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Contagion in the East Asian Stock Markets -

Evidence from the 2007-2010 Financial Crisis

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Abstract

This thesis investigates the possible contagion effects between the US and East Asian markets during the recent financial crisis of 2007-2010. We focus on the developing stock markets of Malaysia, Thailand, South Korea, Philippines, China and Indonesia. The applied approach is based on the relatively new method advanced by Pesaran and Pick (2007) and extended by Masacci (2007) using a Full Information Maximum Likelihood (FIML). The results suggest that the transmission of shocks across the markets included in our sample cannot only be attributed to real economic linkages and there are also contagion effects present. Moreover our comparative analysis of contagion coefficients across the Asian countries suggests that the magnitude of drop in stock market indices differs and it might be contributed to diverse capital control levels and different involvement of foreign investors in the market.

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KEY WORDS	Contagion, East Asia, FIML, Financial Crisis, Investors
PURPOSE	The purpose of this thesis is to investigate contagion effects in the East Asian developing economies, focusing on the 2007 financial crisis.
METHODOLOGY	We specify our model as a simultaneous two-equation system with endogenous dummy variables and apply Full Information Maximum Likelihood in order to estimate it.
THEORETICAL PERSPECTIVES	The theoretical framework of the thesis draws on the literature of contagion and transmission of financial shocks across markets. Furthermore we analyse stock market regulations and capital controls.
EMPIRICAL FOUNDATION	We base our study on stock market indices of the US, Indonesia, China, Malaysia, Thailand, Philippines and South Korea in the period 2005-2010.
CONCLUSIONS	We find that East Asian stock markets react to negative events on the US market and there is evidence of contagion effects among them. Furthermore there are differences in magnitude of the drop in the indices depending on the country. This might be due to different effectiveness of capital controls and different levels of foreign investors' involvement in the market.

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1. Introduction

This introductory chapter provides background information on East Asian economies and the recent financial crisis, discusses the problem and explains the purpose of the thesis. Furthermore the limitations of the study and the outline of the thesis are presented.

1.1. Background

In 2007 the world economy was hit by the financial crisis that had its roots in the US subprime mortgage crisis. The crisis spread fast to other financial markets throughout the globe causing significant falls in stock prices and increasing volatility. Many financial institutions experienced liquidity problems and governments were engaged in providing financial rescue.

What distinguishes this crisis from the previous ones, like the Asian crisis in 1997, the Russian crisis in 1998 or the Brazilian crisis in 1999, is that this time the biggest and most influential economy, the United States, is the origin of it. Thus it can give us the opportunity to study the dynamic interrelationships between the international financial markets and the contagion effect on a global scale and to obtain a new insight into these matters.

Moreover, the current crisis also signifies the slow shift in economic influence – the United States are no longer the only, unquestionable powerhouse. They have been hit hard by the recession, output decreased, unemployment grew and there are voices suggesting that dollar may lose its position as the world's reserve currency (Chinn, Frankel, 2008; Galati, Wooldridge, 2008). In the meantime Asian emerging economies have been acquiring a bigger share of the word's GDP. There are forecasts predicting that in the future the East Asian region will have the largest economy in the world (Xu, 2003; Fleishman-Hillard, 2009). Only recently the region has been experiencing double-digit expansion of its industrial production base. In this thesis we focus on fast developing markets of Malaysia, Indonesia, China, South Korea, Philippines and Thailand.

An important factor that distinguishes the current situation in the East Asian region from the time when the 1997 crisis hit is the rapid development of China and its stronger integration with the global market. In 1997 the crisis did not have as severe impact on China, which can

be explained by strong capital controls (Ahearne et al., 2001). Xiao and Kimball (2005) calculated capital control indices for a set of countries i.e. China, Malaysia, South Korea and Thailand for the period 1996-2003. By using capital control indices (CCI) together with a measurement of actual cross-border flow indices (CBFI) and taking into account the volatility of capital flows, the effectiveness and effects of capital controls in shaping financial flows has been compared among the countries. While the CCI reflects the existence of restrictions on capital flows, the CBFI measures the actual non-official capital flows that cross the country border. For capital account restrictions to be effective in controlling actual capital flows the CCI should be high and the CBFI should be low. The study shows that China, Malaysia, South Korea and Thailand have high average CCI over the entire period 1996-2003 among the ten countries studied. However, China is the only one of these countries that also had a consistently lower CBFI over the entire period. As for Malaysia, South Korea and Thailand, the CBFI fell 2001-2003 as capital control measures were added. The restrictions on capital flows have hence in overall been effective in controlling actual capital flows. South Korea and Thailand have similar CBFI to China and not much lower CCI, but they have a substantially greater openness of capital flows via portfolio securities and banks which makes them more similar to the Asian financial centres of Hong Kong and Singapore. Hence, they were more affected by the financial crisis 1997 than China, which as a result of their tight capital controls did not experience a single year of net capital outflows over the examined period. China is however continuing its opening policy targeting complete convertibility of the RMB and liberalizing restrictions on cross border capital flows.

Not being at the point of origin of the present crisis, the East Asian countries trusted that with improved macroeconomic fundamentals and stronger capital controls they would be relatively unaffected by the financial happenings. However the bankruptcy of Lehman Brothers at the end of 2008 triggered substantial falls in the East Asian equity markets and depreciation of regional exchange rates as international investors significantly reduced their exposure to the region. Furthermore, following the collapse of demand in the Western economies, East Asian exports and industrial production decreased notably (Kato, 2009).

The speed and severity of the impact put in question some prevailing opinions concerning the emerging East Asian economies like Malaysia, Thailand, South Korea, China, Philippines and Indonesia.

It was argued that the increase in intra-regional trade over the last decade might indicate weakening dependence on external trading patterns (Moneta, Rüffer, 2009). In reality, the increase in intra-regional export is strongly correlated with American imports due to Asia's integration into a global supply chain. Thus, a big part of trade within East Asia reflects intra-industry processing and assembly through vertically integrated production chains. When it is controlled for that it turns out that the total export exposure of Asia to the Western countries has increased over time. Since a large share of emerging Asia's GDP is made up by export this makes the region in reality more vulnerable to shocks in advanced economies than other areas (Asia-Pacific Regional Economic Outlook, 2008).

The East Asian economies also have a large amount of foreign exchange reserves which was thought to serve as an insurance against capital account crisis. However, the reserves are only useful to a certain degree, which could be observed at the end of 2008 when countries could resort to them to alleviate the damages caused by the dollar shortages and reduce the speed of currency depreciations. This was not enough to prevent the transmission of the real and financial strains from the West to Asia (ADB Asia Regional Integration Center, 2008).

Financial institutions in the developing East Asian countries like China were also characterised by limited exposure to subprime-related instruments, and most had rather sound financial positions and strong capital buffers. Nonetheless, the great increase in Asian participation in international financial markets has brought about several channels of transmission of the global financial crisis to the region (Kato, 2009).

1.2. Problem discussion

The risk exposure for the Asian countries during the current financial crisis is different from the Asian financial crisis 1998-1999. This is explained by the fact that the crisis has spread from the US rather than originated from Asia and because the direct exposure to sub-prime-related structured products is relatively limited for Asian financial institutions. The countries in East Asia have implemented different reforms since the Asian financial crisis in order to strengthen regulations and risk management practices, i.e. developed more resilient financial systems. The capital accounts of East Asia are also still not convertible which makes the region less exposed to the turmoil in the global capital markets (ADB, 2008).

Even though most of the Asian countries are still relatively closed economies they are exposed to the contagion effect of instability in global debt and equity markets. This is leading to reduced capital inflows, capital outflows and tightening credit in the international financial markets. Asian financial and economic systems are also affected by the current crisis since their main export markets in North America and Europe has contracted due to the crisis. The equity values and external funding conditions have also deteriorated in the Asian region due to re-pricing of financial risk. If tightening credit conditions and financial instability affect broader economic activity within the region, contagion may affect the region's economies and financial systems more seriously. Some South Asian economies face large and uncertain amortization of short-term debt and trade financing is becoming scarce. The tightening of credits implicates less private investments in South Asia to finance priority development needs such as health, education, infrastructure, technological innovation etc. which threatens the long-term growth potential and ability to continue reducing poverty (ADB, 2008).

The globalisation of financial markets is also affecting the performance of international portfolios and risk management. For investors, international diversification of risk is important. If the financial markets are more closely linked during times of crisis however, then the opportunity for international diversification is decreasing during this time. The perceived increase in contagion around the world financial markets makes it important for regulators of financial markets to understand such linkages (Ahlgren, Antell, 2009). The distinction between interdependence and contagion is of interest to policy makers both in international financial institutions, such as the IMF, and at central banks. It is also important for investors that want to maximize their profit. In the former case, if a random jump from a ‘good’ to a ‘bad’ equilibrium (i.e. contagion) occurs, then a policy intervention could be effective conversely, in the case of interdependence a similar action is unlikely to have any significant effect. In the case of investors, the exposition to market risk can be generally reduced by portfolio diversification; however, if contagion occurs then the degree of dependence between markets increases, and portfolio diversification may not be an effective strategy to follow. Therefore, because of the different effects they have on economic agents’ decision process, the distinction between interdependence and contagion effects has to be achieved.

In previous studies, for example by Calvo and Reinhart (1996), researchers have tested for contagion based on the correlation coefficients, and if the correlation between returns increases significantly after a crisis this is interpreted as contagion. These studies have however been criticised by i.e. Forbes and Rigobon (2002). Their study suggests that increased correlation coefficients may be induced by heteroskedasticity, which is higher volatility during a crisis compared to tranquil periods. This makes the test for contagion biased. When correcting for heteroskedasticity, they find no evidence for contagion during the 1997 Asian crisis, 1994 Mexican devaluation, and 1987 US and Hong Kong stock market crash. Their studies have however also been subject to criticism i.e. for making unrealistic assumptions about volatility. Pesaran and Pick (2007) argues that it is necessary to include market specific regressors into the equations for the individual markets in order to identify contagion. This questions the validity of previous correlation-based tests of contagion which did not include market specific variables. Pesaran and Pick hence base their test on contagion indices which they construct from indicator variables. They also use general instrumental variable estimation (GIVE estimation) in order to take into account the endogeneity of the crises, since ignoring endogeneity and interdependence can introduce an upward bias in the estimate of the contagion coefficient. An improvement to this model was introduced by Massacci (2007) who suggested using Full Information Maximum Likelihood estimators (FIML) which he proved to perform better than GIVE estimators applied by Pesaran and Pick (2007).

1.2.1. Research questions

This thesis is aimed to answer the following questions:

- Are East Asian countries insulated from the world economy?
- If not, through which channels are they affected by the crisis in the US – is it contagion or only interdependence?
- Are different countries affected differently and what could be the reason for it?

