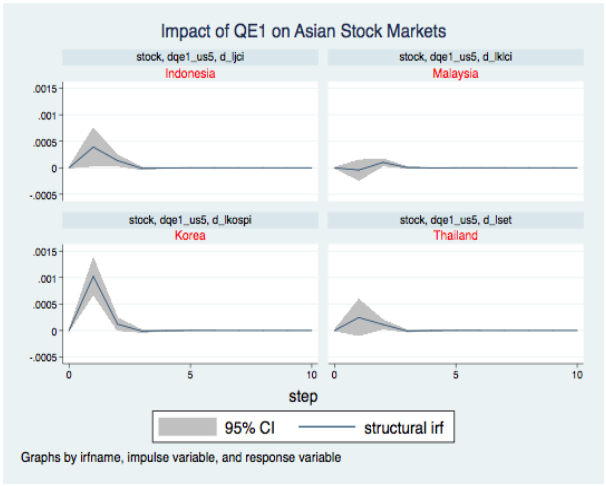


Figure B2.3: Stock Market SVAR
Shock: QE Tantrum
Impulse: 5 yr US Sovereign Yield * QE Tantrum

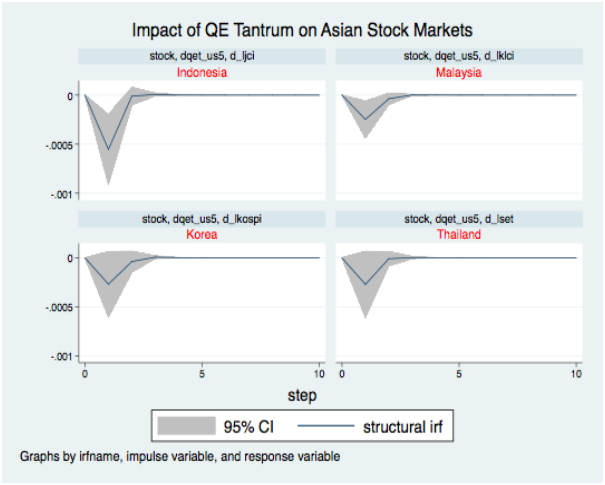


Figure B2.4: Stock Market SVAR
Shock: QE Scaleback
Impulse: 5 yr US Sovereign Yield * QE Scaleback

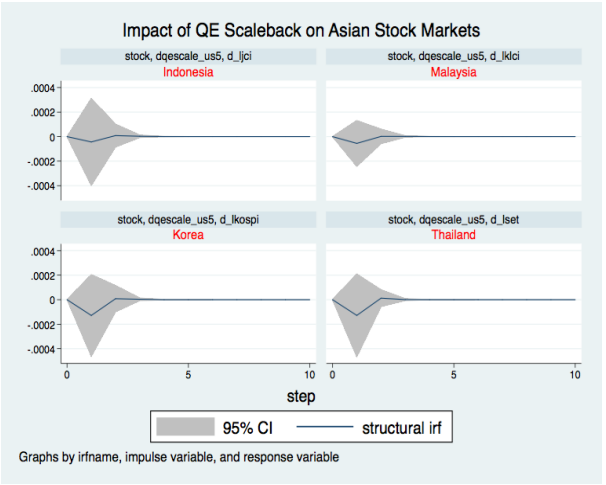
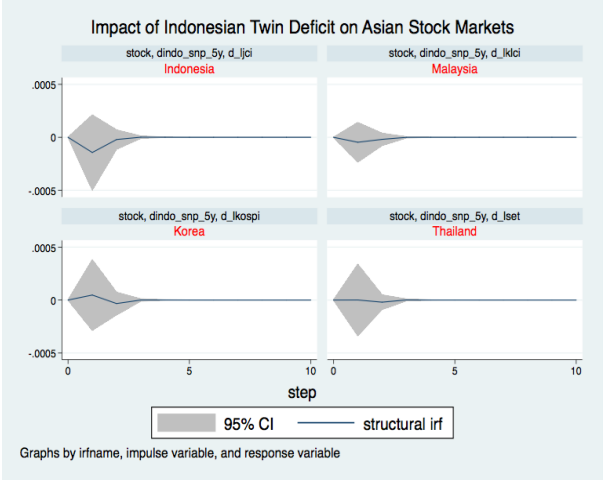


Figure B2.5: Stock Market SVAR
Shock: Indonesia Twin Deficit
Impulse: 5 yr Indonesian Sovereign Yield



Notes: Figures B2.3 to B2.5 are the impulse response functions generated by the stock market SVAR. They indicate the direction and magnitude of the financial shocks on the respective stock market indices of Korea, Malaysian, Thailand and Indonesia (the economies were ranked in this order for the SVAR estimation). The shaded grey areas are the 95% confidence interval bands.

