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Transmission of credit risk in Asia

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Transmission of credit risk in Asia

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Dedication

To my parents

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Declaration

I hereby declare that I am the author of this thesis, that the work of which this thesis is a record have been done by myself, and that it has not previously been accepted for a higher degree.

Signed: [redacted] Date: 18. 01. 2019

Yiling Zha

Certificate

We certify that Yiling Zha has worked the equivalent of nine terms on this research, and that the conditions of the relevant ordinance and regulation have been fulfilled.

Signed: [redacted] Date: 18/1/2019

Professor David M. Power

Signed:________________________ Date: ____________________

Dr. Nongnuch Tantisantiwong

Abstract

Since the onset of the 2008 global financial crisis, significant spillover effects between the credit default swap (CDS) spreads of sovereigns and banks have been evidenced in the US and several European countries. Even though systemic risk seems more likely to be associated with banks, the role of non-financial firms in linking sovereigns and financial institutions is often crucial within Asian economies.

This thesis attempts to facilitate an understanding of the credit risk transmission in Asia by analysing data for non-financial firms. Data for three East Asia countries (i.e. China, Japan and South Korea) and two Southeast Asia countries (i.e. Malaysia and Singapore) are analysed in order to test whether geographical proximity has an influence on credit risk interdependence in Asia. In addition, this thesis uses 1-year and 5-year CDS data enabling a comparison of findings between risk assessments over different horizons. The findings of the variation of credit risk transmission should provide some insights into either direct or indirect credit risk interdependence between sovereigns, financial institutions and non-financial firms.

This thesis initially incorporates the changes in the CDS spreads of a sovereign debtor and that of domestic financial institutions and non-financial firms via a multivariate GARCH model; thus, spillovers in mean spreads as well as the volatility of spreads are considered. This analysis is then extended in a number of ways. Credit risk transmission is split to four groups: (i) *domestic intra-sectoral*, (ii) *domestic cross-sectoral*, (iii) *regional intra-sectoral* and (iv) *regional cross-sectoral*. The main findings evidence the strong credit risk interdependence exist within Asia given that shocks from common creditors such as Japan appears to spill over shocks to sovereigns and non-financial firms. Finally, this thesis uses a panel model to examine the effects of corporate and market factors on credit risk correlations. The findings from this part confirm the

significance of trade links to credit risk interdependence in Asia. Moreover, credit risk correlations increase as the time-horizon gets longer.

Chapter 1: Introduction

1.1 Introduction and background

In the history of credit derivatives development, Credit Default Swaps (CDSs) have been 'blamed for helping inflate the global credit bubble' (Stafford and Rennison, 2016). In fact, 'CDSs became popular among banks … during a credit boom that preceded the crisis' (Rennison and Childs, 2016) . Throughout a period of loose monetary policy, their usage grew such that at the end of 2007; report by the Bank of International Settlements (2008) evidenced that the outstanding gross notional value of CDSs throughout the world was US$62.2 trillion.[1] After the global financial crisis and during the Eurozone sovereign debt crisis which followed, the growth of CDS contracts fell; their outstanding gross notional value had declined to US$26.3 trillion by June 2010 in response to new regulations governing their issuance and tougher capital requirements for banks (BIS, 2010).[2] However, market investors' enthusiasm for CDSs has not disappeared. In 2016, the trading of CDSs experienced a renewed level of growth after a period of decline as market volatility bolstered investor demand for this type of derivative product. CDSs – as a distinctive asset class - have experienced ebbs and flows in their popularity, but remain a permanent feature in the menu of securities that are available to investors. Further, they are viewed as an essential component in the array of products available to investors and companies who want to manage their credit risk.

According to the International Swaps and Derivatives Association (ISDA), a CDS can be defined as a bilateral agreement designed explicitly to shift credit risk between two parties. In a CDS, one party (protection buyer) pays a periodic fee to another party

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[1] The outstanding gross national values for CDSs include the trading of single-name, index and portfolio CDS contracts.

[2] In June 2010, in order to effectively control systemic risk and reform the stability of the financial system, the Dodd-Frank Act was signed into the US federal law; it has had a direct impact on the CDS market in the US. This act introduced the Volcker Rule which aimed to restrict banks from proprietary trading (including CDS trading) in order to reduce their venture capital behaviour which supposedly caused the financial crisis. In addition, banks were required to have more capital reserves and meet stricter liquidity regulations for CDS trading according to the Basel III.

(protection seller) in return for compensation for default (or similar credit event) by a reference entity. In other words, buying a CDS contract is similar to purchasing insurance against default or some other covered credit events; the protection buyer pays a default swap premium (called CDS spreads) to the seller of protection to transfer the credit risk of the reference obligation during the life of the CDS contract.

Prior research has suggested that CDS spreads 'accurately reflect the market price of credit risk' (O'Kane and Sen, 2005, p.17). Further, researchers have argued that variations in CDS spreads represent the market's assessment of changes in the likelihood of default by the reference entity. Several possible reasons have been advanced in the literature to explain the information content of CDS spreads. One possibility could be that CDS spreads correspond to a realisable stream of cash flows depending on the occurrence of specific credit events; any change in these cash flows will be impounded into the CDS spreads assuming that the market is efficient. Another possible explanation may be that the CDS market is relatively liquid. Thus, the aggregate views of millions of investors are distilled into CDS spreads by the many thousands of transactions involving these derivative instruments which take place every day. It is hardly surprising, therefore, that the findings from prior studies such as Longstaff *et al.* (2005), Norden and Wagner (2008) and Forte and Pena (2009) suggested that CDS spreads are superior measures of credit risk compared to bond and loan spreads.

Following the global financial crisis, academic research on the measurement of credit risk from the perspective of CDS spreads has burgeoned. The findings from this relatively recent literature have reached the conclusion that 'CDSs on corporate and banking reference entities are a source of interconnectedness and contain information that may be valuable to policy-makers in measuring potential systemic risk' (Culp *et al.*, 2016, p.xii). So far, despite claims in the financial press, no empirical evidence has concluded that the trading of CDS contracts *caused* the 2008 global financial crisis, or that the booming CDS markets in different parts of the world during 2005-6 *amplified* credit shocks during the crisis (Culp *et al.,* 2016). In contrast, the findings from a great number of empirical studies have evidenced that CDS contracts helped to diversify and transfer default risk as well as 'provide anticipatory information about events other than rating actions' (Culp *et al.,* 2016, p.*vii*). However, the process whereby default risk is transferred across different entities is still not yet fully understood. This is the issue which underpins the current thesis.

The remainder of the chapter is set out as follows. Section 1.2 lists out the motivations of the thesis and the research questions that are examined in the dissertation. An overview of the contents of the thesis is outlined in section 1.3. Section 1.4 concludes the chapter.

1.2 Motivation and research questions

Because of its size and rapid growth, the performance of the CDS market is a topic that interests an increasing number of academics and practitioners. In addition, since the market is relatively new and large scale trading in CDSs is a relatively recent phenomenon, there is still a great deal unknown about these securities. This is the main motivation of the thesis and the key reason why I alighted on this topic. As stated in the previous section of the introduction, the extent to which credit risks are connected across CDS underlying references entities is still unclear; as a result, there isn't a great deal of information about linkages among CDSs – especially for those traded outside of the US and Europe. Indeed, most previous studies that have analysed CDSs have been limited to developed nations such as the US and large European countries. What remains unclear is the extent to which Asian name CDSs are interconnected and whether there is evidence of credit risk spillovers across countries in the region. Moreover, this thesis also explores whether credit risk spillovers are present within different Asian countries and in different sectors of the economy, especially the non-financial sector. Very little is known about the credit risk spillover effects within the non-financial sector since a lot of the prior literature focuses on CDSs for Sovereign debt or for bonds issued by financial institutions; in addition, credit risk spillover effects between the financial sector and the non-financial sector as well as between the sovereign debtor and the non-financial sector have not been widely studied in prior investigations. Both issues are considered in the current thesis within the context of Asian reference entities.

There is a need to understand the source of any credit risk spillover effects that may exist among Asian CDSs; specifically, is any spillover present in the mean spreads or in the volatilities of these spreads? In addition, to further our understanding of credit risk linkages between pairs of CDSs, academics are beginning to examine if the characteristics of the reference entities or the features of the market can explain any spillovers uncovered. Last but not the least, previous studies have focused on the 5-year CDS contracts while the short-term transmission of credit risk spillovers remains poorly understood. This was one motivation for analysing data about 1-year CDS contracts in the current thesis.

Drawing upon different strands of research into CDSs, this thesis empirically investigates whether any credit risk spillover effects are present among Asian CDSs. The first research question in this thesis asks whether there is any evidence of credit risk spillovers within and between different ‘sectors’ for the sample of Asian countries studied. Five Asian countries are examined in this thesis (i.e., China, Japan, Malaysia, Singapore and South Korea), where CDS data were available for three ‘sectors’: the sovereign sector, the financial sector and the non-financial sector. The investigation employs a trivariate GARCH model to examine the connectedness of CDS spread changes as well as of shocks and volatility; thus the credit risks of a sovereign debtor, financial institutions and non-financial firms are examined. The answer to this question has implications for the efficiency of Asian CDS market. Any significant findings of linkages from past to current CDS spread changes would not be consistent with the weak-form of the efficient markets hypothesis (EMH). Moreover, the answer of this question has significant implications for the transmission of credit risk within different Asian economies. The findings of significant spillover effects between the credit risks of the three types of CDS reference entities would call for a further assessment of the interconnectedness of the sovereign with financial firms, the sovereign with non-financial firms and financial firms with their non-financial counterparts within Asia.

The second research question focuses on whether any credit risk spillover effects are different between firms from different sectors/countries in the region. To explore the specific pattern of credit risk transmissions among Asian CDSs, this thesis examines credit risk spillover effects for four groups of CDSs associated with different combinations of sectors and countries; they are: (i) *domestic intra-sectoral*, (ii) *domestic cross-sectoral*, (iii) *regional intra-sectoral* and (iv) *regional cross-sectoral*. This investigation will not only extend our understanding of the credit risk interdependence of Asian CDS reference entities within a sector or a country, but also enhance our knowledge of the cross-sector or cross-country spillover effects in the data. In addition, this thesis will also characterise the dynamic linkages between Asian CDS spread changes and provide details about which firms have a wide range of influences on the credit risk spillover effects in the region. Thus, it is hoped that this thesis will contribute to a deeper understanding of the credit risk spillover effects by seeing if they vary: (i) within a sector and a country, (ii) between sectors within a country, (iii) within a sector across countries and (iv) between sectors across different countries.

The third research question asks whether various corporate and market factors are associated with credit risk correlations (as estimated from CDS spread changes). The answer to this question should shed new light on how firm-, macro-, regional- and global specific-variables impact on the correlations between CDS spread changes. In addition, the answer should also offer some key insights into the importance of potential variables that might be associated with CDS spread changes and how any association might differ across sectors and across countries. The answer should make a contribution to the field of study which looks at the information content and empirical determinants of the interconnectedness of credit risk.

1.3 Overview of the contents

The overall structure of the thesis takes the form of eight chapters. Chapter 2 contextualises the current thesis by providing background information on the global CDS markets and the economic performances of the five Asian countries studies in the current dissertation. This information about CDSs (which is primarily drawn from details about these derivatives in developed markets) should provide a backcloth against which to compare the findings from the developing countries of this thesis. In addition, knowledge about the economic performances of the countries being studied should aid our understanding about the conditions where the CDS reference entities are located.

Chapter 3 reviews the substantive literature about the various theoretical frameworks that have been developed to explain the information content of CDSs (in terms of credit risk). It also summarises the empirical evidence about credit risk spillover effects. Discussion on the theoretical framework begins by laying out the pricing model of corporate debts proposed by Merton (1974), and looks at how the probability of default is affected by various firm characteristics. Meanwhile, empirical tests of this theoretical framework of credit risk as well as its application to credit risk correlations are discussed.

As one goal of the thesis is to investigate the differences between sectoral and cross-country credit risk spillover effects for different types of CDS reference entities, the relevant literatures is split into five sub-sections: that relating to 1) the credit risk of sovereign debtors, 2) the credit risk of financial institutions, 3) the credit risk of non-financial firms, 4) credit risk interdependence of sovereigns and non-sovereigns and 5) credit risk interdependence between financial institutions and non-financial firms.

Chapter 4 considers the over-arching theory underpinning the thesis. The EMH is selected as the theoretical foundation of this study. According to this theory, CDS spread changes should not be predictable; the current thesis will test for the presence of credit risk spillovers from the past spread changes of the same CDS as well as other CDSs. Therefore, any finding of significant own-spillover or other-spillover effects would contradict the weak-form of the EMH. A description of the process whereby the sample data were obtained and a broad overview of research methods are also included in this chapter. The final part of this chapter describes the distribution of the sample CDSs and explains how specific methods are used in the research and how analyses are conducted.

The fifth chapter of the thesis presents the first empirical findings of the dissertation. In particular, this chapter begins with a preliminary analysis of the sample data. Daily CDS spread changes from five Asian countries (China, Japan, Malaysia, Singapore and South Korea) for three reference entities (the sovereign debtor, firms in the financial sector and non-financial sector companies) are investigated. Trivariate GARCH-full-BEKK models are employed to identify domestic credit risk spillover effects among the CDSs of the sovereign debtor, a nation’s financial institutions and a nation’s non-financial firms. In addition, both the 1-year and 5-year CDS spread changes are examined to build a comparison which examines whether the time horizon of the instrument affects any spillover that may be present. The findings of this chapter should answer the first research question about whether any cross-sectoral linkages are present among sovereign and firms' CDS spread changes within a country in Asia and answer the second research question about whether the cross-sectoral credit risk spillover effects are different from countries. The credit risk spillover effects within a country are examined from the perspective of CDS spread changes as well as their shocks and volatilities. In particular, any significant own-effects among credit risk spillovers would suggest that the weak-form of the EMH does not hold for this market.

Chapter 6 brings together the credit risk spillover effects for different groupings of the sample firms: 1) *domestic intra-sectoral* spillover effects, 2) *domestic cross-sectoral* spillover effects, 3) *regional intra-sectoral* spillover effects and 4) *regional cross-sectoral* spillover effects. The analysis of this chapter should also give answer to the first and the second research questions. In particular, the findings of domestic cross-sectoral credit risk spillover effects should answer the first research question about whether any linkages are between firms in different sectors within a country in Asian and the rest of the findings from Chapter 6 should answer the second research question about whether any cross-spillover effects are different between pairs of firms within a given sector from the same country, between pairs of firms within a given sector among different countries and between pairs of firms among different sectors and countries. This classification of credit risk spillover effects is examined by using bivariate GARCH-full-BEKK models for each pair of firms from different sectors and countries; it helps to identify the different credit risk spillover effects from a firm in a given sector to another firm in a different sector/country. In line with Chapter 5, both short-term and the long-term spillovers from past spread changes as well as the past shocks and volatility are analysed, respectively. The findings of Chapter 6 will highlight whether any credit risk spillovers among the sovereign debtor, the financial and the non-financial firms are sector/country specific.

Chapter 7 analyses the effects of corporate and market factors on the credit risk correlations between CDS spread changes. Thus, the last research question posed in the previous section is answered in two ways. First, Chapter 7 identifies the effects of various factors on the credit risk correlations in Asian CDSs. It also illustrates how the influences of firm-, macro-, regional- and global specific-factors vary across different sectors and countries. To maintain consistency with the rest of the thesis, analysis of credit risk correlations between CDS spread changes are also conducted separately for the above four sub-groupings as well as for each maturity of CDS.

Chapter 8 is the conclusion chapter. It supplies a summary of the main findings of the thesis, outlines a number of potential contributions made by the thesis, identifies possible limitations of the current study and provides several suggestions for future work in the area.

1.4 Implication of findings

The findings in this thesis should help to provide some support for the conceptual premise of credit risk management and credit derivative investment in a number of ways. First, any findings of credit risk spillover effects between a sovereign, financial institutions and non-financial firms should have important practical implications for policy-makers. For example, an increase in a sovereign's CDS spreads possibly may be associated with a raise of the CDS spreads of domestic financial institutions owing to transmission channels where such institutions hold government bonds, reducing domestic banks' ratings and pushing up their funding costs (BIS, 2011). Meanwhile, the sovereign's creditworthiness can deteriorate when the domestic financial sector is in destress if a nation's financial system is large compared with the government. Thus, a feedback loop may exist between a sovereign and its domestic financial sector. In addition, the taxation of domestic non-financial firms also links the credit risk of a sovereign and non-financial firms together. More importantly, the government may provide bank bailouts and these rescue programmes are likely to be funded through the future taxation of the non-financial sector (Acharya et al., 2014). Thus the magnitude, the spread and the direction of any potential credit risk spillovers are important factors, which are strongly associated with the risk of financial contagion and optimal bailout size if any. In particular, as part of this thesis investigates the transmission of credit risk by selecting any two firms to conduct a number of pair-wise analyses, the directions and magnitudes of transmission can be easily detected from different combinations of pairings for various regulatory purposes. Meanwhile, the appetite of investors may link banks' and sovereign credit risk together after rescues. Hence, the sovereign's creditworthiness carries a growing weight in the overall financial market. Thus, policy-makers also can look at spillover effects as an early warning indicator since credit risk shocks can be transmitted from the troubled country to its adjacent country and the amplification of spillover effects could result in financial contagion.

Second, employing a GARCH modelling approach, any findings of volatility spillovers may have important implications for investors, who are interested in investing in the credit derivative market. With respect to portfolio management, any findings relating to the transmission of volatility from the GARCH model considered can be used to compute the optimal weighs and the hedge ratios of a credit derivatives portfolio. For example, an investor can consider a hedged international portfolio of CDSs written on a sovereign debtor and a foreign financial institution in which this investor attempts to hedge exposure to crude CDS spreads movements. Meanwhile, the conditional volatility of the sovereign debtor, the conditional volatility of the foreign financial institution and the conditional covariance between the sovereign debtor and the financial institution, all can be obtained from the GARCH model. Thus, the estimates from the GARCH model are important inputs for investors when constructing their own desired portfolio.

From the perspective of the effects of various factors on the linking of credit risk between different Asian firms, any findings of significant effects would seem to suggest the potential transmission channels of credit risk at cross-sectoral or cross-country levels. Furthermore, the signs and the magnitudes of any significant effects should also provide useful insights for investors when designing and adjusting their investment portfolios.

1.5 Conclusion

This chapter has provided a brief introduction to the current thesis. The main research motivations and three main research questions have been outlined. In addition, an overview of the contents for the various chapters and an introduction to the implications of potential findings should help readers of the thesis understand how the dissertation fits together.

Chapter 2: Background

2.1 Introduction

The burst of the US house price bubble in early 2007 triggered the 2007-2008 global financial crisis that subsequently spread to the real economy (Brunnermeier, 2009; Shiller, 2012). The development of credit derivatives, such as the Credit Default Swap (CDS), was blamed by some to constitute the primary underlying force behind the crisis (Eichengreen *et al.*, 2012; Greatrex and Rengifo, 2010; Heise and Kühn, 2012). The sentiment towards CDSs seemed wary, as there was a sharp drop in the trading activities associated with CDSs in advanced nations. Nevertheless, this derivative attracted an increasing amount of interest from investors in emerging markets (Reuters, 2016).[3] Therefore, this thesis focuses on this type of credit derivative, namely the CDS contracts, which have grown in popularity over the last decade. The information supplied in this chapter aims to help the readers understand the nature of CDS contracts as well as the recent past economic performances of the Asian sample countries.

The remainder of this chapter is structured as follows. Section 2.2 provides a brief introduction to the CDS contracts, background information is given and the characteristics of various types of CDS contracts are discussed. Section 2.3 outlines the history and the development of international CDS markets; it includes a discussion about the size of global CDS markets in addition to these derivatives' maturities, sectors, investment grades and location of counterparties. The economic performances of five Asian countries included in this thesis are presented in section 2.4; an analysis of the key economic indicators aims to shed light on the relationship between their financial and non-financial sectors and the economic significance of their non-financial sectors. Section 2.5 concludes this chapter.

[3] For example, the notional amount of single-name CDSs with Japan and other Asian countries as their counterparties increased from US$116 billion to US$137 billion from the first half of 2015 to the second half of 2015 according the semi-annual survey data from the BIS. More details of statistics are provided in the following part of the section 2.3 in this chapter.

2.2 An introduction to CDS contracts

This section of the chapter starts with a brief description of several important elements in a CDS contract. It includes an explanation of the contract parties, the CDS spread, the definition of various credit events and the alternative settlements. It also provides an overview of the CDS baskets and the CDS indices. The uses of CDSs are discussed in the second part of this section in order to provide the readers of this thesis with a better understanding of the functions of CDSs.

2.2.1 Definition of a CDS contract

In broad terms, a CDS is a bilateral contract in which one party (i.e., the ‘protection buyer’) makes a periodic payment to another party (i.e., the ‘protection seller’) in exchange for a single contingent payment following a credit event on a specified underlying instrument (i.e., the ‘reference obligation’) (ISDA, 2014; Sundaram and Das, 2011). The ‘protection buyer’ in a CDS contract is the contract party who sells the credit risk of the ‘reference obligation’ through a series of fixed payments in a CDS contract. By contrast, the ‘protection seller’ is the contract party who buys the credit risk from the ‘protection buyer’ in that CDS contract. In addition, the reference obligation can be a credit-related obligation issued by any entity (i.e., a sovereign debtor or a firm). Thus, the trading of CDSs provides an opportunity to transfer the credit risk in an underlying obligation issued by a given entity; however, the underlying market risk still remains with the protection buyer side.

As part of a CDS contract, the protection buyer pays a default swap premium to the protection seller in order to transfer the credit risk of the reference obligation. This premium is called the CDS spread. It is expressed in terms of the number of basis points per annum of the contract’s notional amount and is usually paid quarterly; the notional amount refers to the par amount of credit protection bought or sold, and is equivalent to the amount of the debt or bond of the reference entity.[4] In theory, the fair value of the CDS spread is given approximately by $\lambda(1-\phi)$, where λ is the risk-neutral default likelihood of the reference entity and ϕ is the anticipated recovery rate in the event of default.

An important point here is that the CDS spread does not usually equal to the concept of the yield spread; the yield spread is the difference between the yield of a given underlying bond and the US Treasury yield. Of course, CDS spreads should be closely related to the bond yield spread because the cash flows from the portfolio consisting of the CDS spread and the bond yield from the same reference entity are very close to that from the risk-free bond yield. If the CDS spread is greater than the yield spread, an arbitrager will have the opportunity to profit by buying a riskless bond, going short in a corporate bond and selling the CDS written on the underlying reference entity. By contrast, if the CDS spread is less than the yield spread, the arbitrager can buy a corporate bond and the CDS contact but short a riskless bond. However, there are a number of factors which cause these two spreads to be different. For example, Junge and Trolle (2015) argue that this argument ignores the information (i.e., especially the liquidity factor), which is uncorrelated to the credit risk but is priced in the bond yield. Hull *et al.* (2004) also indicated that 'there is a counterparty default risk in a CDS (that is, there is some possibility that the seller of the CDS will default)' (p. 2,800).

To make the payoff of the CDS contracts as close as possible to the cash flows in the event of default, ISDA provides detailed guidance about the definition of 'default'.

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[4] For instance, a CDS spread of 200bps for a 5-year China sovereign debt means that the default insurance for a notional amount of US$10 million costs US$200,000 p.a. This premium is paid quarterly, i.e., US$50,000 per quarter. Therefore, the protection buyer of a CDS pays US$20,000 p.a. to the protection seller to obtain the right to sell bonds with the face value of the bonds for the face value of the bonds in the event of default. In addition, the notional amount of a CDS is also used to derive the recovery amounts in the event of a default. Because it is consistent over time; that is, the notional for a deal does not change except in limited cases that are not likely to have a significant effect on the overall measure.

Table 2.1 provides details of the definitions of these events, which are the standard occurrences covered by CDS contracts. The first two credit events take into the consideration the failure to pay a debt and bankruptcy; they are self-explanatory and are uniformly used in CDS contracts. In practice, repudiation (or moratorium), obligation acceleration and obligation default are not used in the CDSs issued for G7 (i.e., Canada, France, Germany, Italy, Japan, UK and US) corporate bonds; although repudiation (or moratorium) is included in the context of credit events in emerging markets.[5]

Table 2.1: Description of credit events

No.	Credit Event	Description
1	Failure to pay	This is subject to a materiality threshold (the amount due must be at least some specified minimum) and a stated period (usually three days).
2	Bankruptcy	The corporation becomes insolvent or unable to meets its debts, obviously, there is less relevant for sovereign bonds.
3	Repudiation/ Moratorium	The borrower declares a moratorium on serving the debt or repudiates the debt.
4	Obligation acceleration	The obligation becomes due on account of non-financial default.
5	Obligation default	The obligation becomes capable of being due and immediately payable.
6	Restructuring	This is a ‘soft’ credit event.