1.3. Purpose

Our objective is thus to examine the dynamic interrelationships among the global stock markets and possible contagion effect during a worldwide financial crisis. More specifically we would examine how the current shock originating from the US market spread out into

the Asian developing countries: China, South Korea, Indonesia, Malaysia, Thailand and the Philippines and study contagion among these markets.

1.4. Delimitations

We limit our study to six fast growing East Asian economies, Indonesia, Malaysia, Thailand, South Korea, Philippines and China. We investigate their relation with the US market. Furthermore we take into consideration only the last five years i.e. the period 2005-2010 in order to capture the situation during the latest financial crisis. We also limit our study to stock markets and do not include bond- or currency markets. Taking into consideration multiple asset classes would result in adding more dimensions thus increasing the complexity of the problem and it goes beyond the purpose of our analysis.

The World Bank (2010) divides contagion into three categories: a broad definition, a restrictive definition and a very restrictive definition. Following Pesaran and Pick (2007) as well as Massacci (2007) we will apply the very restrictive definition which defines contagion as an increase in cross-country correlation during a crisis relative to correlations during stable periods.

1.5. Thesis outline

The remainder of the thesis is constructed as follows: Chapter 2 explains the theory behind contagion and presents the research literature on the subject. Chapter 3 gives an overview of the East Asian economies, regulatory and foreign investment issues. Chapter 4 focuses on methodology and data. Chapter 5 describes the applied empirical analysis and the results. Finally, Chapter 6 presents the conclusions and suggests areas of future research.

2. Contagion: theory and literature review

This chapter discusses the matter of defining contagion and presents the main theories behind it. It also describes the possible transmission channels of the shocks among the markets. Finally it reviews the current literature on the subject of contagion with special focus given on available study methodologies.

2.1. Concept of contagion

There exist numerous definitions of contagion. World Bank (2010) uses three definitions of contagion. The first one is as follows: *Contagion is the cross-country transmission of shocks or the general cross-country spill over effects*. Under this definition contagion can occur both during "good" times and "bad" times. Thus it does not need to be connected to crisis. Nonetheless, it is during the crisis periods when contagion effects draw most attention. The mentioned definition is a very broad one and contains fundamental linkages between countries. Fundamental links can be divided into three groups: financial links, real links and political links.

Financial links are present when two economies are related through the international financial system. An illustration of this type of link is the behaviour of open-end mutual funds. If they anticipate redemptions after a shock in one country occurs, they need to raise cash and in consequence sell assets in third countries.

Real links on the other hand are the fundamental economic relationships among countries. They are usually connected with international trade. For example, if two countries trade among themselves or if they compete in the same foreign markets, one country's competitive advantage will worsen when the exchange rate in the other country is devalued. The result is that both countries will most probably devalue their currencies in order to re-balance their external sectors. Foreign direct investment is another example of real links.

Finally political links are the political relationships among countries. For instance if a country is a member of a group of countries with an exchange rate arrangement, the political cost of devaluing is much lower when other countries have devalued. As a result, crises are likely to be clustered. A crisis in one country is followed by crises on other countries.

Many researchers however tend to differentiate between fundamental linkages and contagion (for example Calvo and Reinhart (1996), Kaminsky and Reinhart (2000), Forbes and Rigobon, 2002). Thus the second definition offered by World Bank is more restrictive: *Contagion is the transmission of shocks to other countries or the cross-country correlation, beyond any fundamental link among the countries and beyond common shocks.* This definition is frequently denoted as excess co-movement and is usually explained by herding behaviour. Asymmetric information is commonly perceived as the basis for this kind of market reactions: since information is costly less informed investors might choose to follow the ones that they perceive to be more informed. This causes the markets to move jointly. What is more, investors re-evaluate their risks of investing abroad when they see a crisis in another country and they might not distinguish between different foreign markets. This in turn can result in a situation where crisis in one country causes decrease in investing in all foreign markets (Cheung et al., 2009).

The third definition of World Bank is very restrictive: *Contagion occurs when cross-country correlations increase during "crisis times" relative to correlations during "tranquil times"*. Thus according to this approach only increases in correlation are considered as contagion. This implies that a shock in one economy increases the likelihood of a crisis in another economy over and above what could be predicted by macroeconomic fundamentals (Pesaran and Pick, 2007).

2.2. Transmission channels

Stock markets are characterised by diverse sizes, structures and geographic locations and they all can show a high level of co-movement after a shock to one market occurs. This high degree of co-movement among stock markets that are very different across countries implies that there exist certain channels through which domestic shocks are transmitted internationally.

As there are many definitions of contagion there are also many views on what these transmission mechanisms might be. Masson (1998) identifies three main categories. The first one is the theory of *monsoonal effects*, which are defined as *major economic shifts in industrial countries that trigger crises in emerging markets*. According to this concept financial crises come out to be contagious due to the correlation between underlying

macroeconomic variables. Second category contains *spill-overs*, which rise from *interdependence among developing countries themselves*. Under this theory a shock influences another country through external links such as trade. Finally, the third category consists of all the transmission channels that are left and cannot be connected to observed changes in macroeconomic fundamentals. It might be that a crisis causes changes in market sentiment or alters the interpretation subject to existing information. For example because of a crisis investors might want to reassess the fundamentals of other economies even if they had not changed, or their risk tolerance changes. This theory of *pure contagion* can be explained from the perspective where financial markets are subject to multiple equilibria or self-fulfilling expectations and the market jumps from a 'good' to a 'bad' equilibrium. The first two cases are what Pesaran and Pick (2007) call interdependence and they refer to the third case as contagion. This approach is also similar to Forbes and Rigobon (2001, 2002) definition and corresponds the most restrictive definition by World Bank.

Claessens, Dornbusch and Park (2001) divide contagion into two groups. To the first group belong transmissions resulting from the normal interdependence among economies. Shocks are then spreading based on real and financial linkages. Calvo and Reinhart (1996) refer to this kind of propagation as *fundamentals-based contagion*. It includes common shocks (for example in oil prices), trade links and competitive devaluations as well as financial links like banks, FDI or loans. The other group are transmissions stemming from the investors' or other financial agents' behaviour. Very often it is associated with 'irrational' phenomena like financial panic, herd behaviour, a loss of confidence or an increase in risk aversion. These occurrences can be also individually rational and nevertheless cause a crisis.

Within this second group there are three possible types of behaviour that transmit the shocks. First, there is so called investors' practice channel. It can be further divided into behaviour caused by liquidity and incentive problems; information asymmetries; and market coordination problems. Secondly, multiple equilibria can result in contagion of similar nature to the commercial bank runs. And thirdly, changes in the international financial system or rules of the game can prompt investors to behave in a different way after the shock.

Forbes and Rigobon (2001) suggest yet another classification basing it on shift-contagion defined as *significant increase in cross-market linkages after a shock*. According to this view

transmission channels can be divided into two groups: crisis-contingent and non-crisis-contingent. Crisis-contingent theories describe why transmission mechanisms change during a crisis and hence why cross-market linkages increase after a shock. Multiple equilibria, endogenous liquidity and political economy fall under this category. In multiple equilibria models transmission of the initial shock is driven only by a change in investor expectations or beliefs and not by any real linkages.

Endogenous liquidity shocks as proposed by Valdes (1996) occur when a crisis in one country reduces the liquidity of market participants. In this case they might be forced to change the composition of their portfolios and sell assets in other countries so that they can still operate in the market, fulfil margin calls or meet regulatory requirements. Likewise, when this shock is big enough, a crisis in one economy might increase the degree of credit rationing forcing investors to sell off their assets in countries not affected by the initial crisis. Calvo (1999) suggests a different model of liquidity shocks, which assumes asymmetric information among investors. Informed investors obtain information about the fundamentals of an economy and are hit by liquidity shocks (margin calls) that force them to sell their assets. Uninformed investors cannot tell apart a liquidity shock and a bad signal, and so they demand a premium when the informed investors are net sellers. In both of these models, the liquidity shock increases correlation in asset prices.

Finally, in political contagion it is assumed that central bank presidents are under political pressure to keep their countries' fixed exchange rates. If one country chooses to abandon its peg, political costs to other countries of doing the same decrease, which makes it more likely for them to switch their exchange rate regimes. This way exchange rate crises can cluster.

Non-crisis-contingent theories assume that transmission mechanisms are the same during a crisis as during more stable periods, and thus cross-market linkages do not increase after a shock. The first transmission channel is trade, as discussed earlier. The second one is policy coordination that can force one country to respond to an economic shock similarly to another country. The third mechanism is “country re-evaluation or learning” according to which a shock in one country can serve as a lesson to investors who can later use the knowledge for other countries with similar macroeconomic structures and policies. Lastly, the fourth mechanism in this group states that random aggregate or global shocks could at

the same time affect the fundamentals of several economies. An example of such aggregate shock is an increase in the international interest rate, a reduction in the international supply of capital, or a decline in international demand for instance for commodities. Such shock would result in co-movement of asset prices in all the involved countries and possible increase in cross-market correlations between them.

2.3. Literature on financial contagion

The empirical research on financial contagion is vast and in general contagion has been proven to exist. The studies on the transmissions of shocks across mature markets were triggered by the 1987 stock market crash in the States and 1992 Exchange Rate Mechanism (ERM) crisis. Emerging market crises in the 1990's, especially the Asian crisis resulted in increased number of analyses on emerging markets.

Although the theory assumes involvement of multiple markets when modelling contagion during a crisis, due to extreme dimensionality of the problem most of the empirical studies focus on cross-border transmissions for a single class of assets. For instance Eichengreen et al. (1995, 1996) and Dungey and Martin (2004) investigate currency markets. Bae et al. (2003) and Forbes and Rigobon (2002) concentrate on equity markets. Dungey et al. (2006) and Debelle and Ellis (2005) look at bond markets. One of a few studies that takes into consideration multiple asset classes is for example the work by Dungey and Martin (2007).

The literature on contagion in East Asia predominantly focuses on the 1997 crisis, there is yet far less research on the current crisis. Research on contagion in Asian currency markets is limited since the dominant regime before 1997 was fixed exchange rate, which makes comparing pre-crisis time volatility hard, and the results do not give one clear answer. For example Baig and Goldfajn (1999) find significant increase in correlations as a sign of contagion. On the other hand Debelle and Ellis (2005) and Dungey, Fry and Martin (2004) when applying an alternative statistical method demonstrate very small effects of contagion. Studies on bond markets are even more rare, partially due to relative stability in these markets (Dungey, Fry, Martin, 2006).