Figure B2.6: Exchange Rate SVAR
Shock: Collapse of Lehman Brothers
Impulse: VIX Index

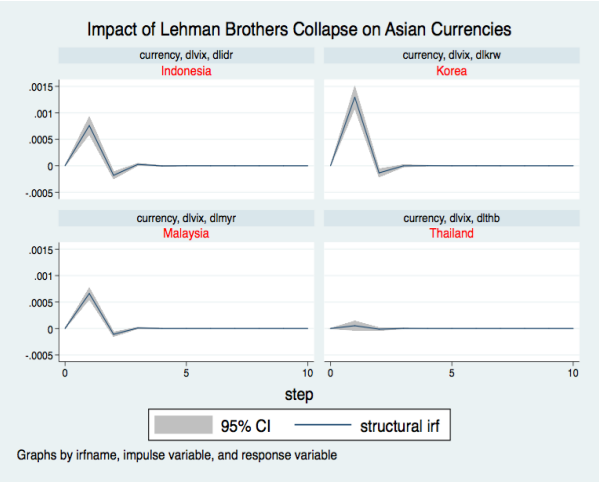


Figure B2.7: Exchange Rate SVAR
Shock: Implementation of QE1
Impulse: 5 yr US Sovereign Yield * QE1

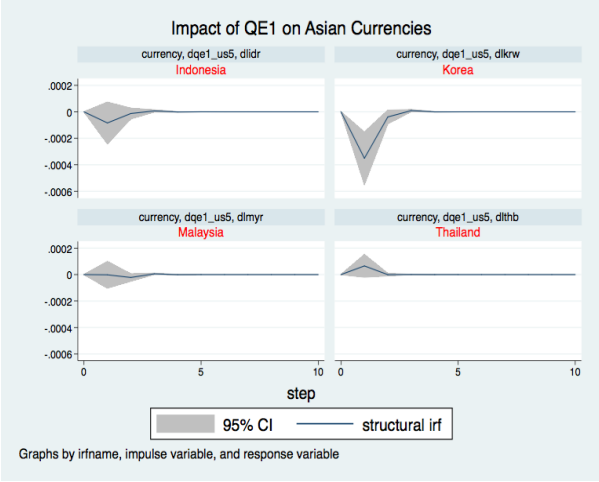


Figure B2.8: Exchange Rate SVAR
Shock: QE Tantrum
Impulse: 5 yr US Sovereign Yield * QE Tantrum

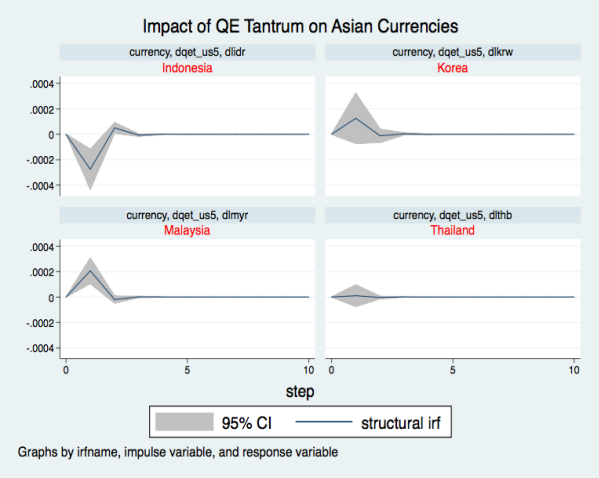


Figure B2.9: Exchange Rate SVAR
Shock: QE Scaleback
Impulse: 5 yr US Sovereign Yield * QE Scaleback