Note: This table reports the classification of credit events. Restructuring is a soft credit event and differ according to the clauses of CDS contract types and trading regions.

The restructuring clause in a CDS contract according to the ISDA (1999) is now called an Old-R; it triggers protection if one of the following happens: 1) There is any reduction in interest or principal payable, 2) There is a postponement of interest or principal payable, 3) There is a change in the priority of the reference obligation, and 4) There is a change in the currency of payment. In 2001, in an attempt to limit the scope of

[5] In contrast to the corporate market, the sovereign bond market only has a limited number of defaults and restricting events-does not provide enough experience from realised defaults.

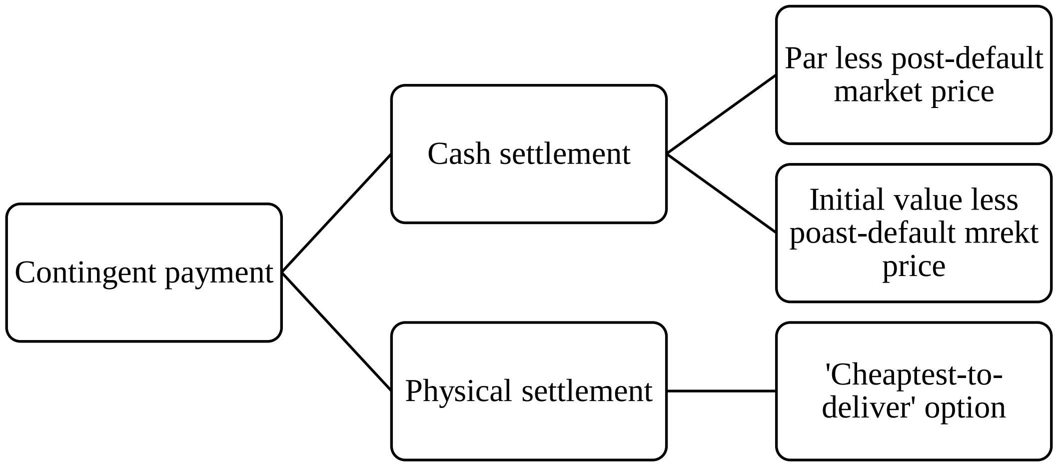
opportunistic behaviour by sellers in the event of restructuring agreements that did not cause loss, the ISDA published a modified restructuring (i.e., Mod-R) clause; it was introduced for the North American derivative market. Since 2003, reference may be made to four choices concerning restructuring: 1) Old restructuring (i.e., Old-R), 2) Modified restructuring (i.e., Mod-R)[6], 3) Modified-modified restructuring (i.e., Mod-Mod-R)[7] and 4) No restructuring (i.e., No-R). Mod-Mod-R was introduced in 2003 for the European derivative market and the last No-R refers to a CDS contract, which excludes restructuring as a credit event. In particular, the Mod-Mod-R clause of CDSs is the most commonly traded clause in European and Asian derivative markets.

One feature of a CDS contract is that there are two different ways to terminate the contract in the event of default: *cash settlement* and *physical settlement*. Figure 2.1 illustrates the settlement alternative in CDS contracts. For instance, if the protection buyer chooses cash settlement to terminate CDSs, the protection seller makes a cash payment to the protection buyer; the amount of payment is equal to the loss in value on account of the credit event. There are two different ways to measure the value of the default debt obligation; the initial value could either be the par value of the default debt obligation or the initial value of the debt obligation at the inception of that CDS. Thus, the amount of cash settlement is the par value or the initial value of the debt obligation minus the market price of the obligation in the event of default. By contrast, a physical settlement requires the protection buyer to deliver the defaulted underlying debt to the protection seller in order to receive the par value of the underlying debt obligation. There is one difference between cash and physical settlement, namely the fact that the protection buyer in the physical settlement has a 'cheapest-to-deliver' option. In other words, the protection

[6] Under the Mod-R clause from CDS contracts, the maturity of the reference entity's deliverable obligations following a restructuring is limited to a remaining of a maximum of 30 months.
[7] Under the Mod-Mod-R clause from CDS contracts, the maturity of the reference entity's deliverable obligations is 60 months for restricted bonds and loans, or, 30 months for other deliverable obligations.

buyer can deliver any debt obligation of the defaulting entity that ranks *pari passu* with the reference obligation. This ‘cheapest-to-deliver’ option sometimes becomes valuable (i.e., when credit events contain restructuring), such as the Conseco case.[8]

Figure 2.1: Settlement alternatives in CDS contracts



Sources: Sundaram and Das (2011).

Up to this point, the discussion has focused on the various elements of a CDS contract. In general, the CDS contracts that reference one underlying reference entity are referred to as called single-name CDSs, while the CDS contracts that reference more than one reference entity are referred to as multi-name CDSs. An overview of the most popular

[8] Conseco is a financial institution operating insurance services in the US. In early 2000, its financial position deteriorated, which resulted in a downgrade to its credit rating. Conseco decided to draw on backstop facilities to improve its liquidity and to generate cash. At the end of 2000, Conseco had improved operation and accumulated US$450 million to redeem its back facilities and to repay its back loan. To avoid bankruptcy, Conseco obtained a 15 month extension from its bank to repay its loan; the bank allowed Conseco to repay the outstanding debt of US$450 million in full as well as to extend the maturity of the remaining amount of US$900 million by 15 months in exchange of higher interest rates and some collateralisation. Under the definition of old ‘restructuring’, a restructuring credit event had occurred; since the old ‘restructuring’ defined an action of postponement of interest of the principal payment as a default event. Therefore, investors who had bought the credit protection via CDSs could terminate the contract and get the cash flow back. Investors could choose physical settlement and choose the ‘cheapest-to-deliver’ option in exchange of the par value of Conseco’s debt obligations. Meanwhile, Conseco’s short-term debt obligations were traded at around 92% face value due to improved firm performance, but its long-term debt obligations were trading only at around 70% of their values. Therefore, the protection buyers delivered Conseco’s long-term debt obligations to the protection sellers, which resulted in losses of over US$60 million to the protection seller. Thus, the Mod-R clause of CDSs was introduced in 2003 to protect the protection sellers of CDSs. In North America, most CDSs that have investment grade reference entities are traded in Mod-R.

multi-name credit derivatives, such as the *first-to-default* (FTD) basket and CDS indices, are briefly introduced below.

A basket CDS is written to transfer the credit risk of a number of reference entities; there are typically 5-10 underlying reference entities within a basket. Buying a basket CDS is similar to how a single-name CDS deals. The protection buyer pays to the seller a periodic payment to receive a full recovery of the notional amount (i.e., US$10 million) in the event of default. The premium on a basket CDS is a multiple of the individual CDS spreads. In an FTD basket, if any of the reference entities experiences a credit event, the protection seller pays the full notional amount to the protection buyer. Meanwhile, the protection buyer delivers the default reference entity's debt, which is US$10 million at face value. From the standpoint of the buyers, the FTD basket provides an opportunity of inexpensive hedge against defaults on a portfolio; as the protection buyer does not need to buy individual credit protection for each underling debt. If the protection buyer thinks that two or more defaults are likely to occur on the portfolio, then a *second-to-default* or an n^{th}*-to-default* basket is preferred. By contrast, the protection seller sells the protection of a basket CDS with much lower potential losses. Since the likelihood of credit events in a CDS basket is higher than that in a single-name CDS contract, as a consequence, this increases the fair value of the CDS spread. Therefore, as Sundaram and Das (2011) stated 'the FTD basket swap can be viewed as a basket of CDSs with a knock-out feature' (p. 791).

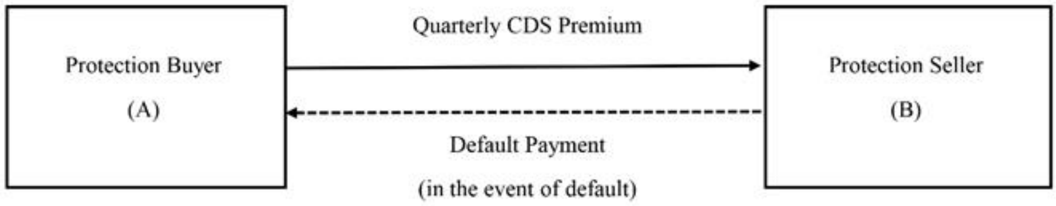
Another popular multi-name CDS product is represented by credit indices. Credit indices are similar to equity indices in some aspects; for example, credit indices are obtained by aggregating CDS spreads, just as equity indices are obtained by aggregating individual equity prices. However, a striking difference between equity indices and CDS indices is that CDS indices have maturity. In other words, if all the CDSs underlying the index have 5-year maturities, a 5-year CDS index is obtained. However, a 'rolling' CDS index can be constructed by changing underlying debts; thus, a benchmark CDS index for a given maturity (i.e., 5-year index) can be obtained. Each index is 'rolled' every six months; rolling is the process whereby old CDSs are replaced by new CDSs, therefore each roll increases the maturity of the 'on-the-run' indices by six months. There are two major families of credit indices: the CDX indices and the *iTraxx* indices. The CDX indices cover underlying debts issued from North America and emerging markets, while the *iTraxx* indices cover Europe and the rest of Asia. In particular, sub-indices referencing on sectors, geography and ratings are available from each of the credit indices, respectively. For example, *iTraxx* Europe is a benchmark index for the European investment-grade market. 125 equally-weighted CDSs on European investment-grade underlying debts constitute it; two-thirds of the reference entities from the UK, France and Germany. The most popular maturities in the trade of these indices cover 3-, 5-, 7- and 10-year CDSs.

2.2.2 Uses of CDSs

The trading features of a CDS makes the analogy with an insurance contract of limited use since the buyer of a CDS need not own any underlying security or have any credit exposure to the reference entity that needs to be hedged. Therefore, CDSs provide an 'alternative vehicle for expression of negative credit views' (Sundaram and Das, 2011, p. 783). This section discusses various uses of CDSs in order to provide readers with an understanding of how investors' credit expression and the default risk of an entity are linked together. In particular, three types of CDS usages are listed, namely 1) A naked CDS, 2) A typical CDS and 3) A CDS chain.

As shown in Figure 2.2, in a naked CDS contract, the CDS buyer can buy a CDS contract from the protection seller without holding the reference obligation. From the standpoint of a 'naked CDS buyer', a CDS enables a 'naked CDS buyer' of the derivative gain either from the protection seller on the date of the credit event or from a sale at an improved CDS spread (Markose *et al.*, 2010).[9] Therefore, a naked CDS is a speculative instrument because the buyer of a naked CDS can find an opportunity to buy CDSs in low CDS spread and take a *short* position of the underlying debt obligation. By contrast, from the perspective of a CDS seller, selling a CDS contract provides an opportunity to speculate on the default probability of the reference entity due to the loose regulation of reserve requirements at the initial stage of the development of the CDS market.[10]

Figure 2.2: A naked CDS



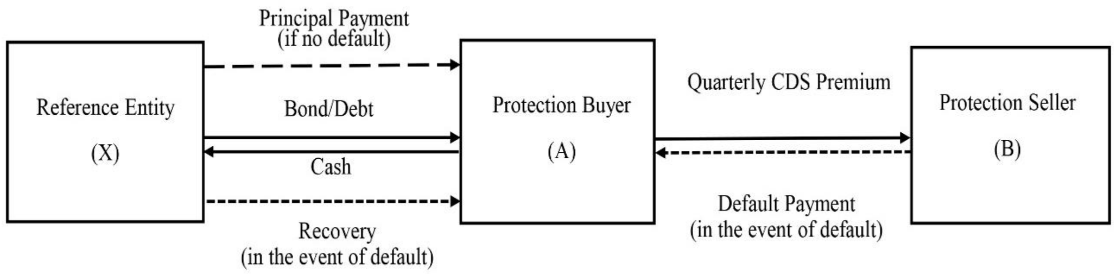
Note: This figure presents the simplified trading procedures associated with a naked CDS contract. Direction of arrows indicates the transfer of payment; the unbroken arrow shows the direction of compulsory premium payment to buy a CDS contract and the broken arrow bellowing implies the payment of default from the contract seller to buyer; transfer of payment only occurs in the event of default, otherwise, no payment back.

Compared with a naked CDS contract, in a typical CDS contract, the buyer of a CDS is the underlying debt holder; this means that investors with a buy position hold the reference obligation and seek credit risk protection through a CDS contract from a protection seller. Figure 2.3 illustrates the structure of a typical CDS contract. When a reference entity, X, issues its debt obligations, either in the form of a loan or bonds to the public, market investors who would like to take on the credit exposure of X can purchase

[9] It has been widely noted that naked CDS buyers even with no insurable interest will gain considerably from the bankruptcy of the reference entity (Markose *et al.* 2010). By giving up exposure to the reference entity's credit risk, the buyer effectively passes up on the opportunity to profit from the exposure to the possibility that the reference entity may default (Stulz, 2010).
[10] Unlike the insurance market and the regulated banking sector, a non-bank AAA rated CDS contract seller need not hold reserves to meet the payoff of a credit event. The main CDS dealers have been known not to post initial collateral and to only post a mark-to-market variation margin, which in a default style situation can imply abrupt jumps in the additional collateral needed for a CDS and its spreads.

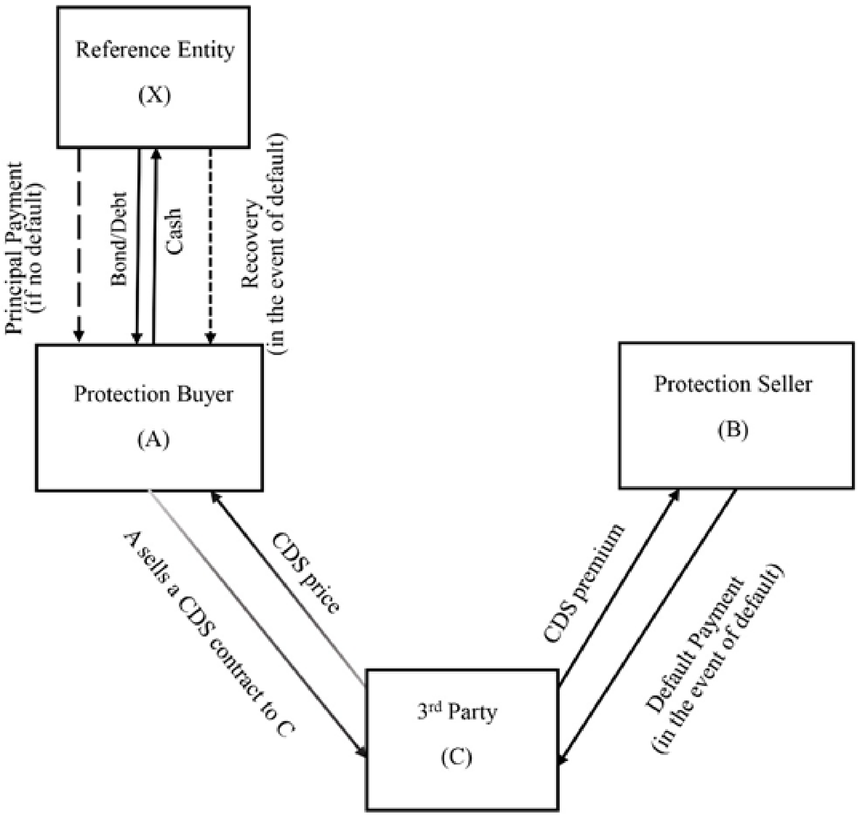
these underlying debts; the reference entity sells public debts to market investors by receiving cash from its creditors. Investors who bear the credit risk of the reference entity can transfer it by buying a CDS contract from a CDS seller; a CDS buyer pays a regular (i.e., quarterly) CDS premium to the protection seller to buy the guarantee of a full payment of the reference obligation. For example, at the maturity date of the underlying obligation, the CDS buyer should be able to get the principal payment of the debt back from the reference entity if there is no credit event associated with the debt issuer. However, even in the event of default, the protection buyer can recover the payment from the reference entity and the default payment from the protection seller. By contrast, a sell position with a CDS contract allows the investor to speculate on the possibility that a default event will occur. Therefore, both buyers and sellers of CDS contracts have the opportunity to speculate on any reference entity.

Figure 2.3: A typical CDS



Note: This figure presents a typical CDS contract trading procedures by adding a reference entity in a naked CDS contract. A reference party can be a corporate, a government or other legal entity who issue debt of any kind.

Figure 2.4: A CDS chain



Note: This figure illustrates a CDS chain which displays an inter-linkage of counterparts in CDS contracts. The 3rd party, C, is a naked CDS buyer who needs not to own the debt of the reference entity.

As one would expected, derivatives markets are not as simple as their exchange market counterparties due to the various connections among derivatives as well as their external connection with other markets. This complexity is shown in Figure 2.4, which illustrates the possibility that the CDS protection cover on a reference entity has been sold on to a third party. Under this circumstance, the third party, C, who is holding a naked CDS buyer position (e.g., C does not own the debts or bonds of the reference entity X), buys the aforementioned CDS contract from A. To continue this contractual relation, C is on due to pay CDS premiums to the protection seller B, while the original protection buyer (A) stops the contract with B, but still holds the underlying assets of the reference entity. It is important to remember that in Figure 2.4, when a naked CDS buyer enters into a CDS contract between an original protection buyer and a seller, only the CDS is transferred, not the reference obligation; A is still the holder of X's debts while C holds nothing but the CDS contract itself.

As stated, a naked CDS buy position is equivalent to shorting the reference entity's bonds without the problems of a short squeeze that raises the recovery value of the bonds (and lowers the payoff on the CDS) when the naked CDS buyer has to 'buy back' at the time of the credit event (Markose *et al.*, 2010). Moreover, a naked CDS buyer (i.e., C) has an incentive to make profits by expecting the credit event on the reference entity (X); that means that C can short X's stock to trigger its insolvency in order to collect the default payment from the protection seller (B). Hence, a naked buying may be combined with the shorting stock of the reference entity. As a consequence, this will harm the reference entity's facial and cash flow position, which raises a negative view of the creditworthiness of the reference entity and increases the price of CDSs.

Indeed, there is also the case that even those CDS buyers who have exposure to the default risk on the debt of the reference entity may find it more lucrative to cash in the protection payment on the CDS with the default of the reference entity rather than continue holding its debt. Furthermore, an event of cross-default occurs if a counterparty of a CDS chain cannot make the payment in a specified time frame. Therefore that counterparty is deemed to have defaulted across other CDSs and these cross-defaults can trigger a domino effect, which harms financial stability (Cont, 2010).

In summary, CDSs enable stripping out and transferring the credit risk of a debt obligation to a separate party and provide another vehicle to express the direction view of credit risk, since the size of the CDS spreads is a reflection of the default probability and recovery rate. However, Münchau (2010) argued that ‘Naked CDSs are the instrument of choice for those who take large bets against European governments, most recently in Greece… using CDSs to destabilise a government that was ‘counter-productive’… unfortunately, it is legal’ (p.1). In November 2012, the European Parliament and its members agreed to a permanent ban on naked sovereign CDS contracts in order to control the after-event effects of the Euro debt crisis. However, the IMF (2013) argued that there was little evidence to support that sovereign CDSs had been out of line with sovereign bond spreads and the evidence did not support the need to ban purchases of naked sovereign CDS protection. The European sovereign CDSs ban is still debatable today.

2.3 Development of global CDS markets

In the 1990s, an increase in the number of bond issuers across the global debt market and illiquidity in loan markets resulted in a demand for credit risk protection so as to create synthetically short and long positions through credit derivatives. Credit derivatives were first proposed via a Master Agreement for Over-the-Counter (OTC) derivatives transactions at a conference of the International Swaps and Derivatives

Association[11] in 1992. The ISDA also put forward this Master Agreement for OTC derivatives transactions internationally; it had many options and was accompanied by standard forms.[12] In 1995, one of the first CDS contracts was introduced by JP Morgan; it provided protection on Exxon's debts against credit default by the European Bank for Reconstruction and Development.[13]

Tables 2.2 to 2.6 illustrate the development of global CDS markets associated with market sizes, maturities, sectors, investment grades and the location of counterparties from 2004 to 2015. The Bank for International Settlements released semi-annual data on CDS contracts from the end of December 2004 including notional amounts outstanding and gross market values for single-and multi-name instruments.[14] For CDS contracts, the notional amounts outstanding refer to the gross nominal or notional value (equivalent to par amount of debt or a bond) of all deals conducted (credit protections bought or sold) and not yet settled on the reporting date.[15] Thus, the notional amount outstanding is a measure of the overall CDS market size; as it is used to derive the periodic premium payment and the recovery amounts in the event of a default. Therefore, the

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[11] The International Swaps and Derivatives Association was founded in 1985 and its aim is to devise standardised agreements and to render over-the-counter derivatives markets safe and efficient.

[12] The Master Agreement is a document agreed between two parties by setting out all the standard terms, which can be applied to all the transactions entered into by the two parties involved; it is designed for the purpose of fully and flexibly documenting all the details involved with the OTC derivatives. A typical document consists of a Master Agreement, a schedule, confirmations, definition booklets, and a credit support annex. After the first version of the Master Agreement in 1992, the ISDA developed subsequent versions of the documentation in 2004 and 2008.

[13] The underlying reasons behind the creation of credit derivatives at this particular time are varied; for example, the increased number of bond issuers in the global debt market and illiquidity in loan markets resulted in the demand of credit risk protection so as to create synthetically short and long positions through credit derivatives. Furthermore, from the perspective of regulatory bodies, CDSs were useful for allowing banks to meet the special capital requirements specified by the Basle Accords.

[14] Data are sourced from the BIS's semi-annual survey of OTC derivatives markets; central banks and other authorities in 13 global countries (Australia, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom and the United States) constitute the participating authorities. According to the BIS (2013), the semi-annual survey captures about 96% of the global OTC derivatives activity.

[15] It is observed that double-counting arises because transactions between two reporting entities are recorded by each of them, which means twice. Therefore, double-counting is eliminated by deducting half of the amount reported under the counterparty category 'reporting dealers'. Reporting dealers refers to the organisations whose head office is located in one of the 13 reporting countries; they are mainly commercial and investment banks and securities houses.

section of the chapter discusses the development of global CDS markets from the perspective of their notional amounts outstanding.

Table 2.2 reports the size of the global CDS market from the standpoint of the trading amount for all types of CDSs; particularly, the trading amount of total CDSs, single-named CDSs and multi-named CDSs, respectively. The H1 and H2 in the second columns of the table represent the first and the second half of a given year, respectively. The statistical data in Table 2.2 reveals a number of interesting findings. First, the notional amount of the total CDS contracts outstanding reveals that the global CDS market expanded exponentially from US$6,396 billion in 2004 to US$57,894 billion in the second half of 2007; in particular, the notional amount of the total CDS contracts doubled from US$28,650 billion in 2006 to US$57,894 billion in the second half of 2007. This growth in the CDSs trading volume may have been associated with a rise in the demands for a low-cost means of taking on credit exposure, since CDS spreads are expressed as basis points of the contract notional amount. In addition, the increase in the amount of CDS traded also implied that credit risk was gradually changing from being relatively illiquid (e.g., that was not considered suitable for trading) to a risk that can be stripped out and traded in the market through CDSs (Stulz, 2010). Another feature of the market during 2005 was that the proportion of the single-named CDSs dropped from 80.00% of the total CDSs in the second half of 2004 (i.e., US$5,117 billion out of US$6,396 billion) to 55.70% at the end of 2007 (i.e., US$32,246 billion out of US$57,894 billion). Thus, there was an increase in the popularity of multi-named CDSs since the notional amount outstanding of multi-named CDSs grew by a factor of 20 from US$1,279 billion at the end of 2004 to US$25,648 billion at the end of 2007. A possible explanation for this change suggested by the BIS(2008) is that banks started to employ credit derivatives to handle credit risk (i.e., unwanted loan risk) through a strategy of diversification across a large number of borrowers (i.e., the underlying reference entities of multi-named CDSs).

By the second half of 2007, the notional amount of the total CDSs outstanding for the sold position exceeded the total CDSs for the bought position; this was the first time that this situation occurred because ‘insurance firms showed a high growth rate (89%) as purchasers of the protection sold by the reporting dealers’ (BIS, 2008, p.1). In fact, the notional amount outstanding for the sold position was US$1,238 billion greater than that for the bought position (i.e., US$45,626 billion for the sold and US$44,298 billion for the bought position). The increased trading in multi-named CDSs may have contributed to this increase because the notional amount of multi-named CDSs for the sold position was US$1,140 billion greater than that for the bought position (i.e., US$20,885 billion compared with US$19,745 billion). However, the situation was reversed over the next 6 months during the first half of 2008; the notional amount of total CDSs outstanding for the sold position became US$1,298 billion less than that for the bough position (i.e., US$44,555 billion for the sold and US$45,853 billion for the bought position).