However, most of the analyses has been done on equity markets. There is little consensus on the results. Some researchers find little or no evidence of contagion like Forbes and Rigobon (2002) or Kleimeier, Lehnert and Verschoor (2003) who test if there was a statistically

significant increase in the correlation coefficient between returns in these markets in their analyses. Other researchers however do find evidence of contagion in East Asia. For example Caporale, Cipollini and Spagnolo (2003) use conditional correlation analysis when looking at pairs of eight Asian economies and prove that there is contagion between them. Also Bond, Dungey and Fry (2005) investigate the matter in equity and real estate markets in Asia and draw similar conclusions. Bekaert, Harvey and Ng (2005) and Wongswan (2003) find contagion significant within Asia but the effects are not significant to other regions. Wongswan (2003) takes into consideration common effects by using a CAPM model, incorporates GARCH conditional variances and studies the residual correlations between countries and regions. Baig and Goldfajn (1999) find contagion effects between South Korea and Indonesia, and the Philippines and Thailand as well as between Indonesia and Malaysia and Thailand, however not among other combinations of these countries. Cerra and Saxena (2002) apply Markov switching model and uncover contagion from South Korean and Thai to Indonesian equity markets.

Dungey et al. (2005) present an overview of methodologies used to test for contagion. In the paper the authors compare correlation analysis by Forbes and Rigobon (2002), the VAR study by Favero and Giavazzi (2002), the probability model by Eichengreen et al. (1995, 1996) and the co-exceedance study by Bae et al. (2003). It is concluded that differences in the definitions employed in the tests are not significant and under certain conditions even equivalent. More specifically, they argue that all definitions are working from the same model and the differences come from the amount of information the data that is used to test for contagion contains. Thus models can be ordered based on the information spectrum. In Forbes and Rigobon (2002) approach information on all of the shocks in the crisis period is used. Favero and Giavazzi (2002) approach is using shift dummies at selected crisis points to stand for potentially contagious transmissions. Eichengreen et al. (1995, 1996) apply dummy variables as well but they convert both the dependent and independent indicators into binary variables, and that further cuts the information used in estimation. Bae et al. (2003) expand the Eichengreen et al. method by adding a special dependent variable, derived from the number of co-exceedances in their crisis indicator. Dungey et al. (2005) also found that the Forbes and Rigobon approach was the most restrictive one as it did not find evidence of

contagion in any of the linkages analysed. The Favero and Giavazzi test was the least conservative as it found evidence of contagion in all linkages examined.

The summary of different methodologies is presented in Figure 1. First of all depending on the used definition of contagion we can divide approaches into two groups – without identified linkage and with identified linkage(s). In the indentified linkages the applied definition is broad, and contagion is modelled as non-linearities with identified channels as explanatory variables. This can include trade channels, financial flows or economic similarities. For example Glick and Rose (1999) investigate patterns in international trade. However in our thesis we want to distinguish between interdependence and contagion hence broad definition and this kind of approach is not applicable.

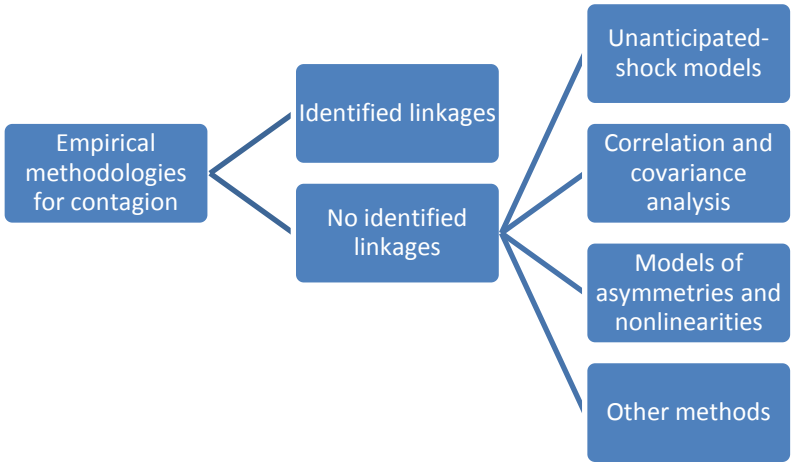
Our focus lies on the second group of models, where there is no identified linkage, and the restrictive and very restrictive definitions of contagion are used. Here we have four main subgroups. Unanticipated-shock models were developed for example by Dungey, Fry, González-Hermosillo and Martin (2002a,b) and consider contagion as the effects of unanticipated shocks across asset markets during a period of crisis. This approach is based on factor model analysis.

The next group of models is widely used in the literature and involves correlation and covariance analysis. In studies by for example Forbes and Rigobon (2002) contagion is identified as significant increase in correlation between two asset returns during the time of crisis. The approach is based on pair-wise comparisons and hence does not take into account potential multivariate analogues of the test. The presence of endogenous variables in the model can result in simultaneity biases and thus the strong assumption of no endogeneity between markets is imposed. The approach is not valid if there are exogenous global shocks or if there is feedback from one market to the other. It is also required that the crisis period is determined a priori which can lead to sample selection bias. Furthermore, multicountry and multiasset generalizations are likely to be meaningless since they require existence of much longer periods of continuous crisis for the estimation and testing approach to be reliable. Moreover the correlation method cannot be applied in forecasting and has limited possibilities to understand the structure of the crises and the factors behind their occurrence.

Another popular set of models are models of asymmetries and nonlinearities. In this case contagion occurs when significant relationships across asset markets are detected during periods of extreme movements. A number of studies, for example by Favero and Giavazzi (2002), Bae, Karolyi, and Stulz (2003), as well as Eichengreen, Rose, and Wyplosz (1995, 1996) are exploring this idea. Pesaran and Pick (2007) show that the use of binary choice models as in Eichengreen et al. (1996) and ignoring the endogeneity of the contagion indicator as well as interdependence of the error terms can cause a substantial upward bias in the contagion coefficient estimates. These methods are also subject to sample selection bias.

Finally the last subgroup includes additional methods like principal components, multiple equilibria, spillovers and multiple classes of assets. Principal component approach draws on the assumption that the variance-covariance matrix is constant, which is not likely to hold for high frequency data especially during the crisis period when volatilities can change. In this group there is also the study by Pesaran and Pick (2007). Their approach is meant to overcome the shortcomings of the previously described models, especially the correlation analysis and binary choice models, and we decide to apply it in our thesis with certain modifications suggested by Massacci (2007). The details of this approach are described in chapter 4.

Figure 1 An overview of empirical studies on contagion



Source: Based on Dungey et al. (2004), Cheung (2009).

3. Overview of the East Asian markets

In this chapter we present the overview of the emerging East Asian markets. We show the connections between the economies based on the holdings of foreign securities. We also include general stock market characteristics and describe the involvement of foreign investors in each of the markets.

3.1. Basic stock market characteristics

When we compare the basic characteristics of the stock exchanges in East Asia it turns out that the largest one in terms of total market capitalisation as well as total value of share trading is Shanghai, then South Korea and much smaller are Malaysia, Indonesia, Thailand and Philippines. Shanghai has also been growing the most rapidly. Naturally NYSE is much larger than any of the Asian markets but its growth has been much slower and most severely affected by the crisis. Before the crisis the total market capitalisation of the six East Asian emerging markets amounted to around 19% of the US market. Afterwards, at the beginning of 2010, it came to 26% (World Federation of Exchanges, 2010). In general, bigger market capitalisation means that fund managers are more willing to allocate resources into tracking and analysing equities in these markets (Freeman, Bartels, 2000). However large capitalisation itself is not a sufficient determinant where foreign portfolio investments go, another important issue is regulations and capital controls.

Table 1 Stock market characteristics as of year-end 2007

Exchange	Total market capitalization (USD millions)	% Change in market cap / 06	Total value of share trading (USD millions)	Number of listed companies
Shanghai	3 694 348,0	302,7%	4 028 590,3	860
South Korea	1 122 606,3	34,5%	2 005 640,8	1 757
Malaysia	325 290,3	38,1%	169 722,8	986
Indonesia	211 693,0	52,4%	114 631,1	383
Philippines	102 852,7	51,6%	29 172,0	244
Thailand	197 129,4	40,6%	117 893,2	523
New York	15 650 832,5	1,5%	29 113 786,7	2 273

Source: World Federation of Exchanges

3.2. Holdings of foreign securities

The participation of Asian countries in international financial markets has increased significantly over the last several years. Table 3 presents Asian holdings of US portfolio securities and US portfolio holdings of foreign securities for each of the markets: China, South Korea, Malaysia, Indonesia, Thailand and Philippines. In general it can be seen that foreign investors increased their holdings of assets in the Asian markets during the boom. Hence the exposure of these countries to a change in investors' sentiment increased as well. We can also notice that the outflows during the crisis have been quite substantial.

Among the Asian countries we are investigating, China has been the top investing country in US securities followed by South Korea, then Malaysia, Thailand, Philippines and finally Indonesia. Over the years China has been increasing its amount invested and in 2008 it became the second major investor in the US securities after Japan. Similarly other Asian countries enhanced their investments in the US although on a much smaller scale. Only Indonesia decreased their investments after 2007. When it comes to US holdings of Asian securities, they have increased dramatically over the years, most notably in China and South Korea, on a slower pace in the rest of the Asian countries, the slowest being Malaysia. However after the break of the crisis in 2007 these investments decreased in most of the countries except for Malaysia. Furthermore it seems that just before the crisis, in 2006 the mutual investments between Malaysia and the US fell down. Also South Korea decreased its investments in the US before the crisis.

China is the country most connected to the US market through securities holdings. However US investors allocate more of their funds in South Korea. The smallest amount invested in US securities before the crisis had Malaysia and it was also the country where US investors invested the least.

3.3. Capital controls

Cross border capital flows are closely related to international financial integration and domestic economic and financial stability, hence they are of great concern. As mentioned in the introductory chapter, China, Malaysia, South Korea and Thailand have high average CCI throughout the entire period 1996-2003 (see Table 2). China however also had a consistently lower CBFI over the entire period, indicating that their capital account restrictions are

effective in controlling actual capital flows. For Malaysia, South Korea and Thailand, the CBFI fell 2001-2003 as capital control measures were added. Overall, the restrictions on capital flows have hence been effective in controlling actual capital flows. Thailand and South Korea have similar CBFI and CCI to China, but they have a substantially greater openness of capital flows via portfolio securities and banks which makes them more similar to the Asian financial centres of Hong Kong and Singapore. They were hence more affected by the financial crisis 1997 than China, which did not experience a single year of net capital outflows over the examined period. This can be explained by the country's tight capital controls. However, capital controls are not always effective since there also are other factors that might influence the capital flows, such as exchange rate, interest rate and investing environment. China is now continuing its opening policy and aiming for complete convertibility of the RMB and liberalizing restrictions on cross border capital flows. Once they release their capital controls they will become ineffective in controlling actual cross border flow, hence it's important for China to be cautious and prudent during their capital account liberalization (Xiao and Kimball, 2005).