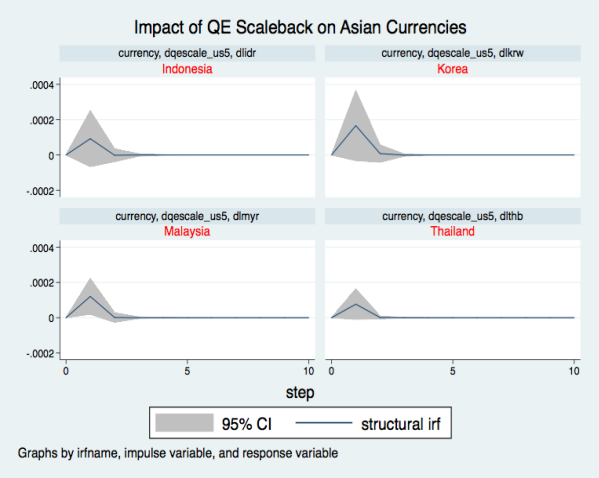
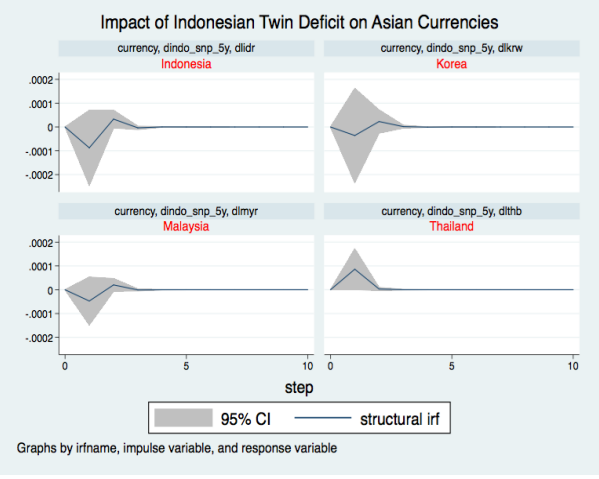


Figure B2.10: Exchange Rate SVAR
Shock: Indonesia Twin Deficit
Impulse: 5 yr Indonesian Sovereign Yield



Notes: Figures B2.6 to B2.10 are the impulse response functions generated by the exchange rate SVAR. They indicate the direction and magnitude of the financial shocks on the respective stock market indices of Korea, Malaysian, Thailand and Indonesia (the economies were ranked in this order for the SVAR estimation). The shaded grey areas are the 95% confidence interval bands.

Figure B2.11: Sovereign Yield SVAR
Shock: Collapse of Lehman Brothers
Impulse: VIX Index

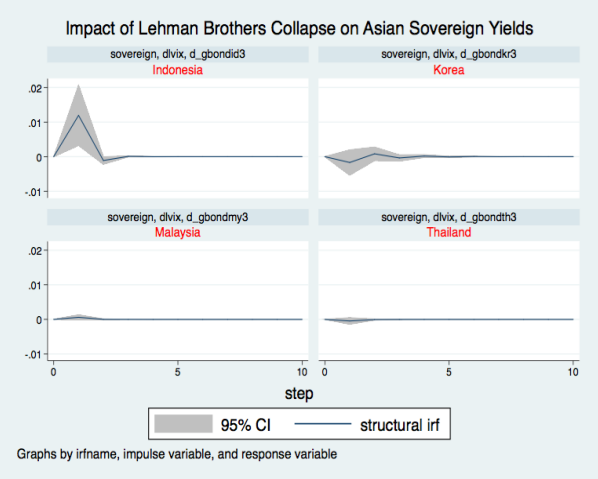


Figure B2.12: Sovereign Yield SVAR
Shock: Implementation of QE1
Impulse: 5 yr US Sovereign Yield * QE1

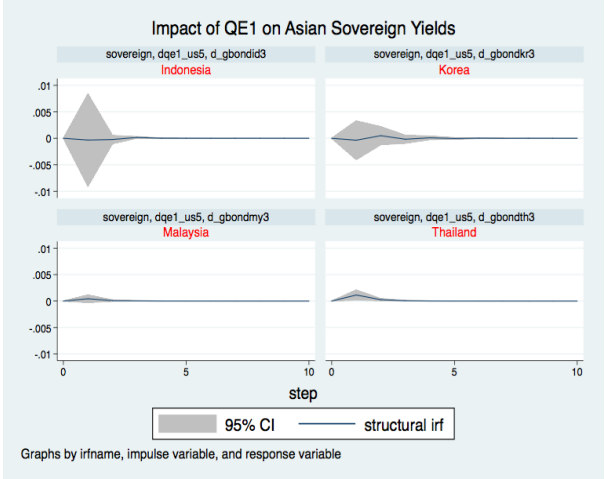


Figure B2.13: Sovereign Yield SVAR
Shock: QE Tantrum
Impulse: 5 yr US Sovereign Yield * QE Tantrum