Thirdly, the notional amount outstanding of the total CDS contracts dropped to US$57,325 billion in the first half of 2008 and this decline continued in the following years; for instance, the notional outstanding for CDSs over the entire period of 2008 dropped to US$41,883 billion. One reason for this decline could be that a lot of financial institutions and corporations became financially distressed during the 2008 global financial crisis triggering CDS protections, which resulted in contract settlement. The continued decrease in the notional amounts of CDSs outstanding after 2009 may have been due to a decline in market appetites for this derivative, and can be partially explained by the continuing efforts towards portfolio compression by the reporting dealers (BIS, 2009). Portfolio compression is a netting method operated by the central clearing house to clear standardised CDS contacts. According to BIS's records, the notional amount of CDSs declined by 21% among the reporting dealers in 2009. For instance, BIS (2013) stated that 'central clearing made further inroads in the CDS market in 2013' (p.5). The shrinkage of the size of the total CDS market continued from 2010; for example, it declined from US$25,069 billion at the end of 2012 to US$12,294 billion at the end of 2015.

According to Table 2.2, single-name CDS contracts still dominate the market. They account for 61.67 % on average of the overall CDS market over the examined period as opposed of multi-name CDS contracts, which only represent 38.38 %[16] of the contacts entered into over the course of the last decade. These results highlight the importance of single-name CDS contracts and indicate the important position of single-named CDSs in the whole CDS markets. As a result, the current thesis focuses on single-named CDSs in order to investigate the credit risk spillovers in terms of CDS spreads changes between different individual entities. Tables 2.3 to 2.5 demonstrate the growth of global single-named CDS contracts; in line with the reporting approach adopted for Table 2.2, data are shown for different levels of remaining maturity (in Table 2.3), by sectors (in Table 2.4), for different investment grades (in Table 2.5) and according to the various locations of CDS counterparties (in Table 2.6).

The development of three types of CDS contracts is presented in Table 2.3. In general, CDS contracts with maturities between 1-year to 5-year tenor dominated the global CDS market. In mid-2008, the total notional amount of 1-year to 5-year CDSs outstanding was US$21,812 billion, while that of CDSs with less than 1-year maturities was only US$2,786 billion. This finding is not surprising because 5-year CDSs were

[16] This is calculated by the average of the market share for single-name CDS contracts on a semi-annual basis from 2005 to 2015.

Table 2.2: Size of the global CDS market from 2009 to 2015

Year		Notional Amounts Outstanding in Billions of US Dollars								
		Total Contracts			Single-name CDSs			Multi-name CDSs		
		Bought	Sold	Total	Bought	Sold	Total	Bought	Sold	Total
2004	H2	4,653	4,495	6,396	3,732	3,698	5,117	920	797	1,279
2005	H1	7,659	7,405	10,211	5,521	5,428	7,310	2,138	1,977	2,901
	H2	10,672	10,174	13,908	7,882	7,737	10,432	2,790	2,437	3,476
2006	H1	15,729	15,232	20,352	10,646	10,448	13,873	5,082	4,784	6,479
	H2	22,571	22,372	28,650	14,463	14,401	18,885	8,108	7,971	9,953
2007	H1	32,979	32,917	42,580	18,543	18,020	24,239	14,436	14,897	18,341
	H2	44,298	45,626	57,894	24,554	24,740	32,246	19,745	20,885	25,648
2008	H1	45,853	44,555	57,325	26,610	25,812	33,334	19,243	18,743	23,991
	H2	33,879	33,038	41,883	21,079	20,480	28,740	12,800	12,558	16,143
2009	H1	27,995	27,235	36,046	19,057	18,604	24,112	8,938	8,631	11,934
	H2	25,512	24,898	32,693	17,599	17,219	21,917	7,913	7,679	10,776
2010	H1	23,247	22,789	30,261	14,487	14,366	18,379	8,760	8,422	11,882
	H2	22,768	22,228	29,898	14,188	13,854	18,145	8,580	8,374	11,753
2011	H1	25,182	24,575	32,409	14,493	14,429	18,105	10,690	10,146	14,305
	H2	22,889	22,369	28,633	13,811	13,658	16,881	9,078	8,710	11,752
2012	H1	21,619	21,059	26,931	12,871	12,707	15,566	8,748	8,352	11,364
	H2	19,844	19,373	25,069	11,711	11,629	14,309	8,133	7,744	10,760
2013	H1	19,257	18,820	24,349	10,886	10,808	13,135	8,371	8,013	11,214
	H2	16,223	15,850	21,020	9,292	9,248	11,324	6,931	6,602	9,696
2014	H1	14,779	14,224	19,462	8,639	8,464	10,845	6,140	5,760	8,617
	H2	12,227	11,889	16,399	7,123	7,037	9,041	5,104	4,852	7,358
2015	H1	10,764	10,333	14,594	6,399	6,263	8,205	4,365	4,070	6,389
	H2	9,072	8,673	12,294	5,526	5,408	7,183	3,546	3,264	5,110

Note: This table reports notional amounts outstanding of CDSs from the second half of 2004 to 2015. Data sourced from the Bank for International Settlements (2004-2015).

assumed to be the most liquid CDS contracts according to prior studies (Calice *et al.*, 2013). However, the notional outstanding of short-term CDSs (i.e., one year or less than one year CDSs) has surpassed that of over 5-year CDSs at the end of 2011. The notional amount outstanding of short-term CDSs was US$3,408 billion compared with US$2,142 billion for the CDSs having over 5 years' maturities. This has implied that the liquidity of short-term CDSs has been improved recently and the gap between the notion amount outstanding of short-term and 5-year CDSs is becoming small.

Table 2.4 highlights that the single-name CDS market has grown in all three different sectors, namely the sovereign sector, the financial sector and the non-financial sector. Several findings emerge after conducting an analysis of the notional amount outstanding of single-named CDSs in these three sectors. First, CDSs referencing non-sovereign sector obligations dominated the single-name CDS market. In particular, the contract notional values of the outstanding amount consistently increased during the first half of 2005 and climbed to its first small peak (i.e., US$5,562 billion) in mid-2008. However, this segment decreased up to the second half of 2010 (i.e., US$3,917 billion). A possible explanation for this initial growth is the growth of single-named CDSs referencing the non-financial sector mainly due to the popularity of the securitisation of subprime mortgages over the course of 2007; thus some commentators suggested that the growth of the securitised debt market increased the demand for the CDS contracts written on these debts (Stulz, 2010). However, after the meltdown of the US real estate, during the 2008 global financial crisis, the attitude of investors changed, and the bankruptcy of a number of large financial institutions led to a reduction in the market participants, who bought and sold CDSs (Markose *et al.*, 2010).

In the first half of 2011, the notional amount outstanding in single-named CDSs for the non-financial sector peaked (i.e., US$10,188 billion for total CDSs), which represented around 66% of all single-name CDS contracts in the first half of 2011. Since then, the size of the non-financial single-name CDS market has declined consistently but without experiencing any dramatic falls; this was down to US$3,585 billion at the end of 2015.

The figures presented in Table 2.5 show the distribution of reference entities for single-named CDSs according to their ratings. In general, single-named CDSs referencing investment grades were the most commonly traded credit derivatives since the end of 2004. For example, the notional amount of single-named CDSs referencing investment grade firms reached its peak (i.e., US$13,024 billion) in mid-2010; the notional amount for higher quality entities was three times greater than that for CDSs involving entities below the investment grade (i.e., US$4,151 billion) and more than nine times greater than the single-named CDSs written for the non-rated entities (i.e., US$1,362 billion).

As the main aim of the dissertation is to study the credit risk spillovers in Asia, Table 2.6 illustrates the location of CDSs (include single-named and multi-named CDSs) counterparties from 2013 to 2015; information about the location of CDS counterparties started to become available on the BIS data platform from 2013. Panel A of Table 2.6 reports the notional amount outstanding of single-named CDSs with home country counterparties (i.e., the protection buyer and the protection seller locate in the same country), while the second panel reports the notional amount outstanding of single-named CDSs with foreign counterparties (i.e., the protection buyer and the protection seller locate in two different countries). A number of findings emerge from the table. Firstly, the total notional amount of single-named CDSs outstanding has declined over the period for which data are available, from US$4,744 billion in the first half of 2013 to US$2,894 billion in the second half of 2015. This finding is in line with the results from Table 2.2, or in other words the global CDSs market has declined after the 2008 global financial

Table 2.3: Development of the global single-name CDSs from 2004 to 2015, by remaining maturities

Year		Maturity								
		One year or less			One to 5 years			Over 5 years		
		Bought	Sold	Total	Bought	Sold	Total	Bought	Sold	Total
2004	H2	312	275	426	2,812	2,866	3,845	608	556	845
2005	H1	445	345	535	3,841	3,951	5,126	1,235	1,130	1,649
	H2	621	402	688	5,623	5,764	7,497	1,638	1,571	2,247
2006	H1	911	765	1,087	7,084	7,110	9,272	2,651	2,574	3,514
	H2	1,201	1,065	1,444	8,508	8,669	11,101	4,018	3,898	5,334
2007	H1	1,530	1,408	1,893	11,200	11,179	14,566	5,812	5,432	7,780
	H2	1,590	1,512	2,003	16,033	16,397	20,896	6,931	6,831	9,346
2008	H1	2,294	2,150	2,786	17,511	17,275	21,812	6,805	6,388	8,736
	H2	1,866	1,794	2,277	13,286	12,973	16,272	5,926	5,713	7,191
2009	H1	2,056	2,014	2,601	12,522	12,343	15,868	4,479	4,248	5,644
	H2	1,999	1,909	2,421	11,594	11,416	14,465	4,005	3,894	5,031
2010	H1	1,830	1,813	2,320	9,964	9,927	12,627	2,758	2,682	3,547
	H2	1,802	1,800	2,252	9,926	9,680	12,716	2,461	2,375	3,176
2011	H1	2,157	2,152	2,659	10,026	10,072	12,555	2,325	2,212	2,907
	H2	2,833	2,820	3,408	9,208	9,180	11,315	1,757	1,657	2,142
2012	H1	2,965	2,927	3,508	8,579	8,522	10,432	1,327	1,257	1,626
	H2	2,923	2,908	3,519	7,923	7,900	9,725	856	821	1,065
2013	H1	2,654	2,618	3,158	7,320	7,247	8,817	912	943	1,160
	H2	2,124	2,134	2,565	6,621	6,599	8,059	548	515	700
2014	H1	1,845	1,830	2,305	6,249	6,142	7,827	545	492	713
	H2	1,530	1,527	1,922	5,179	5,134	6,576	413	376	543
2015	H1	1,352	1,327	1,657	4,580	4,555	5,925	467	381	605
	H2	1,437	1,407	1,803	3,768	3,737	4,972	320	264	408

Note: This table reports notional amounts outstanding of CDSs by remaining maturities from the second half of 2004 to 2015. Data sourced from BIS(2004-2015).

Table 2.4: Development of global single-name CDSs from 2004 to 2015, by sector

Year		Sector								
		Sovereigns			Financial institutions			Non-financial firms		
		Bought	Sold	Total	Bought	Sold	Total	Bought	Sold	Total
2004	H2	124	122	172	353	365	482	851	899	1,197
2005	H1	133	149	206	490	493	689	1,163	1,167	1,604
	H2	873	880	1,258	479	432	598	841	818	1,064
2006	H1	476	466	641	638	631	830	1,219	1,212	1,543
	H2	868	774	1,101	713	659	924	1,562	1,576	1,993
2007	H1	1,276	995	1,490	1,203	1,057	1,487	2,262	2,238	2,864
	H2	1,449	1,425	1,838	1,884	1,759	2,501	3,800	3,703	4,886
2008	H1	1,659	1,641	2,177	2,286	2,124	3,016	4,270	4,179	5,562
	H2	1,277	1,282	1,651	2,686	2,728	3,322	2,907	2,795	3,912
2009	H1	1,324	1,314	1,761	2,903	2,923	3,691	2,354	2,259	3,308
	H2	1,496	1,497	1,943	2,488	2,629	3,235	2,350	2,259	3,273
2010	H1	1,869	1,844	2,393	2,481	2,668	3,319	2,909	2,842	4,019
	H2	2,013	2,028	2,542	2,377	2,583	3,209	2,748	2,668	3,917
2011	H1	2,308	2,278	2,749	4,184	4,237	5,168	8,000	7,914	10,188
	H2	2,536	2,484	2,928	3,668	3,703	4,434	7,595	7,469	9,504
2012	H1	2,468	2,406	2,848	3,471	3,508	4,162	6,932	6,792	8,556
	H2	2,424	2,386	2,799	3,157	3,198	3,853	6,130	6,045	7,657
2013	H1	2,734	2,668	3,098	2,679	2,696	3,202	5,472	5,423	6,836
	H2	2,198	2,167	2,514	2,373	2,402	2,859	4,721	4,679	5,950
2014	H1	2,188	2,150	2,587	2,307	2,292	2,831	4,143	4,023	5,427
	H2	1,969	1,928	2,354	1,755	1,731	2,143	3,399	3,378	4,544
2015	H1	1,821	1,787	2,221	1,525	1,444	1,845	3,053	3,032	4,140
	H2	1,570	1,540	1,941	1,351	1,277	1,657	2,605	2,592	3,585

Note: This table reports notional amounts outstanding of CDSs by sector from the second half of 2004 to 2015. Data sourced from BIS(2004-2015).

Table 2.5: Development of global single-name CDSs from 2004 to 2015, by investment grades

Year		Investment Grade								
		Investment Grade (AAA-BBB)			Below Investment grade (BB and below)			Non-rated		
		Bought	Sold	Total	Bought	Sold	Total	Bought	Sold	Total
2004	H2	1,388	1,405	1,866	196	187	264	146	123	199
2005	H1	1,643	1,681	2,250	351	354	480	365	296	471
	H2	5,642	5,549	7,316	1,028	1,029	1,469	1,212	1,159	1,647
2006	H1	7,426	7,241	9,330	1,362	1,445	2,002	1,858	1,762	2,542
	H2	8,206	8,143	10,529	1,895	1,941	2,481	3,625	3,548	4,870
2007	H1	11,934	11,806	15,685	2,417	2,427	3,248	4,192	3,788	5,307
	H2	15,249	16,071	20,659	3,751	3,716	5,011	5,553	4,954	6,576
2008	H1	17,380	17,218	22,155	5,535	5,343	6,756	3,789	3,314	4,501
	H2	13,736	13,636	16,967	4,672	4,100	5,492	2,671	2,744	3,281
2009	H1	12,585	12,400	16,082	3,986	3,975	5,152	2,486	2,229	2,878
	H2	12,018	11,767	14,949	3,500	3,510	4,521	2,081	1,942	2,446
2010	H1	10,152	10,056	13,024	3,272	3,289	4,079	1,121	1,077	1,390
	H2	9,632	9,494	12,631	3,405	3,337	4,151	1,151	1,023	1,362
2011	H1	9,685	9,637	12,366	3,210	3,273	3,812	1,613	1,526	1,943
	H2	9,084	9,062	11,405	3,297	3,261	3,825	1,417	1,333	1,635
2012	H1	8,637	8,548	10,693	2,852	2,857	3,224	1,382	1,301	1,649
	H2	7,811	7,747	9,712	2,463	2,455	2,830	1,437	1,427	1,767
2013	H1	7,437	7,383	9,150	2,196	2,193	2,490	1,253	1,232	1,495
	H2	6,720	6,720	8,369	2,052	2,049	2,350	519	480	605
2014	H1	5,931	5,845	7,546	1,749	1,739	2,129	959	880	1,169
	H2	4,754	4,717	6,059	1,331	1,327	1,676	1,037	993	1,306
2015	H1	4,456	4,362	5,751	1,405	1,406	1,778	539	459	676
	H2	3,660	3,567	4,774	1,076	1,070	1,410	790	771	999

Note: This table reports notional amounts outstanding of CDSs by investment grades from the second half of 2004 to 2015. Data sourced from BIS(2004-2015).

Table 2.6: Development of global single-name CDSs from 2013 to 2015, by counterparties' locations

Year		Home country		
		Bought	Sold	Total
Panel A: Counterparties located in home country				
2013	H1	3,686	3,606	4,744
	H2	3,069	2,954	4,091
2014	H1	2,857	2,685	3,734
	H2	2,596	2,459	3,423
2015	H1	2,600	2,502	3,510
	H2	2,179	2,101	2,894

Panel B: Counterparties located in abroad

Year		Abroad								
		US and European developed countries			Japan			Other Asian countries		
		Bought	Sold	Total	Bought	Sold	Total	Bought	Sold	Total
2013	H1	11,704	14,403	18,143	172	163	196	111	85	187
	H2	12,278	12,024	15,357	141	130	162	100	77	170
2014	H1	11,049	10,695	14,187	132	112	151	101	74	148
	H2	8,854	8,711	11,617	102	86	117	84	59	127
2015	H1	7,487	7,225	9,941	106	87	116	67	39	100
	H2	6,242	5,968	8,293	121	100	137	69	42	102

Note: This table reports notional amounts outstanding of CDSs by counterparties' locations from the second half of 2004 to 2015. Data sourced from BIS(2004-2015).

crisis. Secondly, by comparing the figures in Panel A and Panel B, it is obvious that the US along with other advanced European countries dominate the single-named CDS market. For example, the total notional amount of single-named CDSs with counterparties from the US or developed European countries as their counterparties was US$18,143 billion in the first-half of 2013. However, this amount declined dramatically by two thirds to US$8,293 billion at the end of 2015. This finding is not surprising due to the reduction in CDS trading activities during that period.

Thirdly, the tiny figures for single-named CDSs with counterparties from Japan and other Asian countries highlight how small this market is - at about 20% of its US and developed European counterparties. However, an upward trend is identified during 2015 because of the increasing notional amount of single-named CDSs with Japan and other Asian countries as their counterparties. For example, this figure increased from US$116 billion to US$137 billion for single-named CDSs with Japan as their counterparties in 2015. This finding implies that Japanese CDS dealers (i.e., Japanese financial institutions) have played increasing role in linking and transmitting counterparty risk via CDS contacts. Although small, this neglected part of the global CDS market warrants further investigation, with the scope of the current dissertation attempting to fill this gap.

2.4 Economic performance of five Asian countries

Substantive literatures (Aretz and Pope, 2013; Baum and Wan, 2010; Constancio, 2012; Shen *et al.*, 2015) have highlighted the importance of macro-economic variables on CDS markets; for example, Baum and Wan (2010) provided a valuable insight into the significant effects of the variation in the macroeconomic factors' uncertainty on CDS spreads. Their findings suggested that variation in the GDP growth rate was statistically significant in determining the CDS spreads. In particular, Aizenman *et al.* (2013b) noted that 'there is strong evidence that high market default risk … are partly attributable to deteriorating fundamentals'(p. 53). This section assesses a range of economic indicators in order to provide some context for the economic conditions of the five Asian countries.

The five Asian countries analysed are grouped into two different groups according to their geographical locations. Mainland China, Hong Kong SAR, Japan and South Korea are grouped together as East Asia. Malaysia and Singapore are grouped together as Southeast Asia. In particular, Hong Kong SAR, China and mainland China are legally referred to as the People's Republic of China. However, due to the 'One country, two systems' policy of the Chinese government, as well as the different income levels of those two regions, the economic performances of these two regions are reported separately in this section. One reason behind this decision is that the World Bank classifies Hong Kong SAR as a high-income 'country', while the macroeconomic data for mainland China is located in the upper middle income level group of countries. Therefore, this leads to macroeconomic data for six region entities being displayed in this section; Table 2.7 illustrates the key economic indicators analysed from 2009 to 2015 for the East Asian countries, while Table 2.8 displays the same variables for the Southeast Asian countries.

A number of interesting findings emerge from Table 2.7. First, it is not surprising that the inflation rate in 2009 was not optimistic in East Asia due to the global recession after the financial crisis year 2008; most of the analysed countries were experiencing an economic deflation in 2009. This was more prominent in Japan (i.e., -1.35 %). Although South Korea was experiencing economic inflation, the rates of inflation (i.e., 2.76% in 2009) were relatively lower than the previous levels (i.e., 4.72% in 2008). In particular, Japan has been experiencing a long period of economic deflation during the period 2009 to 2012; its worst level in 2009 was -1.35%. However, the negative inflation rate of Japan became positive in 2013 (i.e., 0.35%) and reached its peak in 2014 (i.e., 2.67%). However, the total reserves of mainland China and Japan were considerably higher than those of

Hong Kong SAR; mainland China held a total reserve of US$3,405.25 billion, while Japan had US$1,233.10 billion in 2015, respectively.

Secondly, one of the most important economic factors in the right section of Table 2.7 is the ratio of central government debt to its GDP because it provides a view of the credit risk of sovereign debt. It is evident that the share of central government debts to GDP in Japan was continuing to increase from a level of 158.42 in 2009 to 197.95 in 2015. In particular, the central government debt was almost two times that of the Japanese GDP in 2015. This may due to the high deflation of the Japanese economy in recent years and this high level of central government debt to its GDP may also drive up the demand of the credit risk protection of Japanese sovereign bonds. Therefore, this extremely high ratio of government debt on the nation's GDP provides a possible explanation to the growth of CDSs with Japan as their counterparty in Table 2.6.

Thirdly, the positive current account balances of mainland China, Hong Kong SAR, Japan and South Korea imply the current account surplus in all of these 'countries'; in Hong Kong SAR, the ratio of current account to GDP peaked at 9.88% in 2009 but dropped to 3.32% in 2015. In addition, the proportion of the foreign direct investment (FDI) as shares of GDP in Hong Kong SAR continually grew from 27.88 in 2013 to 58.51 in 2015; the upward trend of the shares of FDI in Hong Kong SAR implied a strong interdependency between Hong Kong SAR and foreign countries. By contrast, mainland China, Japan and South Korea received a related limited FDI to their respective GDP; the ratio for FDI in the Japanese GDP steeply decreased from 0.23% in 2009 to 0.13% in 2015.

Fourthly, the levels of ranges for the shares of domestic credit to private sector to GDP, the exports (%GDP) and the imports (%GDP) in Hong Kong SAR were the highest

Table 2.7: Key economic indicators of East Asian countries

Country	Year	Indicator Values		Shares of GDP (% of GDP)					
		Inflation (%)	Total reserve (US$ billion)	Current A/C	Gov. debt	Domestic credit to private	Foreign direct investment	Exports	Imports
Mainland China	2009	-0.70	2,452.90	4.76	32.56	124.21	2.56	24.36	20.15
	2010	3.31	2,909.91	3.90	33.09	126.30	3.99	26.27	22.62
	2011	5.41	3,254.67	1.80	33.09	122.75	3.70	26.49	24.11
	2012	2.62	3,387.51	2.52	34.02	128.50	2.82	25.41	22.70
	2013	2.63	3,880.37	1.54	36.93	133.80	3.03	24.50	22.06
	2014	2.00	3,900.04	2.25	39.83	140.15	2.56	24.08	21.57
	2015	1.44	3,405.25	2.75	42.92	152.55	2.19	21.97	18.49
Hong Kong, SAR	2009	0.63	270.44	9.88	33.98	155.43	25.36	178.14	170.26
	2010	2.25	292.14	7.00	36.23	185.58	36.17	205.32	199.45
	2011	5.26	306.93	5.56	N/A	202.29	38.68	212.85	209.00
	2012	4.07	327.72	1.58	N/A	198.53	28.51	215.85	214.72
	2013	4.35	345.69	1.52	N/A	218.16	27.88	221.61	221.01
	2014	4.49	362.83	1.39	N/A	233.21	44.55	213.09	212.89
	2015	2.97	366.71	3.32	N/A	207.89	58.51	195.88	193.50
Japan	2009	-1.35	1,051.65	2.78	158.42	180.23	0.23	12.52	11.97
	2010	-0.72	1,096.07	3.88	161.60	173.53	0.13	15.04	13.58
	2011	-0.27	1,295.84	2.10	177.49	172.90	0.01	14.92	15.47
	2012	-0.05	1,268.09	0.97	185.12	175.08	0.01	14.54	16.09
	2013	0.35	1,266.85	0.90	187.42	180.21	0.21	15.92	18.23
	2014	2.67	1,260.68	0.75	193.43	180.54	0.41	17.55	20.01
	2015	0.79	1,233.10	3.06	197.95	181.57	0.13	17.64	17.96
South Korea	2009	2.76	270.44	3.72	33.58	144.53	1.00	47.55	42.86
	2010	2.94	292.14	2.64	32.99	135.93	0.87	49.42	46.23
	2011	4.03	306.93	1.55	33.71	138.13	0.81	55.75	54.25
	2012	2.19	327.72	4.16	33.88	136.69	0.78	56.34	53.55
	2013	1.30	345.69	6.22	36.67	134.91	0.98	53.88	48.90
	2014	1.27	362.83	5.98	38.39	138.36	0.66	50.28	45.02
	2015	0.71	366.71	7.66	39.74	140.07	0.30	45.34	38.38

Note: Data sourced from the World Bank (2009-2015) and the National Bureau of Statistics of the People's Republic of China (2009-2015).

in the East Asian region. The domestic credit to private sector (%GDP) in Hong Kong SAR ranged from 155.43- 207.89% from 2009 to 2015. Moreover, the economy of Hong Kong SAR heavily depended on exports and imports trade; the exports (% GDP) for Hong Kong SAR were 195.88% in 2015 compared to 21.97% for mainland China and 17.64% for Japan.