Table 2 Comparison between CCI and CBFI 1996-2003

	Average 1996-2000		Average 2001-2003	
	CCI	CBFI	CCI	CBFI
China	0,825	0,074	0,857	0,078
Malaysia	0,786	0,081	0,857	0,063
South Korea	0,743	0,743	0,786	0,069
Thailand	0,743	0,743	0,786	0,068

Source: Xiao and Kimball (2005).

Table 3 Foreign holdings of U.S. securities and U.S. holdings of foreign securities

Millions of U.S. dollars	2008	% change	2007	% change	2006	% change	1994	Country
Foreign holdings	1 205 080	31%	922 046	32%	698 929	38345%	1 818	CHINA
US holdings	54 903	-44%	97 284	29%	75 314	3512%	2 085	
Foreign holdings	130 692	848%	13 787	-89%	124 213	2058%	5 755	SOUTH KOREA
US holdings	56 055	-60%	139 607	13%	123 876	1689%	6 925	
Foreign holdings	34 515	1200%	2 655	-84%	16 127	182%	5 709	MALAYSIA
US holdings	11 936	373%	2 524	-84%	15 404	61%	9 564	
Foreign holdings	12 376	-36%	19 429	63%	11 937	524%	1 914	INDONESIA
US holdings	1 116	-94%	18 356	30%	14 072	550%	2 164	
Foreign holdings	14 729	33%	11 066	28%	8 654	231%	2 617	PHILIPPINES
US holdings	7 098	-51%	14 472	32%	10 989	341%	2 491	
Foreign holdings	32 235	48%	21 709	34%	16 236	137%	6 839	THAILAND
US holdings	7 619	-55%	16 843	29%	13 047	172%	4 793	

Source: Based on the data from United States Department of Treasury.

3.4. Overview of country specific investor characteristics

The Shanghai stock exchange is dominated by retail investors – they account for more than 60% of the market turnover (Reuters, 2010). These retail investors are often more stimulated by sentiment than corporate fundamentals. They invest in the market only for quick profit. That has caused the moves in stock prices to be inflated and as a consequence the Shanghai index has proved to be a weak indicator of China's underlying economic performance. It becomes apparent when the companies listed both in Shanghai and Hong Kong are compared – there is a wide spread between their valuations (Asia Times, 2007). Moreover there are restrictions on foreign investments, making it hard for individual investors from the outside to enter Chinese stock markets. In 2002 China implemented a qualified foreign institutional investors program (QFII) which opened up the securities market to licensed foreign investors. However, it is only possible for foreign investors to invest in stocks divided into Class B shares while domestic investors can invest in both A shares and B shares (Shanghai Stock Exchange, 2009).

In Indonesia foreign investors dominates the market, holding 66% of the capital value in comparison to 64% last year. However, trading might be less volatile especially in times of crisis if local investors dominated the market. There has also been a recent growth in online-trading which has attracted mostly short-term traders while the market lacks long-term investors. There is a concern about what would happen if the foreign traders would withdraw from the market en masse. A solution for regulators could be to coordinate with local institutional investors to fill the gap, i.e. insurance firms or institutions should be ready with funds if foreign investors sell (The Embassy of the Republic of Indonesia, 2009).

The Stock Exchange in Thailand, SET, is dominated by retail investors which in 2009 were accounting for 61% of total trading volume compared to 54% in 2008. The SET is continuing to enhance the attractiveness by offering more investment opportunities to both domestic and foreign investors. New products were launched i.e. gold futures, stock futures with the SET50 Index as underlying asset and derivative warrants with stocks of leading listed companies as the underlying assets. The SET also aims to expand the investor base by increasing the number and quality of local investors and foreign institutional investors (Annual Report SET, 2009).

The Malaysian Stock Exchange has a majority of domestic investors, accounting for 58% of the market demography by trading value while the remaining 42% is accounted for by foreign investors. Furthermore, retail investors' accounts for 24% and institutional investors for 76% (Annual Report Bursa Malaysia, 2009). The Malaysian government has in 2009 eased the restrictions on foreign investors interested in investing in the country's financial sector. It is now possible for the foreign owners to take a stake of 70% (former 49%) ownership within insurance and investment banks. There have also been liberalizations within the service sector, which combined with the liberalizations in the financial sector is thought to attract foreign investors and lead to diversified growth for the economy (BBC, 2009).

In South Korea foreign investors posses nearly 30% of the market capitalization and they are a supply of a considerable part of market liquidity (South Korea Exchange, 2010). After the Asian financial crisis in 1997-98, aggregate foreign investment ceilings have been lifted in the South Korean Stock Exchange but also regulations for securities have been liberalized. Hence the access of foreign investors to the capital markets in South Korea has increased. In 2008 the South Korea Exchange were ranked third in Asia with regards to market capitalization (Estandards Forum, 2010).

The Philippine Stock Exchange is mostly made up by foreign investors, accounting for 66% of the daily transactions (Liu, 2009). There are in general no restrictions on non-resident investors purchasing bonds, money-market instruments or other portfolio investments. However for non-residents to invest in local securities markets, they are required to use inward foreign exchange remittances converted into Philippine pesos through a local bank, funds held in a resident foreign currency account converted into pesos or an existing peso account (Asian Bonds Online, 2010).

Table 4 Composition of investors in the stock markets 2008

	Retail investors	Foreign investors
Shanghai	63%	2%*
South Korea	30%	30%
Malaysia	58%	42%
Indonesia		66%
Philippines		66%**
Thailand	54%	29,1%

Sources: Reuters (2010), South Korea Exchange (2010), Annual Report Bursa Malaysia (2009), The Embassy of the Republic of Indonesia (2009), Liu (2009), Annual Report SET (2009),
* At the end of 2007 China tripled the quotas for QFII to $30 billion (Ni, 2008). Calculated based on the World Federation of Exchanges data for 2008.
** Everyday Stock market transactions

A survey conducted by Freeman and Bartels (2000) gives us some insight into how investors perceive different Asian markets. It covers Thailand, Indonesia, Malaysia and Philippines but unfortunately it does not include China and South Korea. The results indicate that these markets' performance is considered to be driven by volume of capital flowing in and out rather than the actual fundamentals of the listed companies. It applies especially to Thailand and Indonesia, in a slightly lesser extent to Philippines and Malaysia. Retail investors are considered to be most important on Malaysia's and Thailand's markets. When it comes to the sensitivity of each market's performance to those of the major markets (like New York, London and Tokyo) investors perceive Malaysia and Indonesia to be the best hedge since they consider them less sensitive. The summary of selected results from the survey is presented in Table 5.

Table 5 Investors' perception of East Asian markets

Market / % of respondents	Driven by volume	Very important or important retail investors	Sensitive to other major markets
Malaysia	73%	83%	42%
Indonesia	88%	59%	43%
Philippines	81%	53%	61%
Thailand	96%	82%	63%

Source: Based on Freeman and Bartels (2000)

3.5. How can East Asian emerging markets be affected by contagion?

Based on this chapter's analysis of East Asian markets, investors' characteristics and capital control policies we would expect to find evidence of contagion due to turmoil in the US financial market. We can see that foreign investors represent a substantial part of the Asian stock markets' capitalization hence their behaviour can impact the indices. From this perspective China and South Korea seem to be most invulnerable to contagion as opposed to the other economies which have much higher percentage of foreign investors.

Another factor which indicates that contagion among the countries under our investigation might be significant is holdings of foreign securities that increased over time. The US investors own more assets in the Asian portfolios hence the Asian countries are more exposed to fluctuations in investors' sentiments. This also confirms what we have already said about the foreign participation in the markets – that the percentage of foreign investors is generally high.

American investors hold the largest amount of securities in South Korea, then China and much less in other Asian countries, especially Thailand and Philippines. On the other hand China, South Korea, Thailand and Malaysia are the countries that invest the most in the American securities. Larger amount of invested capital might suggest higher correlation between the countries' financial markets.

We can also notice that the year-to-year flows of capital between the countries are highly volatile. One year they can be extremely high and in the next year negative. This kind of behaviour in recent years is particularly extreme in the case of South Korea and Malaysia, but it is also relevant for other Asian economies. This might imply that large capital flows are not only the result of good economic conditions but also depend on other, unobservable factors like change in investors' expectations, liquidity shocks or herding.

It is interesting to note that this observation is supported by the results of the survey on investors' perceptions. They consider the Asian markets to be driven mainly by volume of capital flows rather than the listed companies' economic fundamentals, Indonesia and Thailand being the least connected to the real factors. Thus contagion might be a significant feature of market movements. Moreover the investors regard Indonesia and Malaysia as

being least sensitive to major markets' performance and that might be reflected in smaller contagion effects for these countries.

When we take capital controls into consideration it seems that China and Malaysia would be the countries least affected by the financial crisis in the US since their controls are the tightest. However China is pursuing liberalization policy that can result in less efficient controls of actual cross boarder flows thus making contagion effects more likely to occur. Moreover South Korea's and Thailand's indicators for non official capital flows (CBFI) have significantly improved after implementing stricter regulations as a consequence of the 1997 crisis, which could indicate that contagion might not influence them to a very high extent.

4. Methodology and data

In this section we present and motivate our choice of research approach and research method. We specify the model, estimation technique and data set. Furthermore we discuss potential methodological problems in terms of validity and reliability.

4.1. Research approach

Pesaran and Pick (2007) argues that in order to identify contagion, the equations for the individual markets should contain market specific regressors. They also show that if ignoring endogeneity and interdependence, an upward bias could result in the estimate of the contagion coefficient. Monte Carlo experiments show that the bias is substantial. This finding questions the validity of previous studies which have tested for contagion through correlation-based tests without including market specific regressors.

Pesaran and Pick (2007) have hence developed a canonical econometric model of contagion which includes market specific regressors. The model allows for the three different causes of crises; i) Country or market specific shocks, ii) common observed or unobserved factors, i.e. interdependence and iii) higher correlation in times of crises, i.e. contagion. They also discuss the two most commonly used approaches; *correlation-based tests of contagion* and t*ests based on panel data analysis of currency crises.*

The correlation-based test of contagion does require a priori specification of the crisis period and the data usually used is daily return observations. Furthermore, it does not consider country-specific or global variables in their analysis. The canonical model instead provides a formal statistical framework for a simultaneous analysis of contagion and interdependence without an a priori classification of the observations into crisis and non-crisis periods.

For *tests based on panel data analysis of currency crises, s*ome multi-country panel analyses that Pesaran and Pick (2007) have analyzed, i.e. Eichengreen, Rose, and Wyplosz (1996) do contain country-specific fundamentals and could be used when addressing the issue of contagion versus interdependence. The panel data studies however typically assume that contagion indices are predetermined and that equation errors across countries/markets are independently distributed. This could also result in a substantial upward bias in the estimates of the contagion coefficients.