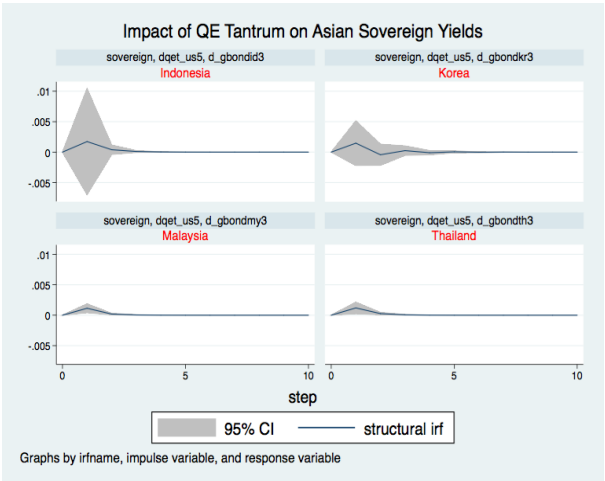


Figure B2.14: Sovereign Yield SVAR
Shock: QE Scaleback
Impulse: 5 yr US Sovereign Yield * QE Scaleback

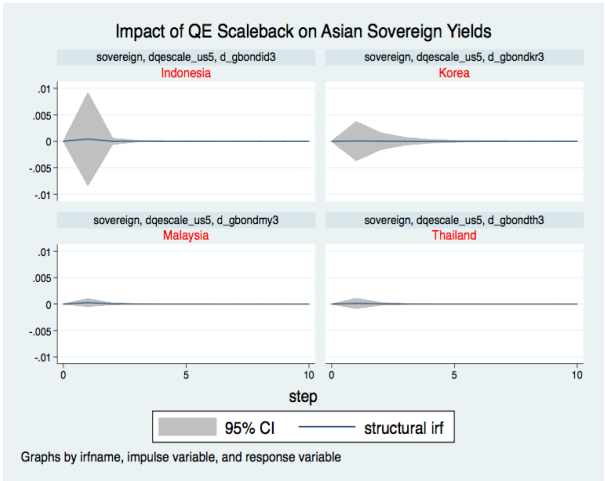
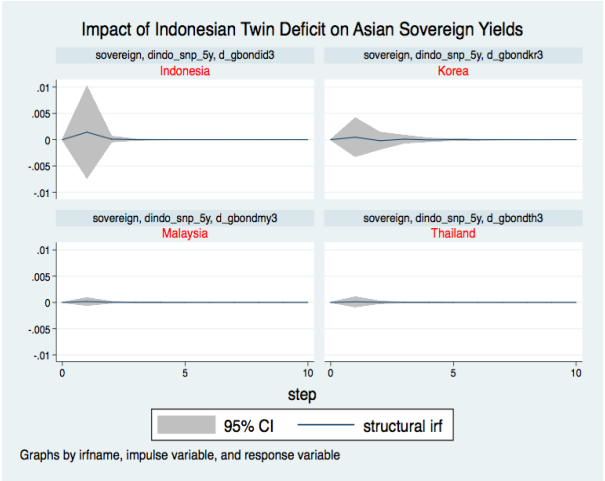


Figure B2.15: Sovereign Yield SVAR
Shock: Indonesian Twin Deficit
Impulse: 5 yr Indonesian Sovereign Yield



Notes: Figures B2.11 to B2.15 are the impulse response functions generated by the sovereign yield SVAR. They indicate the direction and magnitude of the financial shocks on the respective stock market indices of Korea, Malaysian, Thailand and Indonesia (the economies were ranked in this order for the SVAR estimation). The shaded grey areas are the 95% confidence interval bands.

B3. Stage 3 Estimation Results

Table B3.1: Impact of Financial Market Development on Stock Market Contagion (Shock: Lehman Brothers Collapse)

Dependent Variable: Δ Ln Domestic Stock Market Index	Malaysia 1	Indonesia 2	Thailand 3	Korea 4
Δ Reserves (%M2) * Lehman	-0.011	0.013	0.061***	0.032
	(0.013)	*(0.024)*	*(0.022)*	*(0.033)*
Δ Deposits (%GDP) * Lehman	-0.003***	-0.010***	-0.002**	-0.003
	(0.001)	*(0.003)*	*(0.001)*	*(0.002)*
Δ External Debt (%GDP) * Lehman	0.001***	-2.189*	-5.843***	-0.377
	(0.0001)	*(1.237)*	*(2.104)*	*(1.187)*
Ln Market Liquidity * Lehman	0.002*	0.008***	-0.009	0.001
	(0.001)	*(0.002)*	*(0.006)*	*(0.002)*
Δ Bond Market (%GDP) * Lehman	0.003***	0.008**	-0.0003	0.001
	(0.001)	*(0.004)*	*(0.001)*	*(0.001)*
Δ Reserves (%M2)	0.001	0.006	-0.026***	-0.020*
	(0.002)	*(0.004)*	*(0.010)*	*(0.011)*
Δ Deposits (%GDP)	0.00002	0.002	-0.0004	-0.0004
	(0.0002)	*(0.001)*	*(0.0003)*	*(0.001)*
Δ External Debt (%GDP)	0.00002**	-0.088	-0.139**	-0.053
	(0.00001)	*(0.103)*	*(0.056)*	*(0.344)*
Ln Stock Market Liquidity	0.007	-0.012**	0.00003	0.024
	(0.006)	*(0.005)*	*(0.003)*	*(0.014)*
Δ Bond Market (%GDP)	0.0001	-0.001	0.001	0.00004
	(0.0002)	*(0.002)*	*(0.001)*	*(0.001)*
Δ Ln US stock index	0.387***	0.589***	0.739***	0.685***
	(0.074)	*(0.129)*	*(0.137)*	*(0.160)*
Δ Ln JPY/USD	0.017	0.043	-0.275	0.069
	(0.112)	*(0.229)*	*(0.225)*	*(0.139)*
Number of Observations	124	114	125	122
Maximum Lag	12	12	12	12
F(Observed)	36.66	42.32	13.54	110.04