Table 2.8 reveals a number of findings from the economy of two Southeast Asian countries. First, the Malaysian inflation fluctuated from 2009 to 2015; it peaked in 2011 (i.e., 3.20%) but dropped to 1.65% in the next year and continually grew to 3.17% in 2014. A similar pattern was evident in Singapore from 2009 to 2013. Second, the range of total reserve in Malaysia was not as high as that in Singapore and that in the four East Asian 'countries'; the total reserve of Malaysia ranged from 96.70-95.28% during the period 2009 to 2015. Meanwhile, a low level of the ratio of central government debt to GDP was identified for Malaysia during this time span; the range of this ratio was from 50.84-54.46% for Malaysia compared with 107.34-107.21% for Singapore. Thirdly, as one would expect, the economy of Singapore heavily depended on exports and imports trade due to the geographical advantages of this region; the exports (% GDP) ranged from 192.17% in 2009 to 177.93% in 2015 and the imports (% GDP) ranged from 168.76% in 2009 to 152.01% in 2015. However, an economy that is heavily reliant on the imports and exports trades may suffer when the credit default risk is associated with a devaluation of goods. If a devaluation of goods occurs, financial institutions and holders of domestic corporate debt will suffer as their asset values fall. Consequently, domestic companies suffer as their credit risk increases; this is particularly harmful for smaller business, as banks reduce the available amount of loans (Bremus and Neugebauer, 2018).

Table 2.8: Key economic indicators of Southeast Asian countries

Country	Year	Indicator Values		Shares of GDP (% of GDP)					
		Inflation (%)	Total reserve (US$ billion)	Current A/C	Gov. debt	Domestic credit to private	Foreign direct investmen t	Exports	Imports
Malaysia	2009	0.58	96.70	15.72	50.84	111.61	0.06	91.42	71.14
	2010	1.71	106.53	10.06	49.56	107.12	4.27	86.93	71.01
	2011	3.20	133.57	10.90	50.03	108.43	5.07	85.26	69.68
	2012	1.65	139.73	5.19	51.65	114.12	2.83	79.30	68.54
	2013	2.10	134.85	3.47	53.00	119.90	3.49	75.63	67.09
	2014	3.17	115.96	4.39	52.68	120.58	3.14	73.79	64.52
	2015	2.08	95.28	3.06	54.46	125.15	3.33	70.60	62.95
Singapore	2009	0.60	192.05	16.85	107.34	97.74	12.38	192.17	168.76
	2010	2.80	231.26	23.44	102.90	96.22	23.30	199.75	173.70
	2011	5.25	243.80	22.15	106.21	106.13	17.84	203.29	176.31
	2012	4.53	265.91	17.38	110.04	115.29	19.45	197.19	173.77
	2013	2.38	277.80	16.91	101.11	126.14	21.38	194.16	171.80
	2014	1.01	261.58	19.74	101.78	130.92	24.01	193.43	168.87
	2015	-0.50	251.88	18.11	107.21	127.03	23.78	177.93	152.01

Note: This table presents key economic indicators analysed from 2009 to 2013. Data sourced from the World Bank (2009-2015).

2.5 Conclusion

This chapter sought to provide an overview of how the CDSs are operated and how the CDS markets have developed in the past decade. It also aims to give readers better background information related to the economic performance of the Asian countries analysed in this dissertation. It is clear that the CDS contracts have provided a vehicle tool to express market appetite on credit risk and facilitated a different way to trade and transfer credit risk. Although the trading of CDSs related to Asian countries was limited in the past, the CDS spread is still vital to analyse the credit risk of a given underlying entity.

Chapter 3: Literature review

3.1 Introduction

Finance conventionally distinguishes two kinds of risk: market[17] and credit. Credit risk is 'the risk that promised payments of an obligation (e.g., a bond or a loan) will not materialize' (Sundaram and Das, 2011, p.771). It has two components: the risk of default on the underlying obligation and the risk of incomplete recovery in the event of default. Default happens when firms cannot, or choose not to, meet their financial obligations (Duffie *et al.*, 2003); when a default occurs, there is a chance that some of the funds owed will not be recovered. Typically, holders of such financial obligations receive a premium associated with the likelihood of default and the possibility of non-recovery of funds; they get a higher yield than the yield of an obligation with a lower possibility of default as compensation for bearing this credit risk. The credit spread or the extra yield on an obligation with default risk over a risk-free benchmark was a key measure of a firm's credit risk before the development of credit derivatives (Collin-Dufresne *et al.*, 2001; Merton, 1974).

As a result of the significant growth of credit derivatives and the greater availability of CDS data, an increasing number of academic studies have analysed credit risk from a credit derivative perspective (particularly using CDS spreads). A number of studies (Baba and Inada, 2009; Blanco *et al.*, 2005; Chan-Lau and Kim, 2005; Longstaff *et al.*, 2003) have examined the price discovery relationship between bond spreads and CDS spreads. Empirical evidence from this group of studies suggests that CDS spreads capture changes in default risk earlier than bond spreads in advanced economics, but no particular market dominates in emerging markets. Another stream of academic research (Hull and White, 2000a; Hull and White, 2000b; Jarrow and Turnbull, 1995; Miyakawa

[17] Market risk is 'the risk of changes in prices of various sorts' (Sundaram and Das, 2011, p.771), for example, changes in equity prices, interest rates, bonds prices and so on.

and Watanabe, 2014) has focused on the credit risk pricing models from CDS spreads. For example, research in this area has utilised CDS spreads to derive an entity's probability of default (PD), the findings suggesting that the conventional Merton's (1974) model under-predicted the PD (Chan-Lau, 2003; Han and Jang, 2013; Hilscher and Nosbusch, 2010). A related but separated group of studies has reported that an increased level of credit risk spillover effects existed between European sovereigns and banks during and after government bailout programmes; there is a two-way feedback relationship between the credit risks of sovereigns and banks (Acharya *et al.*, 2014; Alter and Beyer, 2014; Alter and Schüler, 2012). Another small group of studies has investigated credit risk transmission between financial and non-financial firms using CDS spreads, the findings evidencing that lending and borrowing activities between financial and non-financial firms create a credit risk transmission channel between these two groups of firm; in particular, non-financial firms which have a multinational borrowing relationship with foreign banks are less likely to be affected the default risk of a bank in their own country.

This chapter discusses a number of relevant studies regarding credit risk from the development of theoretical credit risk pricing models to empirical studies of credit risk spillover effects in the real world. Section 3.2 outlines various theoretical frameworks of credit risk pricing models starting with the classical Merton (1974) model followed by the valuation approaches to credit risk using CDS data. The probability of default, the 'loss-given-default' and the credit exposure are the three main factors in credit risk, but the discussion of the credit risk pricing models in the current chapter focuses on the probability of default because it is the systematic risk component of credit risk (i.e., the underlying factor that generates risk premia).[18] As one of the current thesis's main aims is to identify and examine credit risk spillover effects using Asian CDS spreads, section 3.3 summarises empirical tests for the presence of any credit risk spillovers from a number of investigations based on CDS spreads; the discussion of the findings should provide a comprehensive review of evidence regarding i) the credit risk of the sovereign sector, ii) the credit risk of the financial sector, iii) the credit risk of the non-financial sector, iv) credit risk spillover effects between sovereigns and firms and v) credit risk spillover effects between financial institutions and non-financial firms. A conclusion to this chapter is presented in section 3.4.

3.2 Theoretical frameworks of credit risk pricing

This section begins with a description of the model developed by Merton (1974) and then reviews a number of credit risk pricing models that have subsequently used CDS spreads. In general, there are two types of credit risk pricing models: those which rely on structural approaches and those which adopt reduced-form approaches[19]. One of the most important structural models developed by Robert Merton (Merton, 1974) proposed a valuation approach to corporate debt based on the Black-Scholes (1973) option pricing model by characterising an equity claim as a call option on the value of a firm's assets, with the strike price being equal to the book value of debt at maturity. This characterisation is combined with a distance-to-default model in order to estimate a firm's

[18] Most credit risk pricing models assume that the 'loss-given-default' or the recovery rate is more related to the seniority of debt and the market value of collateral and less responsive to the systematic risk components of credit risk. Meanwhile, credit exposure measures the direct loss that a lender will suffer when its borrower or counterparty defaults. For instance, Lipton and Rennie (2013) considered the exposure at default (EAD) as another component which can affect credit risk for a banking system under Basel II. The Federal Deposit Insurance Corporation (FDIC) defined EAD 'as the bank's expected gross dollar exposure of the facility upon the obligor's default' (FDIC, 2003, p.46).

[19] Approaches which built on the Black-Scholes (1973) and Merton (1974) models are classified as structural models in the literature. Reduced-form approaches were first introduced by Duffie and Singleton (1999) and relied on rather advanced mathematical techniques, and specified the likelihood of default exogenously without necessarily referencing an underlying firm value or capital structure.

probability of default. The success of Merton (1974) promoted a growth in credit risk pricing frameworks. Further developments in this area have employed an alternative estimation framework for the valuation of firm assets (Vassalou and Xing, 2004; Zhou, 2001b), inferred new formulas to estimate a firm's default risk from CDS spreads (Hull and White, 2000a; Hull and White, 2000b; Subrahmanyam *et al.*, 2009; Zhang *et al.*, 2009), or adopted a macro-prudential perspective by incorporating exogenous economic factors into the conventional pricing model (Costeiu and Neagu, 2013; Jang *et al.*, 2016). In order to provide a step-by-step review of these pricing approaches, section 3.2.1 introduces the classic Merton model (1974) and its further development to credit risk using CDS data, while section 3.2.2 evaluates various CDS-based reduced-form models to assess credit risk.

3.2.1 The Black-Scholes-Merton default model

Merton (1974) proposed the distance-to-default (D-to-D) approach to price corporate debt. The Merton (1974) model assumed that a firm has equity and only a single issue of a zero-coupon bond with a maturity of time T. Thus, the value of a firm's assets is equal to the sum of its equity market value and its risky debt. In addition, the default of a firm can only happen on date T, which means that no covenants can trigger the default of the firm before the maturity date. Finally, it assumed that the debt holders of the firm must be paid in full before the equity holders receive any dividends.

Under these assumptions[20], the value of a firm's equity can be treated as a European call option on the value of firm's assets which are assumed to follow a geometric Brownian motion. On date T, there are two possibilities when the firm's debt (D) matures: the firm will not default if $V_A \geq D$; otherwise, default will occur. In other

[20] Classic structural models such as Merton's (1974) model are based on the assumption that markets are frictionless. For instance, these models typically assume that: 1) there are no transaction costs or taxes, 2) assets are perfectly divisible and traded continuously and 3) there are no borrowing and short-selling restrictions (Merton, 1974).

words, if the value of a firm's assets are enough to repay the amount due to its debt holders, the debtor holders will get the full payment that they are owed and equity holders get the rest or the balance. In addition, the probability of default for a firm in a risk-neutral probability[21] measure can be obtained:

$$PD = N(-d_2) = N\left(-\frac{ln\left(\frac{V_{A,t}}{D}\right)+\left(r-\frac{\sigma_A^2}{2}\right)(T-t)}{\sigma_A\sqrt{T-t}}\right) \quad (3.1)$$

Where a *PD* denotes the probability of default if the firm's assets value falls below the respective book value of its liabilities in period *t* for a horizon of *T*. It is clear from this expression that the probability of default depends on the market value of a firm's assets (V_A), the market value of a firm's book liabilities (D) and the volatility of the firm's assets value (σ_A). It also supposes a negative relationship between a firm's probability of default and the market value of its assets, while a positive relationship exists between the firm's probability of default and the volatility of the market value of its assets. In other words, firms which have volatile assets are expected to have a shorter distance between their assets value and the debt barrier, and a shorter *D-to-D* is associated with a higher credit risk.

3.2.2 CDS-based models

Having explained how to examine the credit risk of a firm using a set of observable firm-level data using structural models, this section moves on to discuss recent studies about how to derive the probability of default of a firm using CDS spreads from the standpoint of reduced-form models. Reduced-form models were introduced and developed by Jarrow and Turnbull (1995) and Duffie and Singleton (1999). The main difference between structural and reduced-form models is that default is *endogenously* derived from a number of specific conditions under a structural framework model,

[21] The risk-neutral probability is derived by assuming investors are risk-neutral and desire no risk premia.

whereas a reduced-form model defines default as an *exogenous* stochastic process of the time to default. In other words, a structural model assumes that a firm's asset value is the sum of its equity and debt values and that default occurs when a firm's asset value drops below its debt value. Conversely, a reduced-form model assumes that a firm's default time is unpredictable but the probability of default can be estimated from its debt prices, such as debt market data and CDS spreads. Therefore, the input information required in reduced-form models is less refined than in the case of structural models, as one fundamental assumption under structural models is that the modeller has continuous information on the firm's balance sheet and financial positions in order to compute its probability of default. Since the aim of this thesis is to analyse the transmission of credit risk by using CDS data, the remainder of this discussion will focus on credit risk pricing models from the perspective of CDS spreads.

There are several advantages to using CDS data instead of bond spreads in order to measure credit risk. First, CDS contracts are available for a wide universe of firms and exist for sovereign bond issuers, as well as for firms in emerging markets (Chan-Lau, 2006). Thus, the availability of CDS data makes it possible to overcome one of the difficulties associated with structural models, namely how to derive the probability of default for a sovereign debtor who does not have equity information. For example, Chan-Lau (2003, 2005) used CDS spreads to measure the credit risk of sovereign debtors. Second, 'no arbitrage' arguments support the notion that CDS spreads should be equal to the spreads on a par floater, but many factors may cause a divergence from this idealised situation in practice, such as the fact that the bonds may not be trading at par, differences in coupon convention payments, as well as the treatment of coupons in the event of default (Chan-Lau, 2006; Sundaram and Das, 2011).

With data for both CDS spreads and bond spreads, academics have sought to answer the following question: ‘which instrument captures the changes in default risk first?’ Empirical evidence in advanced economics suggests that CDS spreads capture the initial changes in default risk more quickly than bond spreads, because the liquidity in the CDS market exceeds that of the bond market (Blanco *et al.*, 2005; Chan-Lau, 2006; Chan-Lau and Kim, 2005). Furthermore, the calculations from extracting the probability of default from bond data usually require an assumption about the claim amount by debt holders in the event of default. For example, Jarrow and Turnbull (1995) and Hull and White (1995) suggested that the claim amount was equal to the value of a no-default bond, while Duffie and Singleton (1997) assumed that the claim amount in the event of default was equal to the value of the bond immediately prior to the date of default. However, Jarrow and Turnbull (2000) indicated that the assumption about the claim amount in a number of studies did not correspond to the way bankruptcy laws work in most countries. In contrast, using CDS data avoids this issue and makes it possible to set the payoff from a CDS contract in the event of default to be equal to the face value of the reference obligation minus its market value just after default. In other words, the CDS spreads (i.e., the payment made for credit risk protection) heavily depend on the default probabilities of the reference obligor and the expected recovery rate (Chan-Lau, 2006).

The main underlying assumption behind CDS-based frameworks of credit risk is that the present value of the payment made by the protection buyer on the CDS contract should be equal to the present value of the receipts from the protection seller to the protection buyer in the event of default (Duffie and Singleton, 2012; Hull and White, 2000a; Hull and White, 2000b). Therefore, it is analogous to paying an annuity at a varying rate (i.e., CDS spreads) and this annuity stream is paid until the maturity of the CDS or the date of credit events, whichever comes first.

Beginning with a CDS contact with one period of payment from the protection buyer to the protection seller, Chan-Lau (2006) presented the relationship between a firm's CDS spreads, the probability of default and the expected recovery rate. As assumed in equation (3.15), a CDS spread should be equal to the present value of the expected loss of the protection seller from a one-period CDS contract with a unit notional amount in the absence of market frictions:

$$A\ CDS\ spread = \frac{PD(1-RR)}{1+r} \qquad (3.2)$$

where *PD* is the probability of default, *RR* is the constant expected recovery rate at default and *r* is the risk-free rate. In particular, it is common to use a constant recovery rate based on historical averages in practice; for example, 40% is applied on a standard CDS contract under the ISDA specification (ISDA, 2009). Equation (3.15) also implies a negative relationship between the probability of default and the expected recovery rate; the higher the firm's probability of default, the lower the expected recovery rate because debt holders can claim full payment (i.e., 100 percent recovery rate) from the firm if no default occurs. Therefore, a high CDS spread is usually associated with a high default probability and a low recovery rate.

Hull and White (2000a) and Duffie and Singleton (2012) illustrated more generally how to extract the *PD* from a CDS contract with maturity *T*:

$$Spread_{(T)} = \frac{B(\lambda,T)}{A(\lambda,T)}(1-RR) \qquad (3.3)$$

$$PD(T(i)) = 1 - e^{-\lambda T(i)} \qquad (3.4)$$

where, $Spread_{(T)}$ denotes the CDS spread and it is paid in periods *T(i),i= 1…n, T=T(n).* *A(λ,T)* is the price of an annuity of one unit paid at each coupon date until default or maturity, *T=T(n)*, whichever comes first. *B(λ,T)* represents the value of a payment of one unit at the first coupon date after default and equation (3.16) assumes that the default date is before the maturity data, *T=T(n)*. λ is the hazard rate and *RR* is the expected recovery rate. In equation (3.17), *PD(T(i))* represents the default probability in period *T(i)*. Thus, the probability of default can be derived using the available data on the risk-free yield curve and the expected recovery rate.

Although the advantages of reduced-form models are not to be ignored, there are still several shortcomings to these models. For example, reduced-form models do not allow modellers to rigorously quantify the effects of possible changes in public policies on individual or aggregate behaviour. In addition, reduced-form models are characterised by their flexible functional form, which may lead to strong in-sample fitting properties but a poor performance of the out-of-sample predictive ability, as reduced-form models heavily depend on mathematical frameworks but are associated to a lesser extent with the economics driving default (Arora *et al.*, 2005). Furthermore, the interpretation of results from reduced-form models is difficult and it is premature to explain the findings without performing a set of empirical tests.

3.2.3 Correlated credit risk frameworks

The discussion of the previous two subsections has provided an overview of credit risk pricing models with reference to both structural and reduced-form models. These models have demonstrated the valuation process of credit risk under a single-name reference entity, hence the current subsection extends these models by considering the correlated default risk under multi-name reference entities. Since the main aim of this current thesis is to investigate credit risk transmission, theoretical frameworks underpinning the correlated credit risk between different entities should help to understand the scenario and channels of credit risk transmission. In particular, this study also aims to examine credit risk spillover effects and credit risk correlations using CDS data, hence the discussion of this subsection will focus on prior studies that have used CDS spreads in order to examine the transmission of credit risk.

Zhou (2001a) was one of the first researchers who attempted to develop an analytical formula to compute default correlations for a given pair of firms. He assumed that the default correlation between two different firms depends on their credit statuses at time *t*. In general, assuming the independence of default events, the default correlation between two firms can be defined as:

$$\rho_{ij}(T) = \frac{E[D_i(T) \cdot D_i(T)] - E[D_i(T)] \cdot E[Q_j(T)]}{\sqrt{Var[D_i(T)] \cdot Var[D_j(T)]}} \quad (3.5)$$

where $\rho_{ij}(t)$ is the default correlation between firm *i* and firm *j* over a given horizon *T*. $D_i(t)$ and $D_j(t)$ are the expected credit status of firm *i* and the expected credit status of firm *j*, respectively. For example, there are four possible outcomes considering the credit statuses of both firm *i* and firm *j* together: 1) no defaults, 2) only firm *i* defaults, 3) only firm *j* defaults and 4) both firm *i* and firm *j* default. Hence, equation (3.18) indicates that the default correlation for a given pair of firms depends on the probability of default of firm *i*, the probability of default of firm *j* and the joint default probability of both firm *i* and firm *j*. Unsurprisingly, the joint default probability of default is the key input to compute the credit risk correlation between firm *i* and firm *j*.

As previously stated, the probability of default can be derived from either a structural model or a reduced-from model. Under the assumption of conventional structural models, a firm's probability of default is associated with a number of firm-level factors, such as its asset value and volatilities. Hence, Das *et al.* (2006) claimed that '[T]he correlation between [the] PDs of two firms will depend on the correlation between the underlying determinants of the default probabilities: correlations between individual firm debt levels, firm returns, and firm volatilities' (p.5). In other words, the co-movement of common factors driving default risk should help to explain credit risk correlation. In order to identify the variation of credit risk correlations, Das *et al.* (2006) employed a cross-sectional dataset covering almost all US public non-financial firms between January 1987 and October 2000. The findings from Das *et al.* (2006) evidence a time variation in credit risk correlations; in particular, the variation pattern of credit risk correlations is similar to that of firm volatility correlations, while the correlation of asset returns is stable over time. In addition, the findings pertaining to the cross-sectional difference of high-grade, medium-grade and low-grade credit risk correlations indicated that the volatility of high-grade correlations increases more during a period of economic stress.

In contrast, reduced-form models assume that the trading purpose of credit derivatives, such as CDSs, is to exchange price and quote information. Under this assumption, Hull and White (2000b) mapped a continuous measure of a firm's creditworthiness as a function of the discrete credit rating of a firm *i*. Following the CreditMetrics framework of Morgan (1997), Hull and White (2000b) assumed that the joint default risk is some function of the credit rating of a given pair of firms. The findings of Hull and White (2000b) indicate that the default correlation depends on the life of a multi-named CDS contract; in other words, for a given joint probability of default, the credit risk correlation increases as the life of a multi-name CDS contract[22] increases as a result of the influence uncertain future predictions exert on the instrument. Furthermore, they also found that the probability of joint default increases as the credit quality of a given pair of firms decreases; for instance, the estimated default correlation between a given pair of firms under a 5-year contract increases from 0.35 to 0.43 when their associated credit rating drops from AAA to BBB.

[22] The life of a CDS contract does not always be equal to its maturity, as an event of default can happen before the date of maturity.

The development of credit risk pricing models implies that there are a number of factors, such as asset value, leverage level and jump risk of asset values affecting a firm's credit risk. Although the contribution of these pricing models cannot be underestimated, they have given rise to a number of concerns in the literature. For example, several empirical studies, such as Franks and Torous (1989), Campbell and Taksler (2003) and Eom *et al.* (2004), provide empirical evidence that conventional credit risk pricing models underestimate credit risk especially for high credit-rated firms with low levels of leverage and volatility; therefore, it is difficult to align the predictions from these asset pricing models with actual credit spreads. In addition, these models have assumed a frictionless market in order to derive a firm's credit risk. In the real world, the market is not perfect and there are various market frictions, such as the prohibition of short selling and the impact of investors' shifting appetite for credit risk (Kumar and Persaud, 2002). Therefore, an examination of the efficiency of CDS markets serves as a basis for further investigations, and this is particularly important for emerging market countries, such as those in Asia, since the presence of any firm's own credit risk spillovers in a firm's CDS spreads or in its spreads volatility is indicative of market inefficiency. Hence, one aim of this current thesis is to test the efficiency of Asian CDS markets in terms of both the changes in CDS spread and the volatility of CDS spread changes.

3.3 Empirical studies on credit risk transmission

After investigating numerous theoretical frameworks referring to credit risk pricing models, this section reviews an increasing number of empirical studies focusing on credit risk spillover effects and the subsequent contagion effects. One prominent study that is often cited in the research on financial contagion is that of Allen and Gale (2000), who found that strong spillovers from a distressed region during a banking crisis will cause another crisis in its adjacent region, which has claims on the distressed region.

When the adjacent region's claims on the distressed region fall in value, the crisis may pass from region to region and thus become a contagion. However, the definition of spillovers is unclear in the study of Allen and Gale (2000), which leads to a difficulty in measuring and quantifying the effects of spillovers. Further studies, such as Alter and Beyer (2014), have suggested that spillover effects can be defined as 'the transmission of unexpected but identified shocks from one variable to other variables in the system' (p.147). Thus, the credit risk spillover effect generally refers to the transmission of unexpected but identified credit shocks from one variable to other variables in the system.