The canonical model can simultaneously analyze contagion and interdependence without a priori classifying the observations into crisis and non-crisis periods. Pesaran and Pick (2007) do however recognize a possible problem of weak instruments. Their test results provide some evidence of contagion, but with asymmetric effects. There is no significant effect from sharp declines in the spreads contrary to the OLS estimates. The OLS and GIVE estimates of the contagion coefficients in the interest rate spread equations show that the null of weak instruments cannot be rejected. Their study also shows statistical insignificance of β_i irrespective of the order of the power augmentation of the instruments. This implies that the significance of the OLS estimates of β_i is likely to occur due to interdependence rather than contagion. The results show some evidence of contagion in the transmission of interest rate shocks across the European bond markets during 1988–1992 (ERM period). However, only when the interest rates rise relative to the German interest rate tested and not the reverse.

Following Pesaran and Pick (2007) as well as Forbes and Rigobon (2002) we define contagion as a significant increase in cross-market linkages after a shock to one country (or group of countries). This is the most restrictive definition but using it offers us two major advantages:

- It leads to a straightforward procedure for testing if contagion takes place. We just have to *compare connections* between two markets (for example cross-market correlation coefficients) during a relatively stable time (usually calculated as a historic average) with connections right after a shock or crisis.
- It gives a straightforward way of distinguishing between different explanations of how crises are transmitted across markets. By applying it we can *prove which set of theories has been dominant* during the recent crisis - those expecting a change in cross-country linkages after a shock or those expecting a maintenance of the cross-country linkages that are present in all states of the world.

Massacci (2007) have applied Pesaran and Pick's (2007) canonical model and focused the analysis on the identification and estimation of the canonical model. The empirical validity of the model is supported when conducting a Monte Carlo analysis which also shows that the Full Information Maximum Likelihood estimator used performs better that the GIVE estimators used in Pesaran and Pick (2007). Through an empirical illustration they also find evidence in favour of the contagion effect in equity markets.

The model specified is a two-equation nonlinear simultaneous equations system with endogenous dummy variables, and also an extension of univariate threshold autoregressive (TAR) models to a simultaneous equations framework. The model produces multiple equilibria for a range of economic fundamentals and a selection parameter, and then chooses the resulting equilibrium. In presence of multiple equilibria, the econometric specification is incoherent[1]. The coherency problem does not however affect the identification of the model which is given by utilizing the nonlinear system. For estimation, the expression for the likelihood function is derived and the analytical expression for the probability distribution function is then affected by the coherency issue. Massacci (2007) shows that neither identification nor Full Information Maximum Likelihood (FIML) estimation of the model require knowledge of the randomization process driving the solution choice in the multiple equilibria region. This way Massacci (2007) method is easier to apply.

[1] Coherent model – one with a well defined reduced form. Pesaran and Pick (2007) include Bernoulli randomization process due to which the model is incoherent.

As discussed in part 2.2, Masson (1999) classified the simultaneous occurrence of financial crises across markets into three groups; monsoonal effects, spillovers and pure contagion. Following Massacci (2007) and Pesaran and Pick (2007) we refer to pure contagion as contagion. Monsoonal effects and spillovers are referred to as effects of interdependence.

Pure contagion is defined as when a crisis spreads between countries without any change in macroeconomic fundamentals. Pure contagion is hence modeled as a situation characterized by the existence of multiple equilibria and the economic system jumps from one equilibrium to another one. Therefore this shift of the system from a tranquil state to a crisis state might be due to shift in expectations while the economic fundamentals remain the same.

4.2. Model specification

The canonical model of contagion developed by Pesaran and Pick (2007) can be presented by the following set of relations:

$$y_{1t} = \delta_1' z_t + \alpha_1' x_{1t} + \beta_1 I\left(y_{2t} - c_2\sigma_{2,t-1}\right) + u_{1t} \qquad (1)$$

$$y_{2t} = \delta_2' z_t + \alpha_2' x_{2t} + \beta_2 I\left(y_{1t} - c_1\sigma_{1,t-1}\right) + u_{2t} \qquad (2)$$

where y_{it} is a performance indicator of a country i=1,2, t=1, ..., T, z_t is a s ×1 vector of pre-determined common factors. The regressors, x_{it} , are k_i × 1 vectors of country-specific observed factors which are assumed to be pre-determined and distributed independently of u_{jt} for all i and j. It is possible to allow for country-specific dynamics by including lags of y_{it} in x_{it} such that $x_{it} = \left(\hat{y}_{i,t-1}, \dots, \hat{y}_{i,t-5}\right)'$. Next, u_{it} are serially uncorrelated errors with zero means, conditional variances $\sigma^2_{u_i,t-1}$ and a non-zero correlation coefficient ρ. In general it is possible to allow for time variations in ρ, but such a generalization could obscure the properties of the correlation between y_{it}. Pesaran and Pick (2007) demonstrate that corr(y_{1t}, y_{2t}) can be time varying even if ρ is not. Finally I(A) is an indicator function which is determined as:

$$I(A) = \begin{cases} 1 & if\ A > 0 \\ 0 & otherwise \end{cases} \qquad (3)$$

and $\sigma^2{}_{i,t-1}$=var$(y_{it}|\Omega_{t-1})$

where $\Omega_{t-1}$is information available at time t-1 and A is $y_{it} - c_i\sigma_{i,t-1}$.

The main assumptions of this framework are as follows:

- Contagion takes place only at times of crises, while interdependence is the consequence of normal market interactions.
- Interdependence is expressed by non-zero values of ρ, while contagion effects are captured through non-zero values of β.
- Crisis in country i occurs if the performance index, y_{it}, is strictly greater than the threshold value c_j.
- Contagion takes place if a crisis in country 2 increases the probability of a crisis in country 1 over and above the usual market interactions, and vice versa.
- In order to test for contagion in country i we test if $\beta_i = 0$ against the one-sided alternatives, $\beta_i > 0$ allowing for the possibility of non-zero ρ.

The system of equations 1) and 2) is a two-equation nonlinear simultaneous equations model with endogenous dummy variables. A shift in the intercept in the equation takes place when the underlying endogenous variable y_{jt} crosses the corresponding threshold c_j, for i, j = 1, 2 and i ≠ j. Thus it belongs to the general class of models with structural shifts which is more thoroughly described in Massacci (2007) as well as Heckman (1978). Standard assumptions that we apply from the literature of threshold models:

Assumption 1 The elements of the vector $F_t = (z_t', x_{1t}', x_{2t}')'$ are stationary ergodic predetermined variables.

Assumption 2 The vector u_t is distributed as $u_t \sim$ IID (0, Σ_u); its joint pdf g(.) is absolutely continuous, positive everywhere on R^2, and independent of z_t.

4.3. Estimation technique

Pesaran and Pick (2007) prove in their paper that ordinary least squares (OLS) estimator of β_1 is inconsistent unless $\beta_2 = \rho = 0$, that is if the contagion model is recursive (triangular) and there are no interdependencies through the errors. There will be large sample upward bias if $\rho > 0$ and $\beta_1 > 0$.

In order to ensure consistent estimates of contagion coefficients we follow Massacci (2007) who achieves identification and estimation of the system of equations 1) and 2). The estimation is performed by parametric Maximum Likelihood, given that the joint pdf of $(y_{1t}, y_{2t})'$ contains a normalization factor which guarantees that the function itself integrates to unity, in order to accommodate for the incoherent nature of the system. All the proofs are included in Massacci (2007). Here we simply present the results that are going to be applied in our thesis.

Since our model is a simultaneous equations system, it is important to determine under what conditions contagion effects can be identified from interdependence. Given that the vectors of predetermined variables $x_{1t}\ and\ x_{2t}$ are such that $x_{1t} \cap x_{2t} = \varnothing$, and the Assumption 1 and Assumption 2 hold, then if $\beta_1, \beta_2 > 0$ the model is identified even if $\alpha_1 = 0$ and $\alpha_2 = 0$.

If we assume that the conditional distribution of the shocks $(u_{1t}, u_{2t})'$ is known, the system can be estimated by Full Information Maximum Likelihood (FIML). More specifically, in a full information framework, the threshold parameters c_1 and c_2 will be estimated by grid search, and the remaining set of parameters will be estimated by FIML. The log-likelihood function that is estimated by FIML is then given by:

$$L_T = \sum_{t=1}^{T} log\, f(y_{1t}, y_{2t}|F_t). \qquad (4)$$

The vectors of parameters c and θ are defined as:

$$c \equiv (c_1, c_2)' \text{ and } \theta \equiv (\alpha_1', \delta_1', \beta_1\ , \sigma_1^2, \alpha_2', \delta_2', \beta_2\ , \sigma_2^2, \sigma_{12})'$$

and we denote by c^0 and θ^0 as the true values of c and θ, respectively. Next, we denote the estimators of c^0 and θ^0 that are obtained by grid search and FIML, respectively as $\hat{c}_{FIML}\ and\ \hat{\theta}_{FIML}$ respectively.

4.4. Data set

The dependent variable y_{it} in the set of equations 1) and 2) represents a performance indicator of a country. Depending on the type of underlying market i.e. currency, stock or bond market there are different examples for this indicator in the literature. We follow Forbes and Rigobon (2002), Fry, Martin and Tang (2008) and Massacci (2007) and apply stock

market returns. Particularly we focus on the interactions between the US stock market and five developing East Asian markets: China, Malaysia, Indonesia, the Philippines, Thailand and South Korea. Thus we use daily stock market spot prices for the S&P 500 (New York), SSE Composite (Shanghai), KLCI (Kuala Lumpur), MBX (Jakarta), PSEI (Manila), SET (Bangkok) and KOSPI (Seoul). These benchmark equity indices are listed in Table 6. All the stock market indices are in US dollars since it is the most commonly used currency in the previous work on contagion. We obtain all the data from Datastream for the period from 3 January 2005 to 7 May 2010.

Table 6 Benchmark equity market indices

Equity market	Benchmark index
China	SSE Composite Index
Indonesia	MBX Index
Malaysia	KLCI Index
Philippines	PSEI Index
Thailand	SET Index
South Korea	KOSPI Index
US	S&P500 Index

Source: Datastream

We have to take into account that international stock markets are not open during the same hours which leads to non-synchronous data. Using daily closing prices would result in underestimation of the correlation between the stock markets. To avoid this problem Massacci (2007) following Martens and Poon (2001) uses pseudo-closing prices. However in our case since the US market does not have any common trading time with the Asian stock markets. Instead, we follow Forbes and Rigobon (2002) who calculate stock market returns as rolling-average, two-day returns based on each country's aggregate stock market index.