Notes: Equation 4 is estimated to test impact of several financial market development indicators on the changes in stock index during the collapse of Lehman Brothers. The variables of interest have been interacted with a time dummy 'Lehman' that is equivalent to 1 during the identified contagion period, and 0 otherwise. The same equation is run for all four countries to facilitate comparison.
*significant at 10% **significant at 5% ***significant at 1%

Table B3.2: Impact of Financial Market Development on Stock Market Contagion (Shock: Implementation and Scaleback of US Quantitative Easing)

Dependent Variable: Δ Ln Domestic Stock Market Index	Malaysia 1	Indonesia 2	Thailand 3	Korea 4
Δ Reserves (%M2) * QE	-0.039*** *(0.011)*	-0.026*** *(0.007)*	0.047* *(0.025)*	-0.050* *(0.028)*
Δ Deposits (%GDP) * QE	-0.002*** *(0.001)*	0.004 *(0.002)*	0.0003 *(0.001)*	-0.0003 *(0.001)*
Δ External Debt (%GDP) * QE	0.0003*** *(0.0001)*	0.472 *(0.674)*	-0.807 *(1.143)*	1.759* *(0.976)*
Ln Stock Market Liquidity * QE	0.002*** *(0.001)*	0.009*** *(0.003)*	-0.007 *(0.006)*	-0.001 *(0.001)*
Δ Bond Market (%GDP) *QE	0.002*** *(0.0005)*	-0.002 *(0.005)*	0.001** *(0.001)*	0.003*** *(0.001)*
Δ Reserves (%M2)	0.004 *(0.002)*	0.007* *(0.004)*	-0.033*** *(0.009)*	0.005 *(0.015)*
Δ Deposits (%GDP)	-0.0001 *(0.0003)*	-0.00001 *(0.001)*	-0.001** *(0.0004)*	-0.0004 *(0.001)*
Δ External Debt (%GDP)	0.00002*** *(0.00001)*	-0.136 *(0.157)*	-0.158** *(0.065)*	-0.194 *(0.420)*
Ln Stock Market Liquidity	0.007 *(0.006)*	-0.012** *(0.006)*	0.001 *(0.003)*	0.028** *(0.013)*
Δ Bond Market (%GDP)	0.0001 *(0.0002)*	-0.001 *(0.002)*	0.001 *(0.001)*	-0.0002 *(0.001)*
Δ Ln US stock index	0.414*** *(0.072)*	0.962*** *(0.231)*	0.961*** *(0.180)*	0.899*** *(0.140)*
Δ Ln JPY/USD	0.108 *(0.139)*	-0.025 *(0.182)*	-0.385* *(0.206)*	0.045 *(0.114)*
Number of Observations	124	114	125	122
Maximum Lag	12	12	12	12
F(Observed)	53.49	37.93	11.88	108.58

Notes: Equation 4 is estimated to test impact of several financial market development indicators on the changes in stock index during the implementation and scaleback of QE. The variables of interest have been interacted with a time dummy 'QE' that is equivalent to 1 during the identified contagion period, and 0 otherwise. The QE dummy may vary for each country depending on the results in Table 2a. The same equation is run for all four countries to facilitate comparison.
*significant at 10% **significant at 5% ***significant at 1%

Table B3.3: Impact of Financial Market Development on Currency Contagion (Shock: Lehman Brothers Collapse)