In order to provide a comprehensive review of the research conducted on credit risk spillover effects, this section discusses prior studies that investigated these effects associated with the credit risk of the sovereign sector, the financial sector and the non-financial sector. The remainder of this section is structured as follows: sections 3.3.1 to 3.3.3 emphasise the findings of the empirical analysis with reference to the credit risk interdependence in the sovereign sector, the financial sector and the non-financial sector, respectively. Section 3.3.4 illustrates the transmission of credit risk between the sovereign sector and the non-sovereign sector (including both financial and non-financial firms), while the discussion on the transmission of credit risk within the non-sovereign sector is presented in section 3.3.5.

3.3.1 Credit risk of sovereigns

A considerable amount of literature has been published regarding the evaluation of sovereign CDS spreads during the time of both the US global financial crisis and the European sovereign debt crisis. Studies have analysed contagion effects among government bond defaults during the recent global financial crisis and the Euro debt crisis (Aizenman *et al.*, 2013b; Beirne and Fratzscher, 2013; Groba *et al.*, 2013; Kalbaska and Gątkowski, 2012; Wang and Moore, 2012; Yu, 2015), liquidity spillover effects between sovereign bonds and the CDS market (Calice *et al.*, 2013; Fontana and Scheicher, 2016), the association between credit ratings and sovereign default spreads (Ismailescu and Kazemi, 2010; Micu *et al.*, 2006) and the impact of macroeconomic variables on sovereign CDS spreads (Chiarella *et al.*, 2015; Kim *et al.*, 2015). These studies evidenced that credit risk spillovers among sovereign CDSs vary in terms of both transmission directions and magnitudes in the case of each individual country. This section of the current chapter reviews empirical studies that have provided evidence of significant credit risk spillover effects between sovereign CDSs during the crisis and the underlying explanatory factors of credit risk transmission.

Wang and Moore (2012)[23] employed a bivariate GARCH model with dynamic conditional correlation (DCC) specification in order to investigate the evaluation of credit risk correlations between the US and 38 countries (including developed and emerging countries) using weekly CDS data from January 2007 to December 2009. The findings revealed that the shock associated with the collapse of Lehman Brothers seemed to have consolidated the integration of the global CDS market; for instance, the mean correlation between the US and developed countries increased significantly (i.e., from 0.18 to 0.39) after the shock from the demise of Lehman Brothers,[24] whereas that between the US and the emerging markets remained at a similar high level (i.e., from 0.57 to 0.54). In particular, the mean credit risk correlation between the US and China grew from 0.306 for the pre-Lehman crisis period to 0.424 for the post-Lehman crisis period. The mean

[23] It is noticeable that Wang and Moore (2012) used 7-year CDS spreads for the US but 5-year CDS spreads for the remaining 37 countries (including both advanced and emerging countries) in order to cover the onset of the global financial crisis, as the 5-year data starting from January 2007 for the US sovereign was unavailable in Datastream. They claimed that 'the correlation between the 5-year and seven-year CDS is 0.998' (p.4), so the use of 7-year US CDS data may be permissible.

[24] They defined the period from the 1st of January 2007 to the 15th of September 2008 as the pre-Lehman shock time and that from the 16th of September 2008 to the 1st of December 2009 as the after-Lehman shock time. The mean correlation between the US and Japan grew from 0.213 to 0.285 from the period before the Lehman shock until the period after the Lehman shock.

correlation for other Asian countries, such as South Korea and Malaysia, also revealed an increase after the Lehman crisis.[25]

Unsurprisingly , the onset of the European sovereign debt crisis in 2009 has been one of the most difficult challenges faced by governments and central banks since the introduction of the euro, as investors started to express concerns about the solvency and liquidity of the debt issued by the European countries following the bailout of the Greek government in April 2010 (Alter and Beyer, 2014). Furthermore, the European Financial Stability Facility (EFSF) was created as a temporary solution in June 2010, while a more permanent settlement referred to as the European Stability Mechanism (ESM) was introduced in October 2010 to help the distressed countries (i.e., Ireland, Portugal and Greece) overcome their macroeconomic imbalances. The bailout and rescue from the European Economic and Monetary Union (EMU) lead to a need for reassessing the default risk of a number of European countries.

There have been a number of empirical studies investigating the credit risk spillover effects among European countries from the standpoint of sovereign CDS spreads. For example, Kalbaska and Gątkowski (2012) investigated the transmission of credit risk among PIIGS (i.e., Portugal, Italy, Ireland, Greece and Spain) countries and advanced European economies (i.e., the UK, France and Germany) between August 2005 and September 2010.[26] The findings derived from the EWMA correlation analysis and the Granger-causality tests identified an increasing amount of credit risk correlations and significant contagion effects among European Union (EU) member countries after August 2007. In particular, the findings also implied that advanced economies seemed to be able to trigger instability in the financial markets of a whole region. Thus, even though

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[25] For instance, the mean correlation increased from 0.240 to 0.431 for South Korea and from 0.249 to 0.420 for Malaysia.

[26] They focused on the interdependencies between PIIGS and 'core' countries because France, the UK and Germany bought a significant amount of the debts issued by the PIIGS countries.

government deficits among PIIGS countries caused financial panic during the Euro debt crisis, the core countries, such as the UK and France, had the most significant influence on other sovereigns' credit risk and they had extensive assets to absorb any shock that was triggered by the debt markets of other countries.

Similarly, Beirne and Fratzscher (2013), Dieckmann and Plank (2012) and Groba *et al.* (2013) also found greater interdependence in the case of European sovereign credit risk. In particular, Groba *et al.* (2013) investigated the potential effects of market segmentations between the distressed and the non-distressed countries, as well as between the non-EMU and the distressed countries, respectively. They applied a bivariate-GARCH(1,1)-full-BEKK model in order to investigate the credit risk spillover effects from conditional volatilities using a sample dataset covering the period January 2008 to July 2012. They found significant unidirectional cross-country credit risk volatility spillover effects from the distressed countries to the non-distressed countries. In contrast, there were no significant volatility spillover effects between the distressed countries and the non-EMU countries; thus, the local currency served as a firewall and prevented volatility spillovers from the inside to the outside of the Eurozone. In addition, they also conducted a rolling window regression using 1-year CDS data in order to test whether the impact of the distressed countries can represent an average systematic risk during the crisis period. The findings for the 1-year CDS data confirmed a positive impact of distressed economies until the beginning of 2010. However, this impact gradually diminished after January 2010, which indicated a reduced risk of contagion among European countries. The authors interpreted this result as a 'safe haven effect' in the core countries because investors re-allocated their funds and rushed to debts issued by Germany and other core EMU countries.

By drawing on the concept of 'flight-to-quality', researchers have investigated whether there is any liquidity spillover between sovereign bonds and CDS markets. One reason for this linkage is that liquidity risk should be priced into both instruments in such a way that buying exposure to the same default risk would be identically priced; in other words, sovereign debt and CDS spreads associated with the sovereign debt should track each other closely. However, an analysis of the literature illustrates that there is a great deal of variation in the patterns to the transmission of risk between bonds/CDSs of different maturities and from different countries (Calice *et al.*, 2013; Fontana and Scheicher, 2016). In particular, Calice *et al.* (2013) conducted an analysis of most Eurozone countries including Greece, Ireland and Portugal, the findings of which revealed that the liquidity of the sovereign bond markets had a significant time-varying influence on the 'basis' between sovereign bonds and CDS spreads. The findings indicated that a 'flight-to-quality' behaviour was driving the yield of 'core' countries to very low levels, which should be reflected in the risk premium. Hence a relatively lower bond yield spread is associated with a larger 'basis' between bond and CDS spreads. The results from Calice *et al.* (2013) also highlighted that the EU successfully coordinated the actions of several countries during the crisis since contagion might have otherwise led to the failure of sovereign debt instruments in a number of Eurozone countries.

Turning to the effects of macroeconomic shocks on sovereign credit risk, exogenous factors, such as changes in a credit rating and shocks to economic variables can also affect sovereign CDS spreads (Ismailescu and Kazemi, 2010; Wang and Moore, 2012). Ismailescu and Kazemi (2010) examined the impact of the sovereign credit rating change announcement to the sovereign CDS spreads in 22 emerging market countries[27]

[27] The 22 emerging market countries are: Argentina, Brazil, Chile, China, Colombia, Ecuador, Egypt, El Salvador, Indonesia, Israel, Lebanon, Malaysia, Mexico, Panama, Peru, Philippines, South Africa, South Korea, Thailand, Turkey, Venezuela, and Vietnam.

for the period of 2001 to 2009. They found that during the recent financial crisis, the intensity of responses among CDSs seemed to vary over time and across countries; the recent financial crisis witnessed a significant increase in the sensitivity of CDS responses to news because CDS spreads were highly sensitive to changes in credit ratings during the crisis. Financial contagion from one country to another, in respect of credit rating changes was related to the CDS response to a country's own ratings change. Moreover, the impact of these changes was nonlinear; it depended on the previous credit rating of an individual country: the higher (lower) the initial credit rating, the lower (greater) was the response of CDSs to credit rating upgrades (downgrades).[28] They also extended their studies by examining the credit risk transmission mechanisms (i.e., common creditors and trade links) suggested by Van Rijckeghem and Weder (1999) and Kaminsky and Reinhart (2000). The findings evidenced the significance role of a common creditor in spilling over credit risk in Asia. This finding is in line with Kaminsky and Reinhart (2000) who stated that 'contagion is more regional than global' (p.146). In other words, common creditors, such as Japan that links the credit risk of Asian countries (i.e., China and South Korea) together via the lending and borrowing activities. The impact of the US to the credit risk of its borrowers is also identified among the emerging market countries. Research evidence from Wang and Moore (2012) implies that a decline in US interest rates was the main factor behind an increase in the correlation between the CDS spreads of the US and other sovereign markets; in particular, CDS markets were heavily influenced by the economy of the US when the crisis was at its peak. This finding is in line with Kim *et al.* (2015).

[28] To be more specific, the local maximum (-40) estimated at the BB+ rating may be attributable to the fact that this level represents the cut-off point between high speculative grade (BB+) and low investment grade (BBB-) bond ratings.

From the perspective of sovereign CDS markets, it is clear that growing dependencies among different countries may increase the credit default risk at government level. In spite of this view, credit ratings and changes in economic conditions also exert an effect on the changes in the default risk within sovereign CDS markets. Empirical evidence confirms the important role of macro-prudential factors in CDS contracts. However, only a limited number of studies focus on sovereign CDSs in Asian countries; the current thesis will therefore be able to make a contribution in this area.

3.3.2 Credit risk of financial institutions

In general, banks and other financial institutions such as insurance service corporations constitute a majority of the financial sector. Since the onset of the 2008 global financial crisis, several academics have suggested that the booming credit derivatives markets triggered financial panic among large financial institutions and led to the subsequent euro debt crisis (Calice *et al.*, 2013). They highlighted the importance of interdependence among large financial institutions and the possibility of contagion in credit risk within the financial sector. These studies report that the credit risks of large important financial institutions simultaneously respond to systematic CDS shocks (Black *et al.*, 2016; Calice *et al.*, 2013).

For example, Upper and Worms (2004) used the balance sheet information of individual banks in the German banking system in order to test whether the negative shocks from a bank can spill over to others and consequently can lead to contagion. In particular, they examined the implication of domestic and foreign interbank linkages, the findings suggesting that the failure of a single bank can have significant negative effects on the banking system's assets. A recent study by Pagano and Sedunov (2016) investigated the correlations between the riskiness of one nation's financial system and another nation's financial sector.[29] The findings indicate that the systemic risk exposures of several European countries financial sectors were linked during the crisis period; these links were established between countries that are geographically close or culturally similar, or between the crisis-influenced GIIPS countries.

Tamakoshi and Haruorz (2012a) utilised a multivariate DCC-GARCH model in order to estimate the correlations between the US, Eurozone countries and the UK banks' CDS spreads indices from January 2004 to November 2011.[30] They found that there was evidence of asymmetric dynamic correlations between the EU and the UK bank CDS indices and the correlations between them tended to be higher when responding to joint downward shocks, such as the shock of the Euro debt crisis. Furthermore, Calice *et al.* (2013) employed two representative CDS indices: the North American CDX and the European *iTraxx* index from October 2003 to April 2009. The findings outlined that high CDS market indices led to an adjustment in the valuation of a bank's assets. Hence, they suggested that any significant loss in the market value of these assets would require a capital injection of equity in order to maintain the bank's stability because the value of its liabilities is known. Therefore, the safety and soundness of each particular institution was a function of the market value of its assets. As a result, the sensitivity of default risk across the banking system was highly correlated with the CDS index market; the relationship between default risk and the CDS index market was assumed to be positive.

Tamakoshi and Hamori (2012b) investigated the dynamic interdependences of bank CDS index spreads across countries. They demonstrated that the CDS spreads of banks have fluctuated widely in the EU, the UK and the US for the period January 2004 to November 2011; they suggest, therefore, that the sovereign debt crisis has had a

[29] They included all publically traded financial institutions within each individual country for the 2007 to 2013 period from the Bloomberg database.
[30] Tamakoshi and Haruorz (2012a) constructed three series of bank CDS indices by averaging the spreads of a number of 5-year single-name bank CDS with reference to US banks, Eurozone banks and UK banks.

significant effect on the CDS spreads of the UK and the US banks and consequently increased the correlations among them. These findings are in line with Calice *et al.* (2013), who reported that the dynamic correlations between the CDS spreads of mainland EU and UK banks displayed a similar response to downward shocks; their evidence suggests that there is a strong correlation between the CDSs of financial institutions in the EU.

Miquel *et al.* (2012) investigated the relation between the fragility of banks and their CDS spreads. They investigated the role of a number of widely accepted factors, which are thought to affect changes in CDS spreads and help explain any co-movement between banks' CDS spreads, the *iTraxx* CDS market index as well as the sovereign debt CDS market spreads. The empirical results indicated that the *iTraxx* index played an important role in explaining co-movements in the CDS market. During the period of financial stability studied, CDS spreads only exhibited a limited amount of co-movement among the different markets. However, after July 2007 and the burst of the subprime crisis, the leading role played by the *iTraxx* index disappeared and the entire market seemed to be out of control.

Black *et al.* (2016) noted that connections between financial institutions are very important in determining the systemic risk of individual banks. They designed a systemic risk measure referred to as the hypothetical distress insurance premium (DIP), which integrates the main economic characteristics of systemic risk: size, default probability, and interconnectedness. Their evidence supported the 'too-big-to-fail' hypothesis drawing on a macro-prudential perspective. When studying the marginal contribution of each bank (or bank group) to the systemic risk indicator in the Eurozone, they found it to be very important for the overall stability of the EU financial system.

Gross and Kok (2013) investigated the interdependence between banks in the UK, in Eurozone countries and in Japan using a Mixed-Cross-Section Global Vector

Autoregressive model.[31] They found that a similar feature in the American and Japanese banking sector influenced the results, namely that both of them have strong intra-sectoral connections. In addition, strong cross-border credit risk linkages among the Eurozone countries emerged during their sample period, as 'European banks were hit by a number of common systemic shocks, such as the global financial shocks merging from the sub-prime crisis and especially the shocks related to the euro are sovereign debt crisis' (p.21).

The findings from prior studies have identified that CDS spreads help in explaining credit risk. In particular, the role of CDS spreads becomes more significant during periods of economic instability, such as the recent global financial crisis and the Euro debt crisis. However, extensive research is still required in this area – especially looking at the spillover of credit risk among financial institutions from different countries in Asia. Furthermore, there is not a great deal of research looking at credit risk contagion from the financial sector to the non-financial sector both within a country and across countries; the current thesis attempts to add to previous work in these areas.

3.3.3 Credit risk of non-financial firms

Unlike financial institutions, where credit risk linkages involving banks' capital structures (and portfolios of assets) have being studied, credit risk contagion in non-financial sectors may be transmitted through other channels. In order to identify the potential of credit risk contagion, among non-financial companies, a number of studies have analysed the links between CDSs and the determinants of credit default risk in non-financial firms. The study of Subrahmanyam *et al.* (2009) was one of the first attempts to highlight the disadvantages of the standard model in measuring and managing portfolio credit risk in non-financial firms. This standard industry model uses a multivariate

[31] Their sample data spans between 2009 and 2012 and there are 41 international banks selected from Eurozone countries, the US and Japan.

Gaussian latent-variable equation where the latent variables are associated with the log of asset values. However, asset values are not observable per se since the balance sheet information for these assets was typically recorded at historic cost. In order to overcome this disadvantage, the author created a model in order to estimate the log of the asset values from the observable CDS spreads. This model is compared with the standard industry model by analysing their effectiveness at hedging the credit risk of the portfolios of non-financial firms. Furthermore, this hedging effectiveness was examined for three different sub-periods within the whole time frame studied by Subrahmanyam *et al.* (2009): the GM/ Ford crisis, the sub-prime crisis and the period in between. The results indicated that the performance of both models was similar in general. However, the standard industry model seemed to underperform in the sub-prime period; the hedging error distribution of the CDS spreads model had a substantially lower dispersion suggesting that the predictions from this model were more accurate.

Zhang *et al.* (2009) developed a structural model in order to measure the default risk and derived values for firms' default probability, equity prices and CDS spreads; these incorporated both macroeconomic risks and firm-specific jump risks. By including these two types of risk in assessing a firm's likelihood of default, the authors reported that more accurate predictions were obtained. Their model highlighted the importance of macroeconomic factors in explaining credit risk; that is, default probability and CDS spreads depend on the current economic state.

3.3.4 Credit risk between sovereigns and non-sovereign firms

In order to illustrate the conceptual framework of credit risk transmission between sovereign debtors and firms, the discussion of this section is structured into two parts: 1) Credit risk transmission between sovereigns and financial institutions and 2) Credit risk transmission among sovereigns, financial institutions and non-financial firms. The discussion of the first part should help provide an overview of the findings from previous research studies regarding the dynamics of credit risk transmission between the sovereign and the financial sectors both domestically and internationally. In addition, as there is a lack of relevant studies focusing on the direct dependency of credit risk between sovereigns and non-financial firms using CDS data, it is difficult to outline a separate discussion on this topic. Therefore, a decision is made to broadly discuss the findings of previous studies from the perspective of investigating credit risk spillover effects across different sectors; thus, these studies assumed that there are either direct credit risk interdependence between sovereigns and non-financial firms or indirect interdependence between them via financial institutions. Since there is limited number of prior studies regarding the direct credit risk spillover effects between sovereigns and non-financial firms, the analysis of the transmission of Asian sovereigns and firms' credit risk from CDS spreads in this current thesis will help to fill this gap.

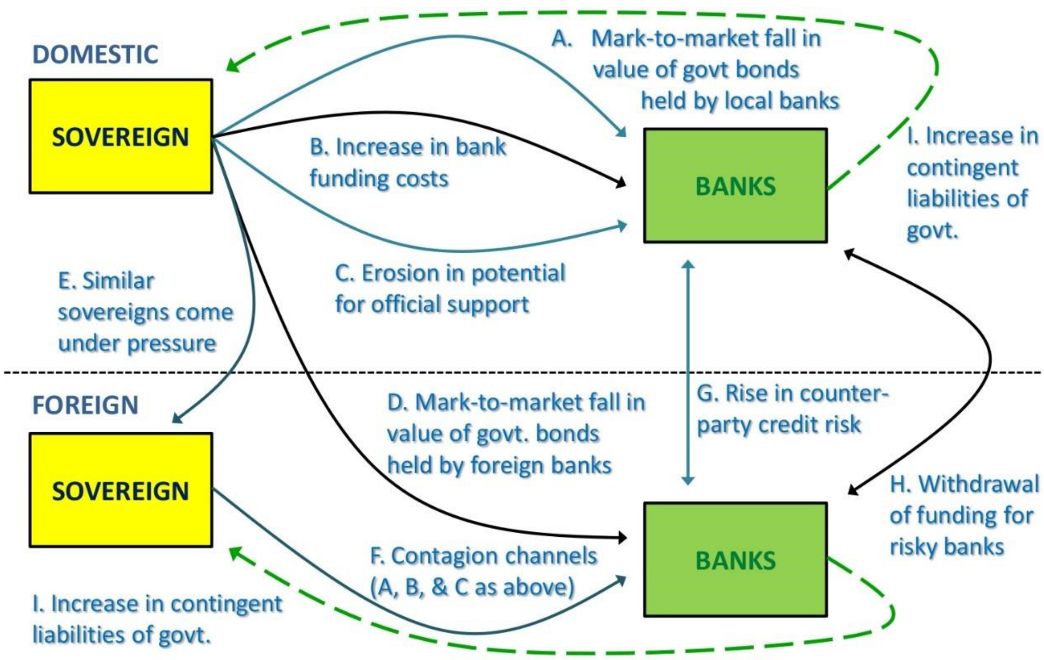
3.3.4.1 Credit risk transmission between sovereigns and financial institutions

More recently, attention has focused on credit risk spillovers between sovereigns and financial institutions after the onset of the 2008 global financial crisis. As previously stated, the extremely amplified interdependence between entities after a shock can lead to a risk of contagion. For instance, Pagano and Sedunov (2016) pointed out that negative shocks from a distressed market (i.e., subprime mortgages) can spill over to the financial institutions and sovereigns; this shock transmission can result in a sudden and sharp increase in the overall risk of a financial system and lead to an increment in systemic risk.

In order to provide an overview of the transmission of credit risk, Figure 3.2 which is reported by IMF (2010), illustrates the transmission of credit risk spillovers between sovereigns and banks. For example, credit risk spillovers can be transmitted between sovereigns and banks at both domestic and foreign levels; in particular, the credit risk spillovers can originate from sovereigns to banks or from banks to sovereigns. For example, if investors demand a higher risk premium for holding a government debt, the mark-to-market value of the government bonds will decrease (i.e., government bond prices decrease and bond yields increase) and domestic banks' asset values will consequently decline (i.e., transmission channel A in Figure 3.1). Thus, domestic banks' funding costs will increase (i.e., transmission channel B). If a domestic bank faces funding or liquidity issues, this can trigger an increase in its default risk and may have consequent contagion effects: failure to repay its financial obligations to other financial institutions and the government might intervene in order to prevent more domestic banks from declaring bankruptcy. When the government intervenes and it is already distressed, the value of the domestic government guarantee provided to its domestic banks will be eroded (i.e., transmission channel C). In particular, if a nation's financial system is large compared with the government, distress in the financial system can trigger a large increase in government financial guarantees (i.e., transmission channel I). This potential cost to the government (i.e., financial guarantees to the financial system) can lead to a rise in sovereign credit spreads. By contrast, banks' credit spreads are lower than in the past because of the government guarantees and the creditworthiness of the sovereign. Therefore, the credit risk of the sovereign and that of its domestic banks are intertwined.

At a cross-border level, foreign banks that hold government bonds issued by the distressed government will also be affected because of the decrease in the mark-to-market bond value (i.e., transmission channel D). Meanwhile, credit risk shocks can be transmitted from the troubled country to its adjacent county (i.e., transmission channel E) through bilateral trade or because both share similar public deficit and funding needs; this linkage will lead to the transmission of credit risk spillovers from the sovereign to its domestic banks via channels A, B and C. Thus, negative feedback effects arise from domestic banks to their sovereign debtor (i.e., transmission channel I). The counterparty risk between banks in affected countries will consequently increase because of interbank exposure (i.e., transmission channel G) and investors might withdraw funding from affected banks under the adverse shocks (i.e., transmission channel H).

Figure 3.1: Credit risk spillover effects between sovereign debtors and banks



Source: International Monetary Fund (2010).

Several empirical studies (Acharya *et al.*, 2017; Alter and Beyer, 2013; Alter and Schüler, 2012; Costeiu and Heagu, 2013; IMF, 2010) have sought to enhance the understanding of systemic risk at an international level and also contribute to the burgeoning literatures on the link between systemic risk and sovereign debt, especially during the 2008 global financial crisis and the 2010 Euro debt crisis. Alter and Schüler (2012) were among the first scholars to examine changes in the credit risk interdependence of European countries and banks after bank aid schemes were implemented in Europe between June 2007 and May 2010. They used 5-year daily sovereign CDS spreads for seven European countries and 5-year CDS spreads for the banks from each country in order to represent their credit risk, respectively.[32] In their analysis of the interdependence of credit risk transmission between European sovereigns and banks, Alter and Schüler (2012) developed four hypotheses to test the dynamic contagion effects of credit risk. Their first hypothesis was set to test whether changes in the default risk of banks could affect the default risk of European governments or not, but not vice versa before government interventions; as they argued 'financial sector issues have a systemic component, leading to the contagion mechanism' (p.3446). Their second hypothesis was two-fold. For instance, they first tested whether changes in the default risk of banks could have a more significant impact on the European sovereigns after government interventions or not. In addition, they also tested whether there were positive interdependence between the credit risk of European sovereigns and banks or not. Alter and Schüler (2012) argued that government interventions linked the credit risk of sovereigns and banks together because banks should be highly sensitive to the credibility of their government after receiving direct capital injections from sovereigns. The third hypothesis was about interdependence between the sensitivity of banks' default risk and the possibility of future government capital support and the last one was set to test the asymmetric interdependence between sovereigns and banks' default risk in terms of the heterogeneity of the bailout programmes adopted by different European countries.