Furthermore, the literature based on works by Engle (1982) and Bollerslev (1986) draws attention to the fact that stock market returns show a high degree of conditional heteroskedasticity. We deal with this problem by devolatising the returns (denoted r_{it}). Our dependent variable, y_{it}, is defined as:

$$y_{it} \equiv -\frac{r_{it}}{\sigma_{i|t-1}}, \quad \sigma^2_{i|t-1} \equiv Var\left(r_{it}|\Omega_{i,t-1}\right), \; i = 1,2 \qquad (5)$$

where $\Omega_{i,t-1}$ is the information set up to time t-1. The conditional variance, $\sigma_{i|t-1}$, is estimated by applying the GARCH(1, 1) − t model set up by Bollerslev (1987), which is a more flexible method to accommodate for the leptokurtosis in the returns than the standard GARCH model with conditionally Gaussian disturbances. The model is defined as:

$$r_{it} = \mu_i + \sum_{k=1}^{5} \gamma_{ik} r_{i,t-k} + \varepsilon_{it}$$

$$\varepsilon_{it} = z_{it}\sigma_{i|t-1}$$

$$z_{it}|\Omega_{i,t-1} \sim iidt_v\ (0,1)$$

$\sigma^2_{i|t-1} = \omega + \alpha\varepsilon^2_{i,t-1} + \beta\sigma^2_{i|t-2}$ (6)

where v is the number of degrees of freedom for the t distribution. In order to control for serial correlation and weekly effects the stock market returns r_{it} are described as an autoregressive process of order five.

4.5. Final model specification and maximization algorithm

Taking all the data adjustments into account the estimated model is specified as:

$$\hat{y}_{1t} = \delta_1^{'} + \alpha_1^{'} x_{1t} + \beta_1 I(-r_{2t} - c_2) + u_{1t}$$

$$\hat{y}_{2t} = \delta_2^{'} + \alpha_2^{'} x_{2t} + \beta_2 I(-r_{1t} - c_1) + u_{2t} \quad (7)$$

where $\hat{y}_{1t} = -\frac{r_{it}}{\hat{\sigma}_{i|t-1}}$, $x_{it} = \left(\hat{y}_{i,t-1}, \dots, \hat{y}_{i,t-5}\right)'$, $i = 1,2$

and $\hat{\sigma}_{i|t-1}$ is the estimate of $\sigma_{i|t-1}$ obtained from the GARCH model in (6). The subscript i=2 always refers to the S&P 500 index.

The normalized log-likelihood function of the model can be obtained as:

$$l_T(\theta, c) = T^{-1} \sum_{t=1}^{T} \log\left[f_y(y_t, \theta, c|x_t) / \int_{y_t} f_y(y_t, \theta, c|x_t) dy_t\right] \quad (8)$$

The algorithm that enables us to obtain the FIML estimators for θ^0 and c^0 consists of three steps. First, for a fixed value of c, the value of θ that maximizes $l_T(\theta, c)$ is obtained:

$$\hat{\theta}_{FIML}(c) = \arg\max_{\theta \in \Theta} l_T(\theta, c).$$

In the second step the estimator $\hat{c}_{FIML}$ is obtained:

$$\hat{c}_{FIML} = \arg\max_{c \in C} l_T\left(\hat{\theta}_{FIML}(c), c\right).$$

Finally the estimator $\hat{\theta}_{FIML}$ is given as:

$$\hat{\theta}_{FIML} = \hat{\theta}_{FIML}(\hat{c}_{FIML}).$$

4.6. Validity and reliability of the model

The application of the canonical model to study contagion as presented in Pesaran and Pick (2007) is relatively new and there is not much research done using this approach. This can be seen as a strength but it might also be a drawback since there is not extensive amount of empirical research backing it up.

The improvement of this model relative to previous approaches is that it includes country specific regressors that are necessary to correctly identify contagion. It also does not require to specify the crisis period which means that we avoid sample selection bias. We also do not need to specify the origin of the crisis so we can investigate contagion in many directions.

Our analysis of contagion in East Asian markets builds on the study by Pesaran and Pick (2007) but is improved by applying FIML estimation that is developed by Massacci (2007) and proved to perform better than the GIVE estimators employed by Pesaran and Pick (2007). To our knowledge no one else used this kind of approach to analyze contagion in East Asian markets during the latest financial crisis.

We perform our estimations using FIML procedure in the econometric software Eviews. The possible weakness of the FIML estimation is that it is likely to be sensitive to misspecification in the underlying distribution of the error terms. FIML assumes that they are distributed normally. If this condition is not met the method might produce poor results. However our sample is large (1388 observations) thus we can disregard this issue.

We obtain our data from Datastream which is considered a reliable source especially since we use stock market indices that are general market variables that cannot be as easily manipulated as for example company specific data. Furthermore we only use one database for collecting our data which adds to the reliability and comparability.

Since we carry out the grid search algorithm manually in Excel doing nine by nine iterations for each of the six markets in the sample we have good control over the process and results. This way of handling the data ensures that at each step we can revise and check the data. The procedure is also easy to replicate, we hence predict that other studies would come to similar conclusions.

5. Empirical analysis

This chapter focuses on the empirical application of the chosen methodology. We present the descriptive statistics of the data in the sample, describe the estimation process and show the results.

5.1. Descriptive statistics

The financial crisis that originated in the US in late 2007 affected many economies around the world including the emerging East Asian markets. In September 2007 the US sub-prime problem emerged and this event affected the East Asian region. As seen in Figure 2, in late 2007 the New York stock market started to fall and this declining trend was also reflected in East Asian markets. We can notice that markets in Malaysia and Philippines continued to rise for some time but after several months all indices suffered from significant falls. The period between the end of 2008 and the beginning of 2009 was the time of the greatest slump on the markets where indices were extremely low. Later in 2009 the US market appeared to improve and other indices also began to rise. The question addressed in our empirical analysis is if this time of high correlations in market movements can be a proof of contagion.

Figure 2 Stock market indices during the 2007 crisis

Notes: Indices are set to 100 on 1 May 2007 and are based on US dollar values

Table 7 presents descriptive statistics for the stock market returns of each of the markets in the sample: China, Indonesia, Malaysia, South Korea, Philippines, Thailand and the US. Average daily returns are all positive, except for the US. The highest rate of return was provided by the Indonesian stock exchange followed closely by the Shanghai stock exchange and then Philippines, South Korea, Malaysia, Thailand and finally the US. Standard deviation values indicate that the Malaysian index was the least volatile followed by the US, Thailand and Philippines. The most volatile indices were the ones in China, Indonesia and South Korea. The skewness statistic shows that all the indices' distributions are negatively skewed compared to the normal distribution. Furthermore all of them are highly leptokurtic compared to the normal distribution. The Jarque-Bera test statistic rejects the null hypothesis of normality at 1% significance level for all returns.

The correlations between the stock returns are presented in Table 8. The correlation between the US market and any other Asian market is lower than the correlation between any other pair of markets. This can be explained by the considerably large difference in trading times between New York and all the other markets. It is also an argument for adjusting returns by taking two-day averages. The only exception is Shanghai for which correlation indicators with other markets are much lower than the correlations between any other two markets including the US. Only its correlation with the Malaysian market is higher

than the corresponding correlation with the US exchange. Furthermore Chinese market is in general the least correlated with the US market, followed by Indonesia, Philippines, Malaysia and Thailand. The highest correlation the US market has with South Korean market.

Table 7 Descriptive statistics – daily stock market returns

	KLCI	KOSPI	MBX	PSEI	SET	SH	SP500
Mean	0.016163	0.017187	0.034011	0.023392	0.009446	0.030162	-0.001822
Median	0.021660	0.000000	0.000000	0.049497	0.021416	0.050571	0.019671
Maximum	1.231437	5.350517	3.454046	2.149996	2.419579	3.600180	2.693543
Minimum	-2.454787	-5.429789	-4.695225	-3.578470	-4.067386	-2.763686	-2.879098
Std. Dev.	0.338827	0.682279	0.676114	0.540230	0.495233	0.601028	0.419634
Skewness	-0.584953	-0.589714	-0.646644	-0.611574	-1.038328	-0.043520	-0.533577
Kurtosis	7.376645	16.73480	9.062249	7.160701	11.61510	5.704189	10.96993
Jarque-Bera	1186.954	10990.41	2222.157	1087.702	4541.797	423.3523	3739.424
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1388	1388	1388	1388	1388	1388	1388

Table 8 Correlation matrix – daily stock market returns

Correlation	KLCI	KOSPI	MBX	PSEI	SET	SH	SP500
KLCI	1.000000						
KOSPI	0.570739	1.000000					
MBX	0.600739	0.555291	1.000000				
PSEI	0.597996	0.533061	0.573824	1.000000			
SET	0.503516	0.499217	0.556700	0.475731	1.000000		
SH	0.323056	0.276644	0.268727	0.257893	0.206013	1.000000	
SP500	0.297764	0.428360	0.285120	0.294755	0.336393	0.113245	1.000000

5.2. FIML estimation

First we determine the threshold parameters c_1 and c_2 using grid search. For each stock market return we choose a grid of values for the threshold parameters and since we model extreme negative events we confine ourselves to the left tail of the empirical distribution of y_t. Thus we choose the width of the grid to include observations for c_1 and c_2 respectively between the bottom 0.5% and 21% quantiles of the empirical distribution of each of the returns and we set a step equal to 0,02. The resulting intervals for the threshold parameters for the US, Chinese, Thai, Malaysian, South Korean, Philippine and Indonesian markets are the following: $c_{US} \equiv$ [-0,64992; -0,19834], $c_{China} \equiv$ [-0,99238; -0,37809], $c_{Thailand} \equiv$ [-0,74556; -0,29806], $c_{Malaysia} \equiv$ [-0,5436; -0,1933], $c_{Korea} \equiv$ [-0,94001; -0,33153], $c_{Philippines} \equiv$ [-0,87701; -0,29454] and $c_{Indonesia} \equiv$ [-1,03119; -0,34597]. Next In each point of such constructed bidimensional grid we maximize the likelihood function, collect the values of each likelihood function and then choose the estimated values of the parameters such that the likelihood function is maximized. The final results of this FIML estimation are presented in Table 9.