Dependent Variable: Δ Ln Exchange Rate	Malaysia 1	Indonesia 2	Thailand 3	Korea 4
Δ Reserves (%M2) * Lehman	-0.001	0.002	0.00001	-0.030***
	(0.004)	*(0.004)*	*(0.005)*	*(0.006)*
Δ Deposits (%GDP) * Lehman	-0.0003	-0.0004	-0.0001	0.0005
	(0.0003)	*(0.001)*	*(0.0002)*	*(0.0004)*
Δ External Debt (%GDP) * Lehman	0.0001*	1.824***	0.617***	0.951***
	(0.0001)	*(0.190)*	*(0.183)*	*(0.280)*
Ln Stock Market Liquidity * Lehman	0.0001	-0.001	-0.001	-0.0003
	(0.0002)	*(0.001)*	*(0.001)*	*(0.0003)*
Δ Bond Market (%GDP) * Lehman	0.0005**	-0.001	0.00003	0.001***
	(0.0002)	*(0.001)*	*(0.0003)*	*(0.0002)*
Δ Reserves (%M2)	-0.001	0.004	0.006	0.028***
	(0.002)	*(0.003)*	*(0.004)*	*(0.004)*
Δ Deposits (%GDP)	0.0001	0.001	0.0001	0.0004**
	(0.0001)	*(0.0005)*	*(0.0001)*	*(0.0002)*
Δ External Debt (%GDP)	0.00001***	0.077	0.002	1.085***
	(0.000003)	*(0.065)*	*(0.033)*	*(0.191)*
Ln Stock Market Liquidity	0.004*	0.002	-0.0003	-0.0001
	(0.002)	*(0.002)*	*(0.001)*	*(0.004)*
Δ Bond Market (%GDP)	-0.0003**	-0.0002	-0.0002	-0.001***
	(0.0002)	*(0.001)*	*(0.0002)*	*(0.0002)*
Δ Ln US stock index	-0.203***	-0.198***	-0.141***	-0.118***
	(0.057)	*(0.046)*	*(0.053)*	*(0.031)*
Δ Ln JPY/USD	0.160***	0.123*	0.228***	0.116***
	(0.043)	*(0.071)*	*(0.055)*	*(0.041)*
Number of Observations	124	114	125	122
Maximum Lag	12	12	12	12
F(Observed)	21.26	405.02	33.41	740.66

Notes: Equation 4 is estimated to test impact of several financial market development indicators on the changes in currencies during the collapse of Lehman Brothers. The variables of interest have been interacted with a time dummy 'Lehman' that is equivalent to 1 during the identified contagion period, and 0 otherwise. The same equation is run for all four countries to facilitate comparison.
*significant at 10% **significant at 5% ***significant at 1%

Table B3.4: Impact of Financial Market Development on Currency Contagion (Shock: Implementation and Scaleback of US Quantitative Easing)

Dependent Variable: Δ Ln Exchange Rate	Malaysia 1	Indonesia 2	Thailand 3	Korea 4
Δ Reserves (%M2) * QE	-0.0005	0.004	-0.012***	-0.034***
	(0.003)	*(0.007)*	*(0.004)*	*(0.008)*
Δ Deposits (%GDP) * QE	-0.001***	0.002*	-0.0004***	-0.001**
	(0.0001)	*(0.001)*	*(0.0001)*	*(0.0004)*
Δ External Debt (%GDP) * QE	-0.002***	1.364**	0.552***	1.202***
	(0.001)	*(0.550)*	*(0.168)*	*(0.314)*
Ln Stock Market Liquidity * QE	0.001*	0.001	0.001	-0.0005
	(0.001)	*(0.001)*	*(0.001)*	*(0.0003)*
Δ Bond Market (%GDP) * QE	0.0002	-0.006**	0.002***	0.001***
	(0.0002)	*(0.003)*	*-(0.0003)*	*(0.0002)*
Δ Reserves (%M2)	-0.001	0.004	0.007**	0.022***
	(0.001)	*(0.003)*	*(0.003)*	*(0.006)*
Δ Deposits (%GDP)	0.0001	0.001**	0.0001	0.001**
	(0.0001)	*(0.0004)*	*(0.0001)*	*(0.0002)*
Δ External Debt (%GDP)	0.00001***	0.084	0.005	1.139***
	(0.000004)	*(0.073)*	*(0.035)*	*(0.245)*
Ln Stock Market Liquidity	0.003	0.001	-0.0003	0.004
	(0.002)	*(0.002)*	*(0.001)*	*(0.004)*
Δ Bond Market (%GDP)	-0.0003*	-0.0001	-0.0003*	-0.001***
	(0.0002)	*(0.001)*	*(0.0002)*	*(0.0002)*
Δ Ln US stock index	-0.197***	-0.295***	-0.150***	-0.193***
	(0.047)	*(0.056)*	*(0.029)*	*(0.033)*
Δ Ln JPY/USD	0.175***	0.062	0.230***	"0.088*
	(0.039)	*(0.114)*	*(0.055)*	*(0.050)*
Number of Observations	124	114	125	122
Maximum Lag	12	12	12	12
F(Observed)	76.96	575.99	149.36	889.57