The findings of the impulse response analysis over the long term (after 22 days) from Alter and Schüler (2012) highlighted significant changes in the interdependence of sovereigns and banks after the bank bailout programme. For example, in the period before the bailout, the CDS spreads of all European banks were found to impact their respective

[32] There are two banks for each country only. Alter and Schüler (2012) argued that 'in order to maintain a homogeneous framework, i.e., the same number of banks from each country, while achieving the longest time frame possible, we were able to use only two bank CXDS series for each country' (p.3,447). But all of these selected banks are important financial institutions because 8 out of 14 organisations belong to the *iTraxx* Europe index.

sovereign CDS spreads but the effects from European sovereigns to their respective banks were insignificant.[33] This finding helped to support their first hypothesis, which stated that sovereign credit risk was strongly affected by banks' CDS spreads before government interventions. By contrast, in the period after the bailout, the consistent effects from sovereign shocks on bank CDS spreads were pronounced and the shock effects from bank CDS spreads were less important.[34] Therefore, a 'private-to-public' risk transfer is confirmed following the interventions by the government.

Bivariate VEC and VAR frameworks were employed to test the third hypothesis; they conducted a set of individual country analyses for Ireland, Germany and Italy; these three European countries were selected to represent the highest, the middle and the low levels of financial support to the local financial sector (%GDP in 2008). Their results suggest that the financial aid provided by the German government to its financial sector was successful in eliminating the default risk, while the higher probability of the further need of government aid to the Italian financial sector from Italian sovereigns amplified the sensitivity of sovereign and bank CDS spreads to shocks. Lastly, to test their fourth hypothesis, the authors standardised the results from a domestic level of impulse response analysis to a regional level by calculating the responses caused by the same shocks. The results evidenced that the interdependence of government and bank credit risk was heterogeneous across European countries, but homogeneous within the same country. In other words, the effects of a sovereign's credit risk shock on its domestic banks' credit risk were significantly linked within each sample country, but different on foreign banks'

[33] According to Alter and Schüler (2012), the percentages of significant responses from European banks to their sovereigns were 100%, but those from the European sovereigns' CDS spreads to the banks were only 14.29% before government interventions. Portugal's and Italy's sovereign CDS spreads seemed to be more important in the interdependencies of credit risk between sovereigns and banks before the bankruptcy of the Lehman Brothers.

[34] The percentages of significant responses from sovereigns' CDS spreads to banks were 100% after government interventions but only 21.43% in an opposite transmission direction.

credit risk. Alter and Schüler (2012) suggested that the heterogeneous interdependence could be partially explained by the different exposure of the banking sector to the systemic risk.

A further study by Pagano and Sedunov (2016) extended Alter and Schüler's (2012) sample size from seven to 15 European countries and provided some insight into the relationship between systemic risk exposure and sovereign debt; in particular, they excluded the Netherlands, but added Austria, Belgium, Cyprus, Finland, Greece, Norway, Poland, Sweden and the UK. Furthermore, Pagano and Sedunov (2016) employed Adrain and Brunnermeier's (2011) Adapted Exposure CoVaR framework in order to determine the aggregated exposure of all banks within a country to the systemic crisis. Their results indicated that the aggregate systemic risk exposure of domestic financial institutions was positively related to the probability of a default on sovereign debt. This finding is in line with Alter and Schüler (2012). In particular, Pagano and Sedunov (2016) found a 'flight-to-quality' effect; an increased level of systemic exposure in distressed European countries (i.e., PIIGS) led to a lower level of sovereign credit spreads in France, Germany and the UK because investors shifted to sovereign debt instruments issued by countries perceived to be safer.

As indicated by Alter and Schüler (2012), the Italian sovereign and bank CDS spreads were strongly correlated with each other during the crisis. Zoli (2013) outlined a comprehensive examination on sovereign spreads in Italy. According to their results, news related to the Euro area debt crisis and Italy specific news were important drivers of Italian sovereign spreads; this finding is in line with the previous outcome and confirms the dominant position of the Eurozone in triggering financial instability across Europe. Furthermore, the pass-through of sovereign spreads on Italian banks' CDSs suggest the significant role of Italian sovereign risk premiums in affecting domestic banks' funding costs and lending conditions. In particular, movements in country risk premiums rapidly affected corporate borrowing costs; within three months, 30-40% of the movements had been transferred to the corporate borrowing costs, and 50-60% could match the corporate borrowing costs in six months. Moreover, the estimation results also identified the effects of public rescues to financial institutions, while shocks exerted an impact on banks' risk profiles; this is in line with the findings of the crisis-contingency theory which assumes that the endogenous liquidity shock transmission channel can affect the construction of the investment portfolio. In this paper, the two-way effects between sovereigns and banks' CDS spreads were also confirmed, or more specifically, the public rescues of financial institutions created a potential financial contagion transmission channel between sovereigns and banks.

Having discussed the transmission of credit risk spillovers between sovereigns and banks on the basis of a number of prior studies, it is now worth examining the resilience of a sovereign (or bank) to a shock from another bank (or sovereign). Alter and Beyer's (2013) study on credit risk spillover effects is of particular interest because it not only quantifies the variation in the amounts of significant credit risk spillovers between sovereigns and the associated banks but also proposes a straightforward measurement of the threshold value of spillover effects for the risk of contagion. In line with Alter and Schüler (2012), Costeiu and Heagu (2013) and Pagano and Sedunov (2016), Alter and Beyer's (2013) results from a vector autoregressive model with exogenous variables also evidenced the existence of a feedback loop between sovereigns and banks during the 2010 Euro debt crisis.[35] In addition to determining when credit risk spillovers can trigger a

[35] They included several first differenced control variables. For example, the *iTraxx* SovX index was used to account for the common factor of the Eurozone sovereign CDS spreads and the *iTraxx* Senior Financial European index was used to account for the common factor of the European bank CDS spreads. Other exogenous variables included the *iTraxx* Europe index, the *iTraxx* Crossover, the spread between 3 month Euribor EONIA swap, the EuroStoxx 50 index, the 5-year US and the 5-year UK sovereign CDS spreads and VIX index.

financial contagion event, they provided a simple method to compute the threshold values of ‘excessive’ credit risk spillovers for a set of empirical distributions of CDS changes in combination with subjective preferences. For instance, the empirical distribution of a CDS spread series is used to identify the frequency of a specific magnitude of change in the CDS spread over a period of time. Therefore, the risk of contagion from a CDS spread series to another CDS spread series is assumed to be a function of the response magnitudes of a shock induced by the first CDS spread series, and the threshold values of ‘excessive’ credit risk spillovers can be determined by setting the critical magnitudes of the spillover effects based on characteristic percentiles. Their analysis of ‘excessive’ spillover effects among European CDSs suggests that, even from the standpoint of a non-risk-averse investor who expects a low level of ‘excessive’ spillover effects, contagion effects from Spanish to French sovereign CDS spreads were uncovered. Risk-averse investors, who feared the credit risk of contagion at much lower levels of spillover effects were evidenced to ‘observe strong evidence for contagion in June 2012 as the threshold value of 37% is passed for almost all variables’ (p.33).

Although studies on the transmission of credit risk between Asian sovereign and bank CDS spreads are scarce, there is some evidence on this topic in the literature. For example, a broad perspective has been adopted by Lahmann (2012), who examined the contagion effects between sovereign and bank CDS spreads on a global scale (including the Asia-Pacific, Middle East, Russia, the US and European countries) from October 2005 to April 2011. The empirical results provided evidence of the interaction between the CDS spreads of banks in the US and European countries before the crisis period (i.e., 01/10/2005 to 28/02/2007). During the burst of the subprime bubble (i.e., 01/03/2007 to 31/07/2008), Asia-Pacific sovereign CDS spreads were led by American and European bank CDS spreads, but European sovereign CDS spreads Granger-caused changes in

Asia-Pacific banks' CDS spreads during and after the financial crisis period (i.e., 01/08/2008 to 30/04/2011).

The findings of various studies exploring the credit risk transmission between sovereigns and banks have reached a general consensus: public bailout programmes may have created a potential credit risk transmission channel between sovereigns and banks due to the strong interdependence which were present; this effect has been identified across several European countries. However, there is a dearth of literature on the existence of credit risk transmission between sovereigns and financial institutions using CDS data in Asian countries. With this in mind, the analysis of the current research on the domestic and regional credit risk transmission between sovereigns and banks should contribute to our knowledge of the credit risk interdependence in Asia.

3.3.4.2 Credit risk transmission across sovereigns, financial and non-financial firms

Recent studies have focused on how non-financial firms react to credit risk spillover effects in the economic system. For example, inspired by Upper and Worms (2004), who examined the interbank market contagion risk in Germany, Degryse *et al.* (2010) investigated cross-border credit risk contagion for the banking system of 14 European countries, Canada, Japan and the United Sates over the period 1993 to 2006.[36] Unlike Upper and Worms (2004), who employed interbank data, Degryse *et al.* (2010) used *bank credit to foreign countries* in order to measure cross-border exposures since these foreign claims represent the exposure of a nation's banking system to other countries in relation to the banking, non-banking and public sectors. The findings from Degryse *et al.* (2010) have evidenced that 'a shock that affects the liability of one country may undermine the stability of the entire financial system' (p.209). However, the effect

[36] The 14 European countries are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

from the credit risk of the non-financial sector is not computable because the sectoral classification was not available for the bank credit to foreign countries data.[37]

Acharya *et al.* (2014) developed a theoretical model which consists of the sovereign, the financial and the non-financial sectors in an economic system. The findings confirmed that a two-way effect may exist between the spreads of sovereigns and banks. They argued that high sovereign default risk is typically associated with severe disruptions in the economic environment leading to economic recessions. In addition, sovereign default risk is usually preceded by a loss of investor confidence and capital outflows, frequently culminating in a banking crisis and/or a currency crisis. Deterioration in the operating and financial environment usually results in large increases in default rates in all sectors and lower recovery rates. When investors believe that a bank's and the sovereign's risks are linked together after public rescues, they may be concerned that the financial status of the government may not be good enough to guarantee those financial institutions. Since the bailout is funded through taxation of the non-financial sector, this induces the non-financial sector to underinvest. Thereby, a destructive feedback loop is triggered via the non-financial sector.

To test the theoretical predication, Acharya *et al.* (2014) employed an OLS regression analysis using the CDS data and the debt-to-GDP ratios of all Euro zone countries plus Denmark, Norway, Sweden, Switzerland and the UK covering the time period of January 2007 to April 2011. They further defined a 'pre-bailout period' starting January 2007 to September 2008 and a 'during-bailout period' from September 2008 to October 2008; the rest of the sample period was defined as post-bailout period. The

[37] They employed data from the Consolidated Banking Statistics in the BIS data resource, but the BIS only reported sectoral classification at the aggregated level. For instance, the BIS reported the foreign claims of a nation's banks on banks from the rest of the world but did not report the foreign claims of a nation's banks in a second country. Therefore, it was impossible to measure the contagion risk from the non-financial sector of a country to that of a foreign country.

findings suggested that an increase in a nation's debt-to-GDP ratio is caused by the cost of bank bailouts; a 10% increase in the distress of the financial sector[38] raises the cost of bank recapitalization by 1.8%. This finding is in line with Laeven and Valencia (2012), who examined domestic estimates of the cost of bank recapitalization relative to GDP. The findings from Heise and Kuhn (2012) also evidenced that defaults tend to cluster around times of economic stress due to poor macro-economic conditions. In an extreme condition, the inability of the government to meet its obligations leads to a systemic financial crisis and a sovereign debt crisis.

The findings from these studies confirm that CDS spreads have a great deal of power in explaining systemic risk, especially during a crisis period; they suggest a high level of correlations among CDS spreads, indicating a sizeable dependency among the government bond yields from different counties. This interdependency may cause financial contagion in extreme circumstances because banks from different nations can own the debt of one sovereign entity. These studies also evidence that sovereign CDS spreads play an important role in exposing systemic risk and maintaining the stability of a country's financial market.

Nevertheless, the analysis of this thesis will make a contribution by addressing this issue via the grouping the CDSs into sovereign, financial and non-financial firms. This classification not only allows me to identify credit risk spillovers from non-financial firms but also to measure credit risk transmission from non-financial firms to different sectors (i.e., the sovereign sector and the financial sector).

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[38] They measured country-level financial sector distress as the weighted average of bank CDS spreads prior to the bank bailout on the 22th September 2008 deducted from spreads during the bailout; thus, each individual country has its own indicator of financial sector distress.

3.3.5 Credit risk between financial and non-financial firms

Since a number of common factors (i.e., a firm's assets value, a firm's leverage ratio and the volatility of a firm's assets value) influencing credit risk in both financial and non-financial firms have been identified, several studies have investigated the sector-level effects on default risk for the two types of companies. One group of academics have concluded that changes in a non-sovereign entity's default risk are strongly negatively related to its equity returns, which in turn predominately depend on country-specific factors. By contrast, another group of academics focus on the credit risk dependency of financial and non-financial firms; it suggests that interdependence between financial and non-financial firms can be influenced via the lending and borrowing channel between them. For instance, the default risk of a bank can have implications for non-financial firms that borrow from that bank or deposit funds with that financial institution. Similarly, default by a large non-financial firm can have repercussions for the credit risk of banks that this firm interacts with, since when a non-financial firm is not be able to repay its bank loans on time, the bank has the right to liquidate the collateral received from that firm. Therefore, the recovery amount of the loan depends on the market value of the collateral, and the bank may face the risk of a tight cash flow chain, as well as the risk of asset value depression. In an extreme situation, when a number of non-financial firms default at the same time, the default risk of the banking sector increases instantaneously. As a result, the credit risk of financial institutions and non-financial institutions is similar in each case.

Galil *et al.* (2014) investigated the determinants of CDS spreads and the changes in CDS spreads for 718 US firms (including both financial and non-financial firms) during the period from January 2002 to February 2013.[39] They argued that market variables have explanatory power in the models of CDS spreads after controlling for the firm-specific variables suggested by structural models. In particular, they found that stock returns, the change in stock return volatility and changes in the median CDS spreads in a rating class are the most important factors when explaining a firm's credit risk. In addition, they note that the explanatory power of a firm's credit rating diminished in the crisis period but had been influential prior to the 2008 global financial crisis. In other words, there was a structural change in CDS pricing after the crisis in the US CDS market.[40] Hence, the findings from Galil *et al.* (2014) suggest that the co-movement between firms' stock returns, between their changes in stock return volatility and the co-movement between their changes in the median CDS spreads may create potential credit risk spillover transmission channels between the financial and non-financial sector if a risk of contagion exists, as these three factors have significant explanatory power over the changes in CDS spreads using the US CDS data.

Costeiu and Neagu (2013) assessed the fragile Romanian banking sector by examining its ability to withstand losses under both normal and stressed economic conditions, as they assumed that the non-financial sector acts as the bridge between the financial sector and the real economy, as non-financial firms constitute the banks' portfolios. The findings identified that a non-financial firm's receivable turnover ratio, sales-to-total assets ratio, short-term bank debt-to total assets and debt-to-equity ratios are important factors affecting its default risk. In addition, they also identified a number of important macroeconomic variables such as a country's annual GDP growth rate, changes

[39] In particular, 695 of the 764 firms are rated US firms and the rest 23 firms are unrated. They used the Markit database to obtain US dollar nominated 5-year CDS data.

[40] They estimated the monthly cross-section regression and reported the average value of the coefficients in order to report their results in four different periods. They are: 1) the full sample period, 2) the pre-crisis period (January 2002 to June 2007), 3) the during crisis period (July 2007 to June 2008) and 4) the after crisis period (July 2009 to February 2013).

in the real effective exchange rate, inflation rate and the foreign exchange interest rate spread, which can affect the default risk of non-financial firms.

Aretz and Pope (2013) addressed an ambiguity relating to the changes in default risk from the previous studies; more specifically, they considered why changes in default risk were strongly and negatively related to equity returns, which in turn depended predominately on country-specific factors. Through the variance decomposition of changes in default risk, changes in the fundamental determinants of default risk and equity returns in global, country and industry effects, the findings suggested that changes in default risk are always dominated by global and industrial effects. However, the significant role of country effects in equity returns was positively correlated with economic stability, rendering it dependent on the sample period.[41] This findings of this study are in line with the results of Gatfaoui (2008), who employed S&P500 stock index returns as a proxy for the market risk component and found that the return of S&P 500 index fails to capture the systematic credit spreads components of US corporate credit spreads while assessing credit risk.[42] However, they reported that a positive and significant correlation between equity markets and economic stability is country-level dependent.

In spite of the analyses, which have primarily focused on Western Europe and the US, there are still a limited number of studies that have investigated contagion effects

[41] Aretz and Pope (2013) investigated the effects of a number of industry, country and global factors on the changes of a firm's credit risk over the period 1990 to 2008. They applied bond market data into Merton's (1974) model to derive the probability of default for 15,754 firms from 24 countries and 30 industries. Robustness tests were conducted by using CDS data for a smaller set of firms covering a period 2006 to 2008.

[42] Gatfaoui (2008) used a flexible least squares regression model to investigate the linkages between the systematic component in credit spreads and the S&P 500 index return by employing bond spreads ranging from May 1991 to November 2000. They assumed the systematic risk component in US corporate credit spreads as a function of the industry sector of the corporate, the associated credit rating and the maturity of the debts issued by the corporates. Namely, they considered four different sectors (i.e., banking and finance, industrials, power sector and telecommunication sectors) whose credit ratings ranging from AAA to BAA with 1-year to 20-year maturities.

between the financial and non-financial sector in the rest of the world. For example, Ongena *et al.* (2013) analysed financial contagion between the banking and the non-financial firms in Eastern Europe and Central Asia by examining the shock transmission of the 2008 global financial crisis. [43] Unlike other previous studies, the analysis of Ongena *et al.* (2013) places a particular emphasis on the financing and performance of Small and Medium-sized Enterprises (SMEs). They examine two transmission channels, for example, the use of international wholesale funding and the ownership of foreign banks. The findings suggest that shocks can be transmitted between the financial institutions to non-financial firms via international borrowing and lending channels, but that firms which have borrowing and lending activities with international-borrowing domestic banks or foreign banks suffer more (particularly in terms of short-term debt) than firms which only have a single-bank relationship. In addition, small firms and firms with a large amount of intangible assets are more sensitive to adverse shocks. By contrast, credit-independent firms are less affected neither by the number of relationship with banks nor the size of the firms.

3.4 Conclusion

The discussion of the current chapter has outlined a number of relevant prior studies on both the theoretical frameworks of credit risk pricing models and the empirical investigations of credit risk transmissions. The findings from these studies suggest that CDS spreads play an important role in researching credit risk spillover effects. However, the aforementioned literatures still have some limitations. One limitation of their work is represented by the sample area selected for the study. They frequently obtain CDS spreads

[43] They investigated bank activities in 14 countries, namely Bosnia-Herzegovina, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Lithuania, Poland, Romania, Serbia and Montenegro, Slovakia, Slovenia, Turkey, and Ukraine. Their final sample covers 256 banks connected with 45,660 firms. In particular, 126 of the 256 are domestic banks while the remaining 130 are foreign banks.

within one single region, such as European countries or the US, with only a limited number of published works focusing on Asia. In order to expand our knowledge of credit risk spillover effects particularly in Asia, this research study uses CDS data from Asian reference entities. Hence, the findings from this thesis should help to identify any f credit risk spillover effects in Asian entities and to compare any differences in the credit risk spillover effects between advanced economies and emerging markets. Another limitation of the prior studies is that their investigations commonly focused on 5-year CDS data instead of on shorter maturity options, because they assumed that 5-year CDS markets were more liquid during the period of their analyses. However, as Chapter 2 indicated, the liquidity of the 1-year CDS market has significantly improved in recent times. In addition, the number of Asian participants in the CDS market, particularly in Japan, also shows an upward trend. Hence, this new feature of global CDS markets calls for studies to utilise more recent short-term CDS data to investigate the credit risk of Asian CDS reference entities. Therefore, the current thesis examines 1-year CDS data in order to broaden our knowledge of short-term credit risk spillover effects, as well as conducting robustness tests using 5-year CDS data for Asian CDS reference entities.

Moreover, most of the previous studies apply the VAR framework in their investigations. By contrast, this thesis employs multivariate GARCH models to allow time-varying conditional interdependency to be investigated from the perspective of both spread changes spillover effects and shocks, as well as volatility spillover effects in CDS spread changes. Apart from the multivariate GARCH models, Diebold and Yilmaz' (2012) spillover index model has become increasing popularity in academic research. Alter and Beyer (2012) were one of the first researchers, who applied Diebold-Yilmaz' (2012) spillover index model to quantify credit risk spillover effects using CDS data. Specifically, Diebold and Yilmaz' (2012) model builds on a VAR model and a variance decomposition approach; their model allows the user to incorporate the information set of the variance decomposition process into one single value. Although this model simplifies estimates, a multivariate GARCH model framework is used in the current thesis since one aim of this thesis is to detect whether a GARCH (1,1) process exists in driving the changes in CDS spreads; it facilitates a test of the weak-form of EMH. Past studies such as Alomari et al. (2018) used a multivariate GARCH model and found significant return and volatility spillovers in Jordan's Amman Stock Exchange. A full set of parameters from a multivariate GARCH model makes it possible to achieve this goal. In addition, the GARCH model with a full-BEKK specification also helps to identify differences between the features of the cross-transmission of shock and volatility spillovers. The findings from the multivariate GARCH type models assist in our understanding of the role of past shocks and volatilities of CDS spreads in credit risk transmission.

Furthermore, the selection of investigation institutions is restricted in most previous works. Banking sector and financial institutions represent the most common investigation targets, but the sample of this current thesis covers sovereigns, financial institutions and non-financial firms. To the best of my knowledge, the investigation part regarding the examination of any direct credit risk transmission between sovereigns and non-financial firms using Asian CDS data is one of the first attempts in this area. The findings of any direct transmission between sovereigns and non-financial firms could enhance our understanding of credit risk interdependence by adding to our existing knowledge.

Lastly, a number of studies indicated that there is a need to clarify the effects of various observable variables on credit risk correlations. Some of the first attempts includes Pu and Zhao (2012), who addressed the poor explanatory power regarding some of the key inputs suggested by conventional structure models. The findings from Jang *et* *al.* (2013) demonstrated that macroeconomic indicators have a significant impact on firm default risk. To extend our knowledge of credit risk correlations, this current thesis conducts a detailed examination of the effects of a number of variables on credit risk correlations between the financial and non-financial sectors. It incorporates firm-level factors, country-level macroeconomic variables, regional and global indicators to conduct a comprehensive investigation about the factors associated with the co-movement of credit risk between Asian firms. This work contributes to existing knowledge regarding the determinants of credit risk correlations using a novel measure of the underlying observable factors for a given pair of firms. Taken together, this thesis will serve as a basis for future studies investigating credit risk spillover effects in Asia and will help provide relevant information on credit risk transmission. So far, the discussion of this chapter has presented a review of various prior studies. The following chapter will provide an overview of the different research methods and theory.

Chapter 4: Theory and data

4.1 Introduction

The aim of this current chapter is to present the research methodology and the financial theory underpinning the current thesis. Views on the various methodological frameworks in the extant literature are documented from the perspectives of their ontological, epistemological, human nature and methodological assumptions. In terms of the discussion on theory, the Efficient Market Hypothesis (EMH) is selected as the most relevant for this research; the theory will be discussed in a more succinct fashion as a detailed explanation of the theoretical foundations for each empirical component of the research will be outlined in each of Chapters 5, 6 and 7.[44]

Section 4.2 describes the reasons for why the researcher decides to adopt a primarily quantitative, functionalist methodological approach is justified. Section 4.3 presents the relevant theory employed in the current study and outlines why it was selected to underpin the work. According to the Efficient Market Hypothesis (EMH) (Fama, 1965), security prices reflect all available information thus making it difficult for investors to earn abnormal returns consistently by trading on historic data. This thesis tests the weak-form of EMH with respect to CDSs; according to this hypothesis, changes of CDS spreads should not be predicable from historic information. The main source of historic information tested in the current thesis is the spread changes of the CDSs themselves as well as the spread changes of other CDSs from the same country as well as from other Asian nations. Section 4.4 introduces the sample and research methods examined in the current thesis while Section 4.5 concludes the chapter.

[44] Again, a detailed explanation of the statistical methods employed for each of the three empirical chapters will be contained within these chapters.