Table 9 FIML estimation results

	China	US	Thailand	US	Malaysia	US	South Korea	US	Philippines	US	Indonesia	US
c_i	-0,37809	-1,01126	-0,29806	-1,01126	-0,1933	-1,01126	-0,33153	-1,01126	-0,29454	-1,01126	-0,34597	-1,01126
n_i	292	642	292	642	292	642	290	642	292	642	292	642
π_i	0,210375	0,462536	0,210375	0,462536	0,210375	0,462536	0,208934	0,462536	0,210375	0,462536	0,210375	0,462536
β_i	0.844924	0.782219	0.971260	0.518369	0.940274	1.023512	0.895455	0.419322	0.924514	0.527171	1.025334	0.458946
S.E. of regression	1.257353	1.254802	1.371995	1.247735	1.337630	1.241783	1.239362	1.239746	1.358647	1.243687	1.192456	1.246893
$\rho u_1 u_2$	2.457272		2.906097		2.721018		2.291927		2.805603		2.199044	
Log ***L***	-4543.191		-4659.113		-4613.641		-4495.057		-4634.795		-4466.470	

Notes: The table presents the results of the estimation of the model in (7) by FIML. c_i denotes the threshold parameter, n_i the number of crisis periods, π_i the proportion of crisis periods, β_i the contagion coefficient, and $\rho u_1 u_2$ the correlation between $u_1$and u_i; log L is the value of the log-likelihood function.

5.3. Results

Table 9. reports results from the estimation of the model in (7) by FIML. First we look at the effect of the US market on the East Asian markets. We can see that New York stock exchange seems to define a negative extreme event (i.e. a crisis) in East Asia in exactly the same way. The markets of China, Malaysia, Philippines, Indonesia, Thailand as well as South Korea react when the (standardised) daily returns in the US stock exchange go below -1,01126% which corresponds to a proportion of crisis periods equal to 46%. The effect of a crisis in the US on the Asian markets seems to be of similar magnitude, however there are differences between the countries. The crisis in the US results in the biggest drop of the index, of around 1,025%, in Indonesia. The US crisis has lesser impact on Thailand, Malaysia and Philippines since the corresponding coefficient values for their stock exchanges are 0,97%, 0,94% and 0,92% respectively. South Korea is even less affected: there the drop is of 0,89%. Finally, the least affected is the Chinese market – the drop resulting from the US crisis is of 0,84%. Thus Thailand, Malaysia, Indonesia and Philippines appear to have similar degree of vulnerability to extreme negative events occurring in the US stock market while China and South Korea being relatively less vulnerable.

Moving on to the effect of the East Asian developing countries having on the US stock market it turns out that China has the highest threshold value of -0,37%, followed by Indonesia (-0,34%) and South Korea (-0,33%). Philippines and Thailand have very similar threshold values of around 0,29% and the smallest value is associated with Malaysia (-0,19%). When it comes to the magnitude of the contagion effect on the US market Malaysia has the biggest one – of about 1,02%, and is followed by China with 0,78%. Then extreme events in Philippines and Thailand result in similar magnitude of drop in the US market of around 0,52%. Finally the effect of the smallest magnitude on the US stock index comes from Indonesia and South Korea – 0,45% and 0,41%. It is also worth noticing that all the Asian indices affect the US market the same number of times as they are considered to be in crisis 21% of the times. Only slightly less often is the US index affected by the South Korean market – 20% of the times.

Our results suggest that there is evidence of contagion in the East Asian markets so the indices' co-movements are not only the result of interdependence and the phenomenon goes beyond the existence of common economic linkages between the countries in the

sample. All the contagion coefficients are significant which means that we detect contagion from the US market to the Asian developing countries but it also indicates that there is contagion effect from Asia to the US. However the effects of turmoil in the East Asian economies are of smaller magnitude since the corresponding beta coefficients are in general smaller on the US side than on the Asian markets' part. The only exception here is Malaysia which crisis results in nearly exact drop in the S&P500 index as the drop in the Malaysian index due to the falls in New York. It is also worth noticing that the effects between China and the US are of similar magnitude. This suggests that stock markets in Malaysia and China seem more influential to the investors on the New York stock exchange than other developing Asian economies. Even if what happens in the US is not that strongly reflected on the Chinese market relatively to other countries in the region, the influence of China on the US is relatively strong compared to other Asian economies.

Another issue worth mentioning is that the contagion coefficients in all the systems have positive values which seems reasonable since it points on the interpretation that negative events in one market result in negative events in the other market. Negative beta coefficient would suggest that the values move in opposite directions i.e. a crisis in one market would cause the index in another country to rise which is counterintuitive.

When we look at our results in the context of previous research based on the same model we see that they agree with Massacci (2007) study which also finds evidence of contagion but this time between the US and three European markets – Frankfurt, Zurich and Paris. The contagion coefficients are in general of similar magnitude (of less than 1%) and have the same, positive sign. This might suggest that there is no significant difference between the Asian and European markets in the way the turmoil in the US market affects them. However it is important to note that Massacci's study is extended over a much longer period (15 years) and this might affect the results: the impact of the US market on other countries is bigger in our sample where we concentrate only on the last several years that include the latest crisis than it is in Massacci (2007) paper. This could indicate that it is better to concentrate on a shorter period to capture the accurate contagion effect and a very long estimation period might result in not that meaningful estimates.

Our results stand somewhat in contrast with Pesaran and Pick (2007) who find only some evidence of contagion effects, not in every market. They do however investigate a different type of market – currency instead of stock exchanges. Moreover some of their contagion coefficients are negative which is difficult to explain in practice.

6. Conclusions and proposals for further research

In this chapter we conclude our study and comment on our findings. Furthermore we give suggestions for possible further research.

6.1. Conclusions

The purpose of this thesis was to determine if the East Asian countries are insulated from the word economy due to their improved macroeconomic fundamentals and stronger capital controls implemented after the Asian financial crisis in 1997. We prove that what is happening in the US market does have effect on these economies - negative events on the New York stock exchange cause indices in East Asia to fall.

Our results also show that the negative events on the East Asian markets are not only the result of common economic fundamentals and real linkages between these countries and the US but also unobservable factors i.e. we find the contagion effects significant in all the markets. A crisis in the US leads the Asian indices to drop by approximately 1%. Furthermore we find that the contagion effect is also significant in the other direction – from Asian economies to the US, though it is of smaller magnitude. This may be linked to the fact that it is the American investors that have more funds and invest in East Asia while the American market is less dominated by foreigners.

The US crisis has the biggest negative effect on the Indonesian stock market and the least affected are South Korea and China. It seems that Thailand, Malaysia, Indonesia and Philippines have similar degree of vulnerability to turmoil on the New York stock exchange. According to our expectations based on the analysis of capital controls China and Malaysia should be the least affected. Our results confirm that Chinese capital controls are most efficient. Bigger effect of the crisis on Malaysia in spite of its high capital controls might be

due to the fact that there are also other factors influencing capital flows like exchange and interest rates or investment environment. As we mentioned before South Korea improved its indicators of non-official capital flows which might explain why it was less affected by the crisis. Another factor that might explain our results is the participation of foreign investors in the stock markets. China and South Korea have the lowest percentage of this kind of investors and at the same time they were least affected by contagion. And Indonesia where we found the highest contagion effect has the largest share of foreign investors on the market.

Furthermore we find support for investors' perceptions that the Asian exchanges are determined more by volume rather than economic fundamentals. The countries that are perceived to be least connected to real economy are Indonesia and Thailand and it is reflected in our results which point at Indonesia as the country being mostly affected by contagion.

On the other hand the US market is most affected by Malaysia and China and the influence of other countries is of smaller magnitude. All the Asian countries affect the US the same number of times which suggest that when there is a crisis in one of them there is a crisis in all other as well. We might interpret this as that the stock market in the East Asian region are highly correlated and mutually affect each other. It hence seems that it is a crisis in the whole East Asian region during the same periods that affects the US.

Not only does Malaysia and China have the biggest negative effect on the US stocks but also the influence of stock markets in Malaysia and China on the US is of nearly the same magnitude as the corresponding influence the US has on them. This can imply that what is happening on these two markets seems to be more important for the investors and in the case of negative events on these markets the investors' reaction is more direct. We can connect it to the fact that China after Japan was holding the largest share of the US securities among all foreign investors. This could also have a psychological effect on the investors and result in relatively larger drop in the market that it would be expected from analysis of real linkages. Other Asian economies invested in the US securities on a much smaller scale and from this perspective they are not that significant to the US.

Our study carries important practical implications for further research as well as investors and policy makers. First of all it provides evidence of contagion across the markets which highlight the importance of unobservable factors in the transmission of shocks. Hence possible herding behaviour, liquidity shocks or change in investor expectations should be taken into account when analysing financial crises and not only real economic linkages. Next, it is useful for policy makers to be able to distinguish between contagion and interdependence. Since we find contagion in our sample markets it implies that policy interventions to prevent a crisis from spreading might be efficient. The countries least affected by contagion in our sample were the ones that had tighter capital controls and smaller share of foreign investors who would be more interested in short-term trading and can leave the market very fast. Finally, presence of contagion in certain markets is necessary information for investors in order to adjust their portfolios according to correlations that increase during the crisis periods. Not taking this effect into account might result in less efficient portfolio diversification.

6.2. Future research

In our thesis we applied a relatively new and uncommon approach to measure contagion across markets. It would be interesting to use this method to investigate other geographical regions like for example Europe or South America. Additional extension could be to incorporate variables from other financial markets into the model so that more dimensions of contagion could be accounted for.

Another point worth considering in future studies is the implementation of the new Basel regulations. Basel III is expected to be introduced at the end of 2012 and it will impose new capital and liquidity rules that can result in stricter capital controls (Westlake, 2010). This in turn can have significant impact on investors' decision making and contagion effects.

It might also be also useful to investigate the dynamics of global contagion such as market imperfections, investors' sentiment, and information efficiency in greater detail.

Lastly, since we focus on the current financial crisis it went beyond the purpose of our thesis to make inferences about future developments. However the model applied in this thesis can be used for forecasting the direction of contagion in the markets.

7. References

ADB (2008), Asia Regional Integration Center, Global Economic Crisis: Impact and Challenges for Emerging East Asia's Financial Systems, http://aric.adb.org/pdf/aem/dec08/Dec_AEM_special.pdf.

ADB (2008), South Asia Forum on the Impact of Global Economic and Financial Crisis, http://www.adb.org/Documents/TARs/REG/42502-REG-TAR.pdf.

Ahearne, A., J. Fernald, P. Loungani (2001), Countering Contagion: Does China's Experience Offer a Blueprint, Federal Reserve Bank of. Chicago Economic Perspectives, issue Q IV, pages 38-52.

Ahlgren, N., Antell, J. (2009), Stock market linkages and financial contagion: A cobreaking analysis, The Quarterly Review of Economics and Finance, Volume 50, Pages 157-166.

Asia Times (2007), Fears over Shanghai's red-hot bourse, http://www.atimes.com/atimes/China_Business/IB21Cb02.html.

Asian Bonds Online (2010), Investment Management, http://asianbondsonline.adb.org/philippines/structure/rules/investment_management.php.