Notes: Equation 4 is estimated to test impact of several financial market development indicators on the changes in currencies during the implementation and scaleback of QE. The variables of interest have been interacted with a time dummy 'QE' that is equivalent to 1 during the identified contagion period, and 0 otherwise. The QE dummy may vary for each country depending on the results in Table 2b. The same equation is run for all four countries to facilitate comparison.
*significant at 10% **significant at 5% ***significant at 1%

Table B3.5: Impact of Financial Market Development on Currency Contagion (Shock: Twin Deficit in Indonesia)

Dependent Variable: Δ Ln Exchange Rate	Malaysia 1	Indonesia 2	Thailand 3	Korea 4
Δ Reserves (%M2) * Twin	-0.0004	-0.004	0.002	0.022***
	(0.002)	*(0.006)*	*(0.005)*	*(0.008)*
Δ Deposits (%GDP) * Twin	-0.0002*	-0.001*	0.0003*	-0.0002
	(0.0001)	*(0.001)*	*(0.0002)*	*(0.0003)*
Δ External Debt (%GDP) * Twin	-0.003***	1.917***	0.942***	-0.151
	(0.001)	*(0.448)*	*(0.217)*	*(0.427)*
Ln Stock Market Liquidity * Twin	-0.0003	0.004	0.003**	-0.00005
	(0.0003)	*(0.003)*	*(0.001)*	*(0.0003)*
Δ Bond Market (%GDP) * Twin	-0.002***	-0.009	0.0004	0.0002
	(0.0004)	*(0.011)*	*(0.001)*	*(0.0002)*
Δ Reserves (%M2)	-0.001	0.007*	0.006**	0.018***
	(0.001)	*(0.004)*	*(0.003)*	*(0.006)*
Δ Deposits (%GDP)	0.0001	0.002***	0.00004	0.0004*
	(0.0001)	*(0.0005)*	*(0.0001)*	*(0.0002)*
Δ External Debt (%GDP)	0.00002***	0.091	-0.005	1.204***
	(0.000005)	*(0.100)*	*(0.029)*	*(0.239)*
Ln Stock Market Liquidity	0.003	0.0002	-0.001	0.001
	(0.003)	*(0.002)*	*(0.001)*	*(0.004)*
Δ Bond Market (%GDP)	-0.0002	-0.001	-0.0002	-0.0004**
	(0.0002)	*(0.001)*	*(0.0001)*	*(0.0002)*
Δ Ln US stock index	-0.199***	-0.349***	-0.152***	-0.229***
	(0.045)	*(0.065)*	*(0.029)*	*(0.032)*
Δ Ln JPY/USD	0.187***	0.146**	0.219***	0.109**
	(0.039)	*(0.058)*	*(0.055)*	*(0.053)*
Number of Observations	124	114	125	122
Maximum Lag	12	12	12	12
F(Observed)	7.54	143.79	21.96	349.25

Notes: Equation 4 is estimated to test impact of several financial market development indicators on the changes in currencies during the Indonesian twin deficit concerns. The variables of interest have been interacted with a time dummy 'twin' that is equivalent to 1 during the identified contagion period, and 0 otherwise. The same equation is run for all four countries to facilitate comparison.
*significant at 10% **significant at 5% ***significant at 1%

Table B3.6: Impact of Financial Market Development on Stock Market Contagion (Shock: Equity Shocks of Similar Magnitude During the Asian Financial Crisis)