4.2 Assumptions about research methodology in the current thesis

Choices about an appropriate research methodology depend on the point of view of the researcher about both the nature of reality and how knowledge is discerned (Burrell and Morgan, 1979).The aim of the current thesis is to investigate the existence of credit risk spillover effects among Asian CDS reference entities and to illustrate the potential factors which explain credit risk correlations; thus, there is no attempt to change the status quo. In addition, this thesis utilises quantitative research methods to analyse the spread changes for a sample of CDS contracts and the results are assumed to be generalisable for other such contracts written by firms across various sectors in similar countries. Further, the researcher believes that CDS contracts are real tangible entities that exist independently of the market participants' consciousness. Therefore, the researcher accepts the assumptions of the functionalist paradigm.

Regarding the epistemological assumptions of the research, the current thesis assumes a positivist view of what constitutes knowledge. This thesis seeks to examine the spillover effects between different underlying reference entities from one firm's previous CDS spreads change to another firm's current CDS spreads change. According to Burrell and Morgan (1979), positivist epistemologies 'seek to explain and predict what happens in the social world by searching for regularities and causal relationships between its constituent elements' (p.5). Therefore, the CDS spread changes are assumed to constitute knowledge about the default probabilities among different CDS contracts issued by the underlying reference entities and are worthy of study by the researcher. They have important implications for the survival of the reference entity. In addition, they have cash-flow consequences for the issuers and holders of these instruments. They facilitate risk sharing and permit insurance against certain adverse outcomes; as such, they possibly influence the actions and decisions of those involved in their usage. In addition, they can be included in pension fund and insurance company portfolios; thus, they can have important consequences for the wider society which are not limited to those directly associated with their issuance or ownership. For all of these reasons, I believe that the current research is located in the functionalist paradigm.

In terms of the assumption about human nature, the current thesis adopts an intermediate position in between the extremes of determinism and voluntarism. One reason for this intermediate position is that the Asian CDS market is assumed to be affected by both a firm's internal and external environment. For instance, political and socio-economic factors in Asia together with regulations from the Bank of International Settlements and International Swaps and Derivatives Association are assumed to affect CDS spreads. In addition, since the CDS contracts are over-the-counter (OTC) products where the securities are not traded on a formal exchange, individual perceptions and subjective assessments may play some role in determining spreads. Thus, dealers in the OTC trading network may influence spreads with their own decisions to some extent. Therefore, this thesis adopts the intermediate position on the determinism-voluntarism continuum. Such an approach is recommended by Burrell and Morgan (1979) since they argue that the researcher should 'adopt an intermediate standpoint which allows for the influence of both situational and voluntary factors in accounting for the activities of human beings (when both may have a role to play)' (p. 6).

Lastly, a nomothetic methodology is employed since the analysis of the current thesis utilises quantitative methods and assumes that findings from models can supply useful insights. Sophisticated statistical and econometric models are used to investigate the CDS spread changes and credit risk spillover effects between different entities and sectors. In addition, linkages between credit risk correlations and the various corporate and market factors are examined in the current thesis as well. By selecting research questions which use concrete 'facts' and measure linkages between CDS spread changes, the nomothetic methodology was deemed to be the most suitable for the current thesis.

The concept of the paradigm is key to the research process in all areas of study. Overall, the current thesis locates itself in the functionalist paradigm since it adopts the assumptions of a realist ontology, a positivist epistemology, an intermediate view between the deterministic-voluntaristic model of human nature and a nomothetic methodology. CDS spreads change of different entities from different sectors in the Asian derivative market are assumed to be objective phenomena and the results of the current thesis should provide generalisable information for all investors rather than a subjective assessment which is unique to a given situation.

4.3 Efficient Market Hypothesis

The development of Efficient Market Hypothesis (EMH) dates back to the 1950s[45], since, at that time, there was a general belief that an active investment strategy based on looking 'at the ticker tape' could outperform the market. However, this belief was challenged by Kendall and Hill (1953), who found that the changes of the British industrial share price index and an index of commodity prices over a 10-year period from 1928 to 1938 appeared to be random. According to Kendall and others, insignificant linkages between current and previous price changes indicated that share returns moved in a random manner. Inspired by the work of Kendall and Hill (1953), Mandelbrot (1975) and Samuelson (1965) conducted more detailed investigations involving models of

[45] Some date the origin of the EMH to the work of Bachelier in 1900 while others credit MacCauley (1925) and Cowles (1933) with the start of a systematic enquiry into the behaviour of share prices. (See Sewell (2011) for a historical analysis of the foundations of the EMH which he attributes to the work of an Italian mathematician in 1564). However, research in this area built up momentum in the 1950s with the work of Kendall (1953) and Roberts (1958) and others which ultimately culminated in the exposition of the EHM as a theory during the mid-1960s (Fama, 1965).

returns but concluded that share prices changes were likely be unpredictable. These pioneering studies have played a fundamental role in the development of the EMH.

In 1965, Eugene Fama published ‘The behaviour of stock market prices’ in the *Journal of Business* and for the first time put forward the concept of an efficient market while discussing the details of a random walk model or returns and its empirical validity. Fama (1965) concluded that ‘the data seem to present consistent and strong support for the model. This implies, of course, that chart reading, though perhaps an interesting pastime, is of no real value to the stock market investor’ (p.34). If the conditions underpinning his random walk model were met, Fama (1965) suggested that a market was efficient. Further work by Fama in 1970 explicitly defined the term ‘efficient market’; according to Fama (1970):

> ‘The prices of stocks at any time always fully reflect all available information; such markets are defined as efficient’ (Fama, 1970, p.383).

Although others have sought to clarify or expand on Fama’s original definition (Jensen, 1978; Beaver, 1981; LeRoy, 1989), it has stood the test of time and remains the cornerstone of most research in the finance area. The EMH is the hypothesis that all available information is fully and instantly reflected by the security prices. If the market is efficient, it should not be possible for an investor to make excess profits consistently. According to this hypothesis, participants in the market will use all available relevant information about securities when formulating their expectations about prices. This information is impounded into the current price, therefore, by investors buying and selling shares; the price will only change as additional news becomes available. Since news arrives randomly in the market, this model of returns argues that prices will change in an unpredictable fashion.

Since Fama’s seminal work in the area, a considerable amount of literature has been published on the EMH. These studies have examined three types of efficiency; these are: 1) Allocational efficiency, 2) Operational efficiency, and 3) Pricing or informational efficiency. The term 'allocational efficiency' describes a market that directs funds to the most profitable ventures (Pike and Neale, 2006). By contrast, an operationally efficient market is one where investors can trade securities at low levels of transaction costs because of competition between market-makers. Meanwhile, pricing or informational efficiency refers to the degree to which available information is impounded into securities prices; a pricing or informationally-efficient market is one where investors cannot systematically outperform.

To date, most of the research on the EMH has focussed on informationally efficiency. Within this research area, Fama (1970) has distinguished between three levels of information efficiency; they are: 1) weak-form efficiency, 2) semi-strong form efficiency and 3) strong-form efficiency. They differ from one another in the types of information which is impounded in share prices and the implications for investment analysis.

Weak-form efficiency implies that the current security prices fully and instantly reflect all trade-related historic information which includes past price and volume data. Consequently, investors in a weak-form efficient market cannot earn excess returns consistently by employing a trading strategy which focuses on past price movements. Tests of the weak-form of the EMH have searched for a non-random pattern in security prices or investigated the profitability of trading rules which assume that trends are present in returns. Evidence for such a pattern or trends would imply that future price changes are related to past returns such that gains can be made by trading on the basis of historical price movements.

The semi-strong-form of the EMH implies that the current security prices fully reflect all publicly available information. The main difference between this variety of the

EMH and its weak-form alternative is that the publicly available information set includes not only the past history of security data, but also announcements by the firms, relevant political events or news, and the current state of the economy. Thus, for investors in a semi-strong form efficient market, it is not possible to outperform consistently by transacting on the basis of publicly-available information since once news is announced, the share price will impound the information quickly into the price and eliminate any arbitrage opportunity. Semi-strong-form efficiency is usually tested by evaluating the speed with which security returns react to specific announcements which are thought to be value relevant. Some announcements are specific to a firm (e.g. a profit warning (Bulkley and Herreias, 2005) or news of a takeover bid (Firth, 1980) while the others are mainly about economy (e.g. a rise in interest rates) (Case, 1988; Cohen *et al.*, 1972). Generally, the information from the announcements should be quickly and correctly reflected by the security prices. Therefore, the securities should not be over- or under-valued. As a consequence, it should not be possible to earn abnormal returns.

The strong-form of the EMH implies that the current security prices fully reflect all information which includes both public and insider or private information. In other words, even the traders, directors or insiders (such as some employees or board members) should not be able to earn consistent excess returns by trading on the basis of their private information; any attempt to do so will be observed by other market participants who will adjust equity prices accordingly. Tests of strong-form market efficiency are difficult to undertake because the inside information is not publicly available for academics to study. In addition, insider trading is a crime in most jurisdictions (King and Roell, 1988) which makes it unlikely that investors will confess to such activity when questioned by a researcher. Nevertheless, a number of investigations do exist in this area – usually conducted by academics with access to proprietary data from stock exchange regulators

(Meulbroek, 1992) or following a court case where details about insider trading were made public (Cornell and Sirri, 1992). The conclusion of this small body of research is that insider trading may be profitable and that the strong form of the EMH may not hold; abnormally high returns can be achieved by certain forms of insider trading[46], around the time of specific corporate events such as takeovers (Agrawal and Nasser, 2012) and involving derivative securities (Augustin *et al*., 2014). For example, Acharya and Johnson (2007) point out that credit derivatives such as CDSs are subject to moral hazard and asymmetric information risks. Although such asymmetric information risk and insider trading problems potentially exist in most markets, credit derivatives are more sensitive and vulnerable to this type of crime because the cost of transacting with derivative securities is much less and most of the CDSs players (such as banks) are insiders. As Financial Times reported on April 25, 2005:

> 'Banks must not use private knowledge about corporate clients to trade instruments such as credit default swaps (CDS), says a report by the International Swaps and Derivatives Association and the Loan Market Association…Many banks and institutions are trading CDS instruments in the same companies they finance - sometimes because they want to reduce the risks to their own balance sheets'

This thesis examines the weak-form of the EMH for one specific type of derivative security (CDSs) in five Asian capital markets. As Fahey (2013) points out 'CDS data are assumed … to follow the assumptions of the efficient market hypothesis' (p. 328). Since the weak-form of the EMH suggests that the current security prices reflect all historical information, therefore, market investors should not be able to beat the market or earn abnormal returns in a consistent manner by trading on the basis of historical price data. To test the weak-form of EMH among Asian CDSs, entities'own previous information

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[46] The vast majority of research into insider trading has focused on its impact on equity markets. For example, Easley *et al.* (1996) and Fisher and Robe (2004) find that insider trading can reduce market liquidity and increase trading costs. It also can lead to a higher cost of equity capital (Bhattacharya and Daouk, 2002) and increased volatility (Du and Wei, 2004).

about CDS spreads as well as the historic CDS spread changes of other entities are investigated.

According to Sensoy *et al.* (2017), ‘Despite the global importance of this [CDS] market, there have only been a few studies of its price efficiency in any of the forms defined by Fama (1970), — weak, semi-strong, and strong.’ (p. 5). Yet, they suggest that the efficiency of this CDs market can have important implications. For example, they argue that ‘[t]he implication of a weak-form efficient … CDS market is that information is impounded into CDS spreads in a timely manner, and that [an entity’s] default probability has an unpredictable pattern. Whereas in the case of weak-form inefficiency, the default probability follows a more or less predictable path over a long horizon.’ (p. 5). Thus, they note that ‘trading the weak-from inefficient … CDS contracts could be profitable for an investor who is skilled enough to exploit market inefficiencies. On the other hand, weak-form efficient … CDSs are less likely to be used as the sole trading instrument to gain speculative returns’ (p. 5).

Sensoy *et al.* (2017) summarise the findings from the small but growing literature which examines the efficiency of the CDS market in the US and Europe. They stated:

> ‘Only five studies have examined the price efficiency of the CDS market, four focusing on the corporate CDS sector and one on the sovereign CDS sector. Two studies, Zhang and Zhang (2013) and Jenkins *et al.* (2016), test the semi-strong form for the U.S. corporate CDS market. Both studies find that this sector of the CDS market is informationally efficient. However, although Jenkins *et al.* (2016) find that the U.S. corporate CDS market is efficient before and after the global crisis in 2008, they call into question its efficiency during the crisis period’ (p.6).

Avino and Nneji (2014) found that European corporate CDS spreads are characterized by the existence of a predictable pattern and argued that the corporate sector of CDS market was not weak-form efficient. Moreover, Kiesel *et al.* (2016) investigated both the US and European corporate CDS markets, they concluded that the market is not truly efficient. Investigating the weak-form, In contrast, Gunduz and Kaya (2013) is the only study that focuses on the sovereign CDS markets for 10 Eurozone developed countries In order to test the weak-form of EMH, they reported that the sovereign sector of the European CDS market has been efficient even during the recent financial crisis.

Recent research has started to examine the efficiency of CDSs in emerging market countries. For example, when Gunay and Shi (2016) 'analyze the long-memory dependency in volatility of CDS spreads of four emerging markets (Turkey, Russia, South Africa, and Brazil) from 2001 to 2014 …[they report] that the Efficient Market Hypothesis (EMH) may not hold for the CDS spreads of those four countries.' Sensoy *et al.* (2017) arrive at a slightly different conclusion when they study some of the countries included in the current thesis. From their analysis, where they 'compare the time-varying weak-form efficiency of Credit Default Swap (CDS) markets of 15 emerging countries, [they] … find that CDS markets have different degrees of time-varying efficiency. Using several robustness test, [they] find that … China, South Korea and Malaysia have the most efficient CDS markets' (p. 5).

4.4 Selecting of data

Building on previous discussion about the underlying theory which underpins the current thesis, this section of the chapter outlines the procedure employed for selecting the sample used in the research; a brief description of the research methods that are used is also given.[47]

The main dataset of this thesis consists of daily observations of CDS spreads obtained from Thomson Reuters Datastream; from this global dataset, information about five Asian countries covering sovereign, financial and non-financial CDSs were selected

[47] In particular, an overview of procedure of sample selection and sample data of the current thesis is presented in this section while further descriptions of datasets utilised are evenly presented in Chapter 5, Chapter 6 and Chapter 7, respectively.

for investigation. CDS spreads for sovereign debtors are used to measure systemic credit risks while CDS spreads for financial and non-financial corporations are analysed to capture firm-level credit risk.[48] There are nine national market participants in the CDS market within Asia according to the dataset provided by Thomson Reuters Datastream; these are: China, Hong Kong, Japan, Malaysia, the Philippines, Singapore, South Korea, Thailand and the Middle East. At the sector level, firms which issue CDSs are drawn from 13 market segments: Agency, Banks, Consumer Goods, Electric Power, Energy Company, Gas Distribution, Manufacturing, Official and Municipal, Other Financial, Service Company, Supranational, Telephone and Transportation. However, the Asian credit derivatives market is still young when compared with its counterparts in some of the more advanced economies of the world (BIS, 2010). At a regional level, the distribution of CDS contracts do not fully cover these 13 sectors. In addition, the dataset of sovereign CDS is partial as these instruments are not issued for each country; for instance, CDS contracts are not available for Indian sovereign bonds.

This thesis divides the CDS market participants in Asia into three categories: sovereign debtors, financial institutions and non-financial firms. One reason for this classification is that this thesis aims to fill the gap in the literature about credit spillover effects among sovereign entities and non-financial firms in Asia; it does not seek to measure the idiosyncratic credit risk in each specific sector using CDS instruments, nor does it aim to study CDS measures of credit throughout the world. Instead, a decision was taken to focus on Asian countries with available data covering sovereign, financial and non-financial CDSs. Five Asian countries satisfied the focus of this discussion and these formed the sample for the current thesis; they are: China, Japan, Malaysia, Singapore and

[48] It is important to notice that CDS spreads also depend on other factors such as market liquidity, counterparty risk and the global financial environment, such as the US interest rates and global risk appetite. A full description of statistics from impact factors is provided in Chapter 7 of the thesis.

South Korea. Therefore, data for these three countries within the Thomson Reuters Datastream region of 'Asia' were excluded from the analysis because of insufficient data: the Philippians, Thailand, and the Middle East.[49]

Hong Kong as a special administrative region of China is grouped with the mainland; this means that firms in the Hong Kong Special Administrative Region (Hong Kong SAR) and in mainland China are incorporated into one group – Hong Kong CDSs are analysed in conjunction with instruments based on Chinese sovereign debt obligations. Sun and Zhang (2009) document a high level of financial integration between mainland China and Hong Kong SAR in terms of their stock markets.[50] Studying the combined entity of mainland China and Hong Kong SAR together with data for Malaysia, Singapore and South Korea is especially useful for testing the informativeness of CDS spreads in emerging credit markets. For example, Ismailescu and Kazemi (2010) suggest that changes of sovereign CDS spreads in emerging markets are different from their counterparts in developed countries.[51] Their findings show evidence of an asymmetric reaction among emerging CDS markets to credit rating events; CDS spreads in emerging markets reacted to positive events immediately while their response to negative events generally took two-days.

The time span of the current study covers the period from January 2009 to March 2014 yielding a total of up to 1,368 daily observations for each series.[52]Although data for

[49]. In addition, the size of the underlying bond markets are small for these three countries. For instance, in the Philippians and Thailand, domestic bonds are mainly issued by the national government although the corporate bond markets in these countries have grown rapidly over recent years. Data available at: www.asianbondsonline.adb.org.
[50] The estimated stock market conditional correlations between mainland China and Hong Kong SAR from a GARCH model in the analysis of Sun and Zhang (2009) are positive and statistically significant. Therefore, their findings echo the results of other studies about the increasing financial integration between China and Hong Kong which enabled this thesis to combine both datasets together.
[51] Ismailescu and Kazemi (2010) studied 22 emerging markets including 6 Asian countries (China, Indonesia, Malaysia, Philippines, South Korea, and Thailand).
[52] A longer time span from January 2009 to December 2015 is employed for Chapter 7, a detailed description of data is provided in Chapter 7.

CDS spreads is available from CMA for New York starting in 2003, this organisation was taken over by S&P500 in October 2010 leading to a change in the recording of CDS spreads; since the current study aims to examine these derivatives products over a recent time frame, this limitation prevents the use of CMA data. By contrast, the Thomson Reuters Datastream database has daily CDS data for research analysis from the end of 2008 up to the present. In particular, the Datastream data are available for all sovereign debtors from December 2007. This start date is unsurprising since most of the sovereign debtors and corporations throughout the world only have started CDS activities since 2006.[53] However, trading of non-sovereign, Asian-named CDS contacts only started recently; for example, the first Asian named CDS iTraxx index (e.g., iTraxx Japan and iTraxx Asia ex-Japan) started to trade in July 2004 and the trading was relatively limited in the first few years (Shim and Zhu, 2010). The short time span of CDS spreads for the Asian credit market and the limited number of market participants restrict the data analysis in the pre-crisis period before 2008. Thus, the time period for this analysis in this thesis spans the months from January 2009 to the most recent.

The Thomson Reuters Datastream provides information for the term structure of CDS spreads with 6 months, 1-, 3-, 5-, 7-, and 10-year contract for each CDS entity. However, this thesis only considers daily CDS spreads of 1-year and 5-year contracts; other contracts were dropped from the analysis because relatively few CDS contracts existed for the 6-month, 3-year, 7-year and 10-year length. As stated before, most previous studies focus on 5-year CDS contracts on the grounds that the market for these contracts is more liquid (Chan-Lau and Kim, 2005; Blanco *et al.* 2005). Commissioned

[53] Despite the relatively recent beginnings of this market, it has grown quickly. The outstanding amount of these derivatives in Asia rapidly reached its peak of $62.2 trillion at the end of 2007, before the global financial crisis lead to a decline in activity; the CDS market fell to $26.3 trillion by mid-year 2010 (ISDA, 2010).

by ISDA, Culp *et al.* (2016) reviewed the most relevant approximate 260 empirical studies on single-name CDSs, where only 42 of them studied 1-year CDSs.[54] To extend our knowledge of short-term credit risk transmission, the analysis of this thesis will also include 1-year CDS contracts, to supplement findings from previous studies, as well as to act as a robustness check on results from the 5-year CDS contracts. Furthermore, usage of daily CDS spreads enables the research to capture any specific patterns which may be present over the different time frames, such as a jump of spreads due to any potential credit event on a specific day; this is particularly important when testing data that may react to level shifts and changes in trends in a very speedy fashion.

A majority of CDS contracts trading in the sample markets are denominated in US dollars; as a result, a decision was taken to convert the spreads of CDS contracts denominated in other currencies into US dollars using daily foreign exchange rate data on same day. Furthermore, to avoid any inconsistency in the dataset as well as any variations in market regulations, this thesis analyses spreads of senior, full-restructuring CDS contracts for the sample of five Asian credit markets.[55] The quoting convention for CDS is the annual premium payment as a percentage of the notional amount of the reference obligation (basis points). Table 4.1 presents selection criteria of the sample analysed in this thesis.

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[54] These 260 empirical studies on single-name CDSs are selected from peer-reviewed academic journals, quasiacademic/trade journals with largely academic editorial boards and working papers distributed through the Social Science Research Network (SSRN), universities, and the research divisions of financial regulators (e.g., the Bank for International Settlements, European Central Bank, and Federal Reserve).

[55] According to the classification set by the ISDA, restructuring constitutes a credit event in CDS contracts. Furthermore, there are four types of CDS contracts concerning restructuring since 2003, there are, full-restructuring (CR), Modified-R, Modified-Modified-R and No-R. The full-restructuring (CR) clause was the standard contract term in the 1999 ISDA credit derivatives definition and the most frequency traded in Asian CDS markets. Under the restriction of a CR CDS contract, protection can be triggered by any of these followings: 1) There is any reduction in interest or principal payable, 2) There is a postponement of interest or principal repayments, 3) There is a changes in the priority of the reference obligation, and 4) There is a change in currency of payment. The Modified-R, the Modified-Modified-R and the No-R. The Modified–R was introduced for the North American market and most investment-grade are traded in Modified-R. By contrast, those on high yield-names have traded in No-R. However, since 2009, new CDS contracts in North America will trade only in No-R form. The most popular form in Europe is Modified-Modified-R.

The final sample consists of 121 corporations that are connected with ten different sectors located in the five different Asian countries. In addition, each country has one sovereign CDS spread index, which leads to a total number of 126 series included in the analysis of this thesis. Table 4.2 provides details about the distribution of sovereign and corporate CDSs by country and sector with codes in parentheses. A list of firms' names is displayed in Appendix 4.1. An analysis of Table 4.2 highlights a number of interesting features about the CDS markets at both the country- and sector-level. From this table, it is apparent that Japanese CDSs dominate the Asian named CDSs sample, representing about 50% out of the total CDSs studied.

Table 4.1: Sample and selection criteria

No.	Selection criteria	Selection details
1	Data source	Thompson Reuters Datastream
2	Sample country	Asian country
3	Sample sectors	Datasets covering sovereign debtors, financial institutions and non-financial firms
4	Data frequency	Daily CDS spreads
5	Time span	Full datasets available from January 2009
6	Maturity	Full datasets available for both 1-year and 5-year maturities
7	Contract type	Senior full-restructuring (CR) clause of CDS contracts

Note: This table shows principal sample selection criteria for datasets usage in this thesis. These selection standards are classified into seven categories: Data source, sample country, sample sectors, data frequency, time span, maturity and contract type. Selected sample country must satisfy all of those seven selection standards to forward the analysis of this thesis.

This is not surprising because Japan and South Korea have the largest bond markets in Asia while in other Asian countries such as China, sovereign bonds or the bonds of government-sponsored entities dominate the bond markets (Shim and Zhu, 2010; Franks et. al., 2012). More surprisingly, non-financial firms represent 75% of CDSs in the sample selection; this finding confirms the importance of analysing non-financial

CDS spreads in Asia. Only 30% of the CDS issues related to bonds issued by financial institutions, and when these are excluded, the 91 remaining series relate to non-financial firms. The CDSs examined are not equally spread across the eight sectors studied. Some 40% refer to bonds issued by manufacturing firms while transportation, electric power and telephone companies are also well represented in the sample.

To analyse these data series examined in the thesis, a Generalised Autoregressive Conditional Heteroscedastic (GARCH) model is typically employed. This is an extension of Autogressive Conditional Heteroscedasicity (ARCH) process proposed by Engle (1982). The GARCH models by Bollerslev (1986) are well known in modelling the volatility of returns for different financial assets. Another advantage of GARCH models is that they facilitate the tracking of spillover effects; in a univariate GARCH model, an

Table 4.2: Distribution of sovereign and corporate CDSs in sectors and countries

Sector/Country	China	Japan	Malaysia	Singapore	South Korea	Obs.
Panel A: Sovereign sector (SOV)						
Sovereign debtor	1	1	1	1	1	5
Panel B: Financial sector (F)						
Bank	5	2	2	2	8	19
Other Financial Institution	2	5	1	1	2	11
Panel C: Non-financial sector (NF)						
Consumer Goods	0	3	0	0	1	4
Electric Power	0	3	1	2	3	9
Energy Company	1	1	1	0	3	6
Manufacturing	3	28	1	1	6	39
Service Company	0	5	0	0	3	8
Telephone	2	4	1	1	1	9
Transportation	2	9	1	0	1	13
Other non-financial Firm	1	1	0	1	0	3
Obs.	17	62	9	9	29	126

Note: This table shows the distribution of types of CDS reference entities in the analysis of this thesis.

entity's own spillover effects are tested; however, a multivariate GARCH approach is increasingly preferred in the literature over univariate settings as the former also specify equations for how the covariances between each pair of series change over time. Therefore, the analysis of the current thesis applies a Multivariate GARCH model to capture the spillover effects between CDS spread changes across different sectors and countries.