Asia-Pacific Regional Economic Outlook (2008), IMF, http://www.imf.org/external/pubs/ft/reo/2008/apd/ENG/areo0408.htm.

Bae, K.H., Karolyi, G.A. and Stulz, R.M. (2003), A new approach to measuring financial contagion. Rev. Financ. Stud., 16(3), 717–763.

Baig, T. and Goldfajn, I. (1999), Financial Market Contagion in the Asian Crisis, IMF Staff Papers, 46 (2), 167-195.

BBC News (2009), Malaysia woos foreign investors, http://news.bbc.co.uk/2/hi/business/8020901.stm.

Bekaert, G., Harvey, C.R. and Ng, A. (2005), Market Integration and Contagion, Journal of Business, 78(1), part 2, forthcoming.

Bollerslev, T. (1986), Generalized Autoregressive Conditional Heteroskedasticity, Journal of Econometrics, 31(3), 307 − 327.

Bollerslev, T. (1987), A Conditionally Heteroskedastic Time Series Model for Speculative Prices and Rates of Return, The Review of Economics and Statistics, 69(3), 542 − 547.

Bond, S., Dungey, M. and Fry, R.A. (2005), A Web of Shocks: Crises Across Asian Real Estate Markets, Journal of Real Estate Finance and Economics, forthcoming.

Bursa Malaysia, Annual Report, 2009.

Calvo, Guillermo (1999). Contagion in Emerging Markets: When Wall Street is a Carrier, University of Maryland Mimeo.

Calvo, S. and C.M. Reinhard (1996), Capital Flows to Latin America: Is There Evidence of Contagion Effects?, In: Calvo, G., Goldstein, M. and E. Hochreiter (Eds.), Private Capital Flows to Emerging Markets, Washington, DC: Institute for International Economics.

Caporale, G.M., Sipollini, A. and Spagnola, N. (2003), Testing for Contagion: A Conditional Correlation Analysis, Journal of Empirical Finance, 12, 476-489.

Cerra, V. and Saxena, S.W. (2002), Contagion, Monsoons and Domestic Turmoil in Indonesia's Currency Crisis, Review of International Economics, 10(1), 36-44.

Cheung, L., Chi-sang Tam and Jessica Szeto (2009), Contagion of Crises: A Literature Review of Theoretical and Empirical Frameworks, Hong Kong Monetary Authority, Research Note 02/2009.

Chinn, M. D., Frankel, J. A. (2008), The Euro May Over the Next 15 Years Surpass the Dollar as Leading International Currency, NBER Working Paper No. W13909.

Debelle, E. and Ellis, L. (2005), The Response of Financial Markets in Australia and New Zealand to News about the Asian Crisis, in Dungey, M. and Tambakis, D. (eds), Identifying International Financial Contagion: Progress and Challenges, Oxford University Press, New York, 150-187.

Dungey M., R. Fry, B. Gonzalez-Hermosillo, V. L. Martin (2005), Empirical Modelling of Contagion: A Review of Methodologies, Quantitative Finance, 5(1), 9-24.

Dungey M., V. Martin (2004), A Multifactor Model of Exchange Rates with Unanticipated Shocks: Measuring Contagion in the East Asian Currency Market, Journal of Emerging Markets Finance, 3 (3), 305-330.

Dungey M., V. Martin (2007), Unravelling financial market linkages during crises, Journal of Applied Econometrics, Volume 22 Issue 1, Pages 89 – 119.

Dungey, Fry, Martin (2006), Correlation, Contagion, and Asian Evidence, Asian Economic Papers, Volume (Year): 5 (2006), Issue (Month): 2 (June), Pages: 32-72.

Dungey, M., Fry, R.A. and Martin, V.L. (2004), Currency Market Contagion in the Asia-Pacific Region, Australian Economic Papers, 379-395.

Dungey, M., Fry, R.A., González-Hermosillo, B. and Martin, V.L. (2002a), International Contagion Effects from the Russian Crisis and the LTCM Near-Collapse, IMF Working Paper 02/74 (Washington: International Monetary Fund).

Dungey, M., Fry, R.A., González-Hermosillo, B. and Martin, V.L. (2002b), The Transmission of Contagion in Developed and Developing International Bond Markets, in Committee on the Global Financial System (ed), Risk Measurement and Systemic Risk, Proceedings of the Third Joint Central Bank Research Conference, pp. 61–74.

Dungey, M., R. Fry, B. González-Hermosillo, and V. Martin (2004), Empirical Modeling of Contagion: A Review of Methodologies, IMF Working Paper, WP/04/78.

Dungey, M.; Fry, R.; Gonzalez-Hermosillo, B.; Martin, V. (2006), Contagion in international bond markets during the Russian and the LTCM crises, Journal of Financial Stability, Volume: 2 Issue: 1 Pages: 1-27.

Eichengreen, B., Rose, A. K., Wyplosz, C. (1996), Contagious currency crises: First tests. Scandinavian Journal of Economics 98 (4), 463–484

Eichengreen, B., Rose, A.K. and Wyplosz, C. (1995), Exchange Market Mayhem: The Antecedents and Aftermath of Speculative Attacks, Economic Policy, Vol. 21, pp. 249–312.

Eichengreen, B., Rose, A.K. and Wyplosz, C. (1996), Contagious currency crises. NBER Working Paper 5681, (National Bureau of Economic Research).

Engle, R. F. (1982), Autoregressive Conditional Heteroscedasticity of the Variance of United Kingdom Inflation, Econometrica, 50(4), 987 − 1008.

Estandardsforum (2010), Financial Standards Foundations, http://www.estandardsforum.org/south-South Korea/standards/objectives-and-principles-of-securities-regulation.

Favero, C. A. and Giavazzi, F. (2002), Is the international propagation of financial shocks non-linear? Evidence from the ERM. J. Int. Econ., 57(1), 231–246.

Fleishman-Hillard (2009), Agency News: Asian Multinational Corporations Poised for Global Success and Asian Region May Be World's Most Influential Economy by 2020, http://fleishmanhillard.com/2009/09/10/asian-multinational-corporations-poised-for-global-success-and%E2%80%A8-asian-region-may-be-world%E2%80%99s-most-influential-economy-by-2020/

Forbes, K. J., Rigobon, R. (2002), No Contagion, Only Interdependence: Measuring Stock Market Comovements, Journal of Finance, Volume 57, Issue 5, Pages 2223-2261.

Freeman N. J., F. L. Bartels (2000), Portfolio Investment in Southeast Asia's Stock Markets: A Survey of Institutional Investors' Current Perceptions and Practices, The Asia Pacific Journal of Economics and Business, Vol. 4 No. 1.

Fry, Martin and Tang (2008), A New Class of Tests of Contagion with Applications, http://cama.anu.edu.au/Working%20Papers/Papers/2008/Fry_Martin_Tang_12008.pdf.

Galati, G., P. (2008), Wooldridge, The euro as a reserve currency: a challenge to the pre-eminence of the US dollar?, International Journal of Finance & Economics, Volume 14, Issue 1 , Pages1 – 23.

Heckman, J. J. (1978), Dummy Endogenous Variables in a Simultaneous Equation System, Econometrica, 46(4), 931 − 959.

Kato T. (2009), Implications for Asia from the Global Financial Crisis and Policy Perspectives, Remarks at the Harvard Asia Business Conference, Boston, Massachusetts, http://www.imf.org/external/np/speeches/2009/021409.htm.

Kleimeier, S., Lehnert, T. and Verschoor, V. (2003), Contagion Versus Interdependence: A Re-examination of Asian-Crisis Stock Market Comovements, LIFE Working Paper 2003-05.

Liu., K.J.R. (2009), Invest Philippines, Foreign Brokers Dominate Philippine stock Market, http://investphilippines.org/2009/11/30/foreign-brokers-dominate-philippine-stock-market/

Martens, M. and S. Poon (2001), Returns Synchronization and Daily Correlation Dynamics Between International Stock Markets, Journal of Banking and Finance, 25(10), 1805 – 1827.

Massacci, D. (2007), Identification and Estimation in an Incoherent Model of Contagion, Cambridge Working Papers in Economics 0744, Faculty of Economics, University of Cambridge.

Masson, Paul R. (1998), Contagion: Monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria (September 1998). IMF Working Paper, Vol., pp. 1-32.

Moneta, F., R. Rüffer (2009), Business cycle synchronisation in East Asia, Journal of Asian Economics, Volume 20, Issue 1, Pages 1-12.

Ni , Y. Nancy (2008), China's Capital Flow Regulations: the Qualified Foreign Institutional Investor and the Qualified Domestic Institutional Investor Programs, 28 Ann. Rev. Banking & Fin. L. 299.

Pesaran, M, H., Pick, A. (2007), Econometric issues in the analysis of contagion, Journal of Economic Dynamics & Control 31, Pages 1245-1277.

Reuters (2010), China stocks slide 5 pct as retail investors flee, http://www.reuters.com/article/idUSTOE64G05X20100517.

Shanghai Stock Exchange, Fact Book (2009), http://static.sse.com.cn/sseportal/en/pages/p1005/p1005_content/factbook_us2009.pdf.

South Korea Exchange (2010), Share ownership distribution by investor type in 2009, http://eng.krx.co.kr/index.html.

The Embassy of the Republic of Indonesia, Helsinki, Finland (2009), Indonesia Emerges As Asia's Third Best-Performing Market on 67% Advance, http://www.indonesian-embassy.fi/in/index.php?lang=EN&p=News__Publications/1&s=45&tr=1250602667_163

The Stock Exchange of Thailand (2009), Annual Report, http://www.set.or.th/en/index.html.

The World Bank, Definitions of contagion (2010), http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTPROGRAMS/EXTMACROECO/0,,print:Y~isCURL:Y~contentMDK:20889756~pagePK:64168182~piPK:64168060~theSitePK:477872,00.html.

Valdés, Rodrigo (1996), Emerging Market Contagion: Evidence and Theory. MIT Mimeo, http://www.bcentral.cl/eng/studies/working-papers/pdf/DTBC07A.PDF.

Westlake M. (2010), Newsletter May 2010: Regulators to stand their ground over Basel III, Global Risk Regulator, Volume:8 Issue: 5, http://www.globalriskregulator.com/article.php?pgkey=2322.

Wongswan, J. (2003), Contagion: An Empirical Test, Board of Governors International Finance Discussion Paper 775.

Xiao, F., Kimball, D. (2005), Effectiveness and Effects of China's Capital Controls, China & World Economy, Volume 13, Issue 4, Pages 58-69, 2005.

Xu Mingqi (2003), East Asian economic integration: China's perspective and policy, Australia-Japan Research Centre, Asia Pacific School of Economics and Government.