Dependent Variable: Δ Ln Domestic Stock Market Index	Malaysia 1	Indonesia 2	Thailand 3	Korea 4
Δ Reserves (%M2) * AFC	-0.104***	-0.022	-0.201***	0.557***
	(0.026)	*(0.063)*	*(0.043)*	*(0.147)*
Δ Deposits (%GDP) * AFC	-0.005***	-0.027***	0.00002	0.005
	(0.001)	*(0.006)*	*(0.002)*	*(0.006)*
Δ External Debt (%GDP) * AFC	0.001	-23.293***	12.246**	-13.495**
	(0.004)	*(5.993)*	*(5.813)*	*(6.409)*
Ln Market Liquidity * AFC	-0.004	-0.003	-0.050***	-0.041***
	(0.003)	*(0.010)*	*(0.010)*	*(0.004)*
Δ Bond Market (%GDP) * AFC	-0.004***	0.098	-0.0003	0.039***
	(0.002)	*(0.061)*	*(0.003)*	*(0.004)*
Δ Reserves (%M2)	-0.004	-0.008	0.014	0.035
	(0.009)	*(0.009)*	*(0.015)*	*(0.026)*
Δ Deposits (%GDP)	0.0003	-0.001	0.0003	0.0004
	(0.0003)	*(0.001)*	*(0.001)*	*(0.001)*
Δ External Debt (%GDP)	0.0001	0.335***	0.163*	-0.722
	(0.0001)	*(0.066)*	*(0.089)*	*(1.090)*
Ln Market Liquidity	0.001	0.013	-0.006	-0.029
	(0.015)	*(0.014)*	*(0.005)*	*(0.035)*
Δ Bond Market (%GDP)	-0.0005	0.002	-0.002	0.001
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*
Δ Ln US stock index	0.136	-0.043	-0.092	0.261
	(0.147)	*(0.149)*	*(0.212)*	*(0.270)*
Δ Ln JPY/USD	-0.167	-0.533**	-0.546	-0.168
	(0.284)	*(0.232)*	*(0.403)*	*(0.249)*
Number of Observations	124	114	125	122
Maximum Lag	12	12	12	12
F(Observed)	6.8	15.4	6.57	34.1

Notes: Equation 4 is estimated to test impact of present financial market development indicators on the changes in stock indices during the AFC. The variables of interest have been interacted with a time dummy 'AFC' that is equivalent to 1 during the identified contagion period, and 0 otherwise. The same equation is run for all four countries to facilitate comparison.
*significant at 10% **significant at 5% ***significant at 1%

Table B3.7: Impact of Financial Market Development on Currency Contagion (Shock: Currency Shocks of Similar Magnitude During the Asian Financial Crisis)

Dependent Variable: Δ Ln Exchange Rate	Malaysia 1	Indonesia 2	Thailand 3	Korea 4
Δ Reserves (%M2) * AFC	-0.004	0.144	0.002	-0.328***
	(0.003)	*(0.110)*	*(0.003)*	*(0.056)*
Δ Deposits (%GDP) * AFC	-0.0001	-0.051***	0.0001	0.009***
	(0.0001)	*(0.015)*	*(0.0001)*	*(0.003)*
Δ External Debt (%GDP) * AFC	0.001***	-45.126*	0.297	5.973*
	(0.0002)	*(24.620)*	*(0.259)*	*(3.101)*
Ln Market Liquidity * AFC	-0.001**	0.034***	-0.002**	-0.003
	(0.0003)	*(0.010)*	*(0.001)*	*(0.005)*
Δ Bond Market (%GDP) * AFC	0.00001	0.379**	0.0002	0.013***
	(0.0002)	*(0.147)*	*(0.0003)*	*(0.004)*
Δ Reserves (%M2)	-0.001	-0.002	0.006**	-0.002
	(0.001)	*(0.006)*	*(0.003)*	*(0.004)*
Δ Deposits (%GDP)	0.0001	-0.0005	0.0001	0.0001
	(0.0001)	*(0.002)*	*(0.0001)*	*(0.0003)*
Δ External Debt (%GDP)	0.00002***	-0.103***	0.007	-0.147
	(0.00001)	*(0.031)*	*(0.034)*	*(0.320)*
Ln Market Liquidity	0.003	-0.0001	-0.0001	-0.005
	(0.002)	*(0.003)*	*(0.001)*	*(0.008)*
Δ Bond Market (%GDP)	-0.0003*	-0.0004	-0.0003	-0.0001
	(0.0002)	*(0.002)*	*(0.0002)*	*(0.0002)*
Δ Ln US stock index	-0.199***	-0.162	-0.152***	-0.148
	(0.045)	*(0.131)*	*(0.030)*	*(0.130)*
Δ Ln JPY/USD	0.181***	0.544	0.243***	0.210
	(0.041)	*(0.428)*	*(0.050)*	*(0.188)*
Number of Observations	124	102	125	122
Maximum Lag	12	12	12	12
F(Observed)	22.8	9.29	10.55	11.91

Notes: Equation 4 is estimated to test impact of present financial market development indicators on the changes in currencies during the AFC. The variables of interest have been interacted with a time dummy 'AFC' that is equivalent to 1 during the identified contagion period, and 0 otherwise. The same equation is run for all four countries to facilitate comparison.
*significant at 10% **significant at 5% ***significant at 1%