Several different multivariate GARCH models formulations have been proposed in the literature, including the VECH model (e.g., Bollerslev, Engle and Wooldridge, 1988), the diagonal VECH model (e.g., Bollerslev, Engle and Nelson, 1994) and the Baba-Engle-Kraft-Kroner (BEKK) model (Engle and Kroner, 1995).[56] In this thesis, a full-BEKK MGARCH model is chosen to estimate spillover effects between CDS spreads changes across sectors and countries. There are a number of reasons behind this choice. First, the MGARCH models can only be estimated by imposing specific restrictions for conditional variance-covariance matrix (Gourieroux, 1997) and it is difficult to ensure positive definiteness of the covariance matrices (Chris *et al.*, 2003).[57] The BEKK model proposed by Engle and Kroner (1995) addressed the difficulty with VECH of ensuring that the variance/covariance matrix is positive definite by using quadratic forms; it also allows for the possibility of dynamic correlations and permits for volatility spillover across markets.

As the number of estimated variables (*N*) in a MGARCH model increases the number of estimated parameters rises. For example, the number of parameters equals to

[56] There are also other forms of multivariate GARCH models, such as factor models which are first introduced by Engle, Ng and Rothschild (1990), see Silvennoinen and Terasvirta (2008) for a comprehensive discussion.

[57] There is another problem with all kinds of MGARCH models, to find starting-value for variance and covariance matrix. It is typically solved by using the estimated unconditional covariance matrix as the initial value (Brooks *et al.* 2003).

$(p+q)(N(N+1)/2)^2+N(N+1)/2$; thus, for a bivariate GARCH(1,1) model, the number of parameters equals 21, but when N is 3, the number of parameters raises to 78. Therefore, a trivariate GARCH model regression was chosen to capture domestic cross-sectoral credit risk spillover effects[58]. To allow an investigation of a large number of possible intra- and inter-sectoral spillovers among 126 reference entities[59], a bivariate GARCH model regression is chosen to capture pairwise spillover effects for both domestic and cross-country level analyses.[60]

A panel model regression is employed to analyse the effects of various factors on credit risk linkages after the potential credit risk spillover effects have been identified. Generally, the mostly commonly used classes of models for panel analysis are fixed-effects models and random effects models (also known as the error components model). Under the first grouping, fixed-effects models can be further divided into entity-fixed effects and time-fixed effects models. For example, the entity-fixed effects models allow the intercept terms in the regression to differ cross-sectionally but not over time. By contrast, the time-fixed effects models allow the intercepts to vary over time but assume that they are fixed across entities at each given point in time.[61] However, the random effects models allow for variation over time and cross-sectionally; in addition, a two-way model can also be envisaged to allow the intercepts to vary both cross-sectionally and over time. The Hausman test will be employed to select between these two approaches.[62]

[58] 7x9 + 7x54 + 3x5 + 3x5 + 10x18 = 651 sets of entities

[59] (7x6 + 9x8 +7x6 + 54x53 + 3x2 + 5x4 + 3x2 +5x4 + 10x9 + 18x17)/2 + (5x4 + 30x29 + 91x90)/2 + (121+651) + (5x 121 + 30x91) = 10380 relationships

[60] Furthermore, as some literatures pointed out that estimation of the parameters is computationally demanding as well (Brooks *et al.* 2003).

[61] For example, the effects of changes of domestic tax rates or government policy regulation during a period may well influence all national institutions, which can be assumed to all be affects equally by the change.

[62] Initially, the Hausman test determines whether or not the random effects are correlated with the explanatory variables. For example, if the Hausman test statistic is significant this indicates that the random effects model is not appropriate and that the fixed effects specification is preferred.

4.5 Conclusion

The thesis aims to investigate credit risk spillover effects in Asian CDSs after the 2008 global financial crisis. Thus, quantitative methods are employed to examine the efficiency of the CDS market; I model the CDS spread changes and the volatility of spread changes to study the spillover effects among five Asian countries. GARCH models are used in Chapters 5 and 6 to examine the efficiency of the CDS market and the identify spillover effects of credit risk among Asia CDSs. To investigate the cross-sectoral and cross-country effects on credit risk spillovers (in Chapter 6), a full-BEKK specification is undertaken. Furthermore, to determine whether corporate and market factors have explanatory power on credit risk linkages, the random effects models is studied in Chapter 7 to assess the effects of various factors.

Chapter 5: Credit risk spillover effects between sectors within an Asian country

5.1 Introduction

Evidence of significant credit risk spillovers in the US and Western countries during the 2008 global financial crisis and the 2010 Euro debt crisis in a number of studies has been indicative of a bidirectional linkage between the credit risk of the sovereign debtor and its domestic financial institutions (Alter and Beyer, 2014; Alter and Schüler, 2012; Gross and Kok, 2013; Pagano and Sedunov, 2016). However, studies on the credit risk spillover effects using CDS data within Asia after the crisis are relatively scarce. Only a limited number of investigations have been conducted in this area, with the majority thereof focusing on the credit risk interdependence between banks (Baba and Inada, 2009) and the transmission of credit risk from advanced countries to emerging markets (Lahmann, 2012; Wang and Moore, 2012). Even though systemic risk is usually associated with the banking system, it may have negative consequences not only for the credit standing of banks but also for the sovereign debt of a country and firms in real sectors (Acharya *et al.*, 2014). Furthermore, the findings regarding the potential exposure to contagion between different sectors also promoted a call for further research using more sophisticated models in order to examine the transmission of credit risk via shocks and volatilities.

This chapter presents an empirical analysis of credit risk spillover effects among three sectors within an Asian nation; it utilises CDS data in the sovereign, the financial and the non-financial sectors in each of the five Asian countries selected for this study (i.e., China, Japan, Singapore, Malaysia and South Korea) in order to measure the transmission of credit risk in an Asian economy. In addition, both 1-year and 5-year CDS data are employed to facilitate a comparison of the difference between the short-term and long-term credit risk transmission. Credit risk spillover effects are examined using a trivariate-GARCH-full-BEKK model for 1,302 sets of CDS data including both 1-year and 5-year CDSs. For each maturity, a set of the CDS data is computed once by choosing three series of changes in the respective CDS spread, including one from the sovereign sector, one from the financial sector and one from the non-financial sector in each of the five Asian countries. Thus, the analysis of this chapter should contribute to our knowledge by considering non-financial firms in the investigation of credit risk spillover effects in Asia. Moreover, the efficiency of the Asian CDS markets can also be assessed by including CDSs from different entities in one model. An efficient market is one in which past information should not be able to forecast current or future prices on a consistent basis. The GARCH model employed makes it possible to test this hypothesis by examining whether the historic information of changes in the CDS spread can be used to predict the current changes in the CDS spread. Furthermore, the GARCH model with a full-BEKK specification also makes it possible to examine the direct and indirect effects of shock as well as the volatility spillovers from the variance-covariance matrices. In this chapter, the mean and the variance-covariance equations in the GARCH model are estimated simultaneously by means of the maximum likelihood estimation method.

There are a number of findings in this chapter. One of the main findings indicates that Asian CDSs show significant reference entities' own- and cross-sectoral credit risk spillovers in each country; credit risk spillovers from both spread changes and volatility are found, although the dynamics of the spillover effects differ. These significant credit risk spillover effects suggest that there is prima facia evidence of inefficiency in Asian CDS markets; in other words, the identification of spillover effects from CDS data potentially represents evidence against the EMH. Furthermore, the identification of cross-sectoral credit risk spillover effects also indicates a potential risk of contagion between different sectors in a nation; for instance, the significant credit risk spillover effects between a sovereign debtor and its domestic non-financial firms evidence the important role played by the non-financial sector in the transmission of credit risk in an economy. In particular, credit risk spillover effects are more pronounced in the long term than in the short term in Japan, as a bidirectional linkage between the sovereign and the non-financial sectors is observed by using 5-year CDSs.

The remainder of this chapter is organised as follows. A brief overview of the background information on the credit risk spillover effects among the sectors within a nation is presented in section 5.2. Section 5.3 introduces the data and research approach undertaken to analyse the credit risk spillover effects among domestic sectors; section 5.3.1 presents a preliminary analysis of the sample data and section 5.3.2 provides an introduction of the trivariate VAR-GARCH-full-BEKK research approach undertaken. Section 5.4 presents the findings of this chapter; section 5.4.1 discusses the findings from 1-year CDS contracts, while the robustness tests based on 5-year CDSs are presented in section 5.4.2. Section 5.5 concludes this chapter.

5.2 Related literature

Along with the growth of trading activities in the CDS markets, there is an increasing number of research papers focused on the investigation of credit risk spillover effects using CDS spreads. Previous studies have reported the existence of significant credit risk spillover effects between the sovereign debtor and its domestic banks in advanced countries, such as the US, and in some European countries. For example, Dieckmann and Plank (2012) suggested that market participants incorporate their expectations for the financial system bailouts and the potential burden of government interventions, which have created a ‘private-to-public’ transfer channel of credit risk. An empirical study conducted by Alter and Schüler (2012) examined the credit risk spillover effects between sovereign debtors and banks in European countries during the 2010 Euro debt crisis. Their results identified the tightened nexus between the credit risk of a

European state and banks during the period of bank bailout programmes, as the bailouts change the composition of both the sovereign debtor and banks' financial positions. Furthermore, the findings from Alter and Schüler (2012) also documented that in the period preceding the bailouts, the transmission of credit risk disperses from banks to the sovereign debtor and switches to the opposite direction after the bailouts. This two-way feedback correlation between sovereign debtors and banks has also been documented by Greatrex and Rengifo (2012), Lahmann (2012) and Pagano and Sedunov (2016). The findings of these studies provide a possible explanation suggesting that the appetite of investors links banks' and sovereign credit risk together after public rescues, thus leading to a concern on the possibility that the government balance sheet may not provide good guarantees to those financial institutions. Hence, there is a potential source of system risk considering that the sovereign creditworthiness carries a growing weight in the overall financial market. Thereby, a destructive feedback loop will be triggered, resulting in the increase of credit spreads of both banks and sovereign debtors. Furthermore, the findings also demonstrated that the transmission of credit risk between the sovereign debtor and banks varies in different countries.

In contrast, very little is known about the credit risk spillover effects between a sovereign debtor and its non-financial sector using information from the CDS markets. However, there are several explicit transmission channels of credit risk between the sovereign debtor and the non-financial sector. The first direct transmission mechanism is the process of taxation; when the credit risk of the sovereign debtor increases, the government responds by raising future tax rates. Hence, the future growth of corporate profitability may be reduced. The second channel is constituted by 'sovereign ceilings', which means that the highest credit rating that a firm can have is indicated by the credit rating of its respective home-country; in other words, non-sovereign entities cannot borrow on better terms than the government (Borensztein *et al.*, 2013). As a consequence, firms with a similar credit risk level as the local government may be affected by the increased credit risk of the sovereign debtor (Almeida *et al.*, 2017). Moreover, the transmission of credit risk can also be conveyed via investments and consumption, as an increase in sovereign credit risk may be associated with a decline in the public demand for goods and services, which can affect the firms that heavily depend on domestic public spending. Several studies have attempted to investigate the impact of sovereign credit risk on the corporate CDS spreads. For example, Haerri *et al.* (2014) found a positive correlation between sovereign CDS spreads and their corresponding corporate CDS spreads in 2009-2011; in particular, this credit risk relationship expanded during the period of the 2010 Euro debt crisis. Augustin *et al.* (2016) conducted an event study in order to examine the credit risk spillovers from sovereign to corporate CDS spreads by using the changes affecting 226 firms in 15 European countries. They focused on the analysis of a short sample period ranging from February 2010 to June 2010 in order to detect any changes in the transmission of credit risk before and after the Greek bailout. The results are in line with Haerri *et al.* (2014), who suggested positive significant interdependence between the changes in sovereign CDS spreads and firms' CDS spreads[63], while no statistically significant linkage was identified before the Greek bailout.

As introduced before, only very few studies investigated the scenario of credit risk transmission by taking the sovereign debtor, the financial and non-financial sectors together in an entire economic system using CDS data. For instance, Acharya *et al.* (2014) developed a theoretical framework of credit risk transmission by adding in the impact of non-financial firms. They assumed that bank bailouts are funded through the future

[63] By using an OLS regression, the findings from Augustin *et al.* (2016) reported that a one per cent increase in the sovereign CDS is generally associated with a 0.11% increase in its domestic corporations.

taxation of the non-financial sector[64], as a consequence, the bailout programme can induce the non-financial sector to underinvest. In this way, the credit risk of the sovereign debtor, along with that of the financial and non-financial sectors are closely correlated. Their empirical findings are in line with Dieckmann and Plank (2012) and Alter and Schüler (2012), confirming the two-way transmission loop between a sovereign debtor and its financial sector because the financial sector holds a significant amount of home-country debt. More importantly, the taxation process of the domestic non-financial sector plays a crucial role in linking the credit risk of an economy; in other words, the credit risk of a sovereign debtor and its non-financial sector are closely correlated and this correlation should be considered in the analysis of credit risk transmission.

Because there is a dearth of studies on the transmission of credit risk using Asian CDS data, it is difficult to outline a separate discussion of the respective findings. However, there are some relevant studies from the analysis of credit ratings (Williams *et al.*, 2013) and bond spreads (Durbin and Ng, 2005); even though they employed bond market data, the findings are still valuable. Williams *et al.* (2013) found that the credit ratings of banks in emerging markets are sensitive to both an upgrade and a downgrade of their corresponding sovereign ratings in 2008-2009; in particular, banks were less likely affected by the downgrades during the 2008 global financial crisis. Moreover, the sensitivity of bank credit ratings to the respective sovereign ratings varies across countries, which depends on a country's macroeconomic condition. However, this finding is not

[64] The tax process has a Laffer curve property so that the optimal bailout size and tax rate can be obtained. In particular, a sovereign debtor can also generate bank bailouts by increasing inflation, therefore the real amounts paid to the holders of sovereign debt can be reduced. However, it is argued that this option also has some limitations, for example, a meaningful deduction of the real sovereign debt amounts is likely to be associated with 'a large surprise increase in inflation' and the costs of such an increase are arguably much worse than a sovereign default because 'a big increase in inflation would further impose large negative costs to everyone else in the economy by distorting private borrowing and saving, wages, employment, and investment'(Acharya *et al.* 2014, p.2735). This assumption is in line with previous studies, such as Acharya and Yorulmazer (2007, 2008) and Philippon and Schnabl (2013), who claimed that the cost of bank bailouts to the government is increasing the quantity of bailout funds.

driven by the ownership of banks, as state-owned, foreign-owned or local private-owned banks are all sensitive to the changes of the respective sovereign credit rating. Durbin and Ng (2005) employed secondary emerging market bond data from January 1995 to June 2000 for 116 corporates (i.e., 49 financial institutions and 67 non-financial firms) providing some possible explanations on the credit risk transfer between sovereign debtors and non-sovereign debtors.[65] For example, they argued that non-financial firms, which have substantial earnings from export, mitigate the impact of their credit risk linkage with the home government because investors may not expect direct interdependence of default risk between them; this finding is particularly significant for South Korean firms, such as Pohang Iron and Steel and Samsung.

5.3 Data and methods

5.3.1 Data

Daily CDS spreads on 1-year and 5-year CDS contracts were gathered from Thomson Reuters DataStream for entities in five Asian countries: China, Japan, Malaysia, Singapore and South Korea. The time span of the chapter covers the period from January 2009 to March 2014, yielding a total of up to 1,368 daily observations for each series. A majority of the CDSs in the sample are traded in the US market, so they are denominated in US dollars. Two exceptions here are the CDSs (i) for the sovereign entity for Malaysia and (ii) for some Japanese firms; the CDS contracts written for the Malaysian sovereign entity are denominated in Euros, while those for a number of Japanese firms are denominated in Japanese Yen. Therefore, their CDSs spreads were converted into US dollars using daily foreign exchange rate data.[66] Furthermore, to avoid any problems with heterogeneity in the type of the CDSs studied as well as variations in market regulations,

[65] In particular, 19 of them are Asian bonds from South Korea, Malaysia, the Philippines and Thailand.
[66] There are 26 non-financial firms, whose CDS contracts are denominated in Japanese Yen.

the discussion of this chapter only analyses the spreads of single-name senior full restructuring CDSs. The analysis of the final sample contains daily CDS spreads for 121 corporations and 5 sovereign debtors; the 121 corporations are drawn from both the financial and non-financial sectors located in five Asian countries.[67] In particular, most previous studies have focused on 5-year CDSs on the grounds that the market for long-term contracts (i.e., 5-year CDSs) has more liquidity (Tamakoshi and Hamori, 2013b), but this chapter focuses on 1-year CDSs in order to enhance our knowledge of credit risk transmission over the short-term. A robustness check on the results of 5-year CDSs is also provided to supplement the findings.

The Asian derivative market has rapidly expanded over recent years; it is estimated that the Asian derivative market occupied 10% of the global credit derivative markets in 2015 (BIS, 2015). In particular, Tokyo and Hong Kong are the main trading centres of Asian derivatives. As introduced in the background chapter of this thesis and similar to the European and American credit derivative markets, CDSs dominate the Asian derivative markets, accounting for a half of the OTC activity.

The first single-name CDS contract issued by an Asia-Pacific borrower dates back to the late 1990s. The first regional CDS indices were iTraxx Japan and iTraxx Asia ex-Japan. These two CDS indices started to be traded in the market in July, 2004. The trading was relatively limited in the first few years, but after the reconstitution of these indices in response to a surge in bond issuance by new large borrowers in the region starting in the fourth quarter 2006 trading has soared. The liquidity in the index market has also spread

[67] At the sector level, firms which issue CDSs are drawn from 10 sectors. The financial sector contains institutions from banking and other financial sectors. The non-financial sector includes firms specialised in the provision of consumer goods, electric power, energy, manufacturing services, telephone services, transportation, and other non-financial firms. A detailed distribution of these firms is provided in Table 4.3 in Chapter 4.

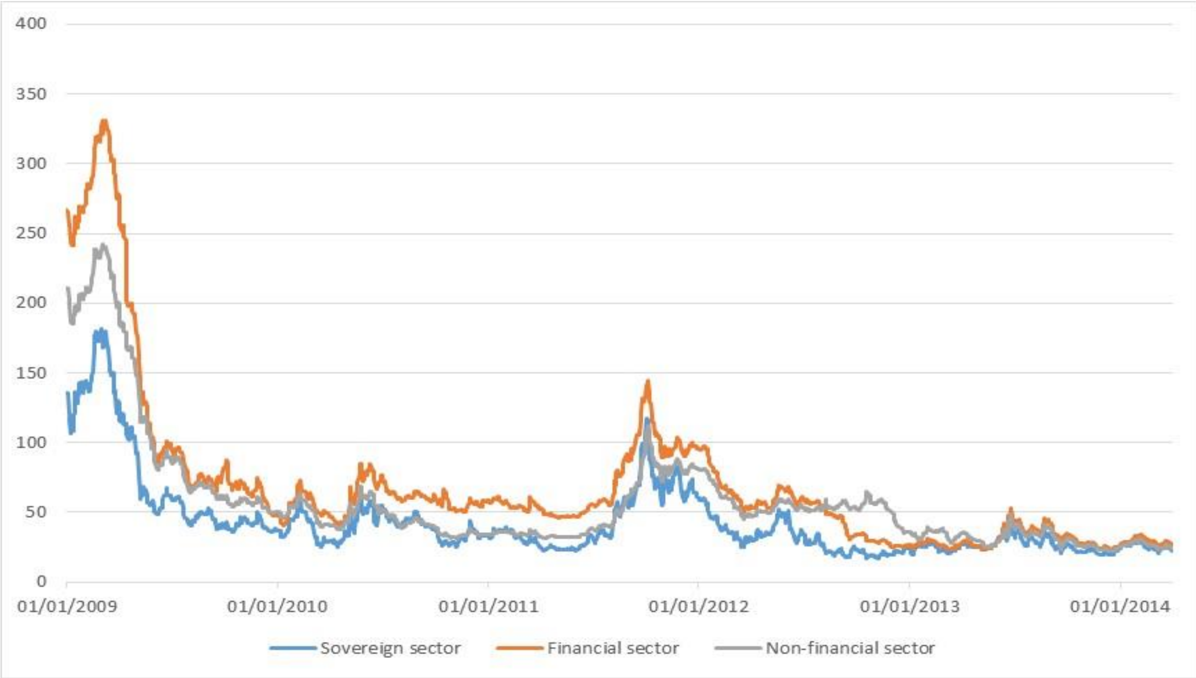
out to the market for single-name CDS contracts. Consequently, the Asian CDS market started to emerge as a potentially important market in its own right. (Shim and Zhu, 2010).

Similarly, as with the European and American CDS markets, the market for credit risk trading in Asia has also grown rapidly in the past decade. However, in comparison to Europe and the United States, the CDS market in Asia is still relatively small and illiquid. The Asia-Pacific CDS market still provides only limited access to international investors. The reason behind this peculiarity is that the domestic bond market with its debt obligations denominated mainly in local currencies has a tendency to accept only an issuer with the highest rating (Remolona and Shim, 2008). Therefore, the domestic bond buyers may not need or show little interest in having credit risk protection in the form of CDS contracts. However, from the international investor perspective, highly rated debt issues in Asia which are rated by domestic agencies might not receive the same rating score, when assessed by international rating agencies. For example, depending on the state of the economy an Asian rating agency may give a superior AAA rating to a domestic bond, while in the international bond market it is often rated several notches lower at A or BBB. Thus, foreign investors would be interested in hedging the higher credit risks (as assessed by the international rates).

Furthermore, as pointed out by Longstaff et al. (2005), the credit spreads of a firm not only represent the default component but also the non-default component. In spite of the default component, they find that the non-default component is strongly time-varying and related to the market liquidity of the respective bonds and CDSs. In other words, the life of a CDS contract and the liquidity of the market also contribute to a firm’s CDS spreads. Hence, the differences between the short and long run CDSs could be partially due to the impact of liquidity. In addition, a number of studies also identify the significant effect of market appetite on a firm’s future default risk. For instance, uncertainty over a firm's long-term financial position may result to higher CDS spreads compared with the short-term one. Taken together, the analysis of this thesis regarding the transmission of credit risk should contribute to the literature regarding the differences of credit risk spillover effects in the short and long run.

Figure 5.1 presents the time series dynamic of CDS spreads ranging from January 2009 to March 2014 for 1-year CDSs and 5-year CDSs; the upper half of Figure 5.1 shows the 1-year CDS spreads series while the lower half reports the 5-year CDS spreads series. In particular, the time series of CDS spreads for the sovereign, financial and non-financial sectors are illustrated separately in order to identify any co-movements between them during the sample period. A number of findings are presented in more detail in Figure 5.1. First, what stands out in Figure 5.1 is that the CDS spreads peaked in the beginning of 2009 regardless of the different maturities and sectors. For example, the average 1-year CDS spreads of the financial sector rose steeply from approximately 270bps to 330bps and that of its 5-year counterparty increased from 320bps to 280bps. This is not monitored because the 2008 global financial crisis was still ongoing in 2009; while the crisis centre was in the US, this finding also provides evidence on the fact that there was a significant transmission of the credit risk shock from the US to emerging markets such as Asian

Figure 5.1: Time series of CDS spreads in 2009-2014



1-year CDS spreads

5-year CDS spreads

Table 5.1: Summary statistics of Asian CDSs in 2009-2014

Market participant	1-year CDSs						5-year CDSs					
	CDS spreads			Average CDS changes			CDS spreads			Average CDS changes		
	Max.	Min.	ADF	Mean	SD	ADF	Max.	Min.	ADF	Mean	SD	ADF
Panel A: Sovereigns												
All sovereign debtors	299.02	0.02	0	0.31	8.88	0	465.00	0.22	0	0.06	4.03	0
China	156.01	5.74	0	0.37	10.72	0	465.00	55.41	0	-0.05	3.82	0
Japan	0.87	0.02	0	0.70	14.12	0	1.26	0.22	0	0.26	7.89	0
Malaysia	299.02	7.11	0	0.25	9.02	0	405.45	84.52	0	0.01	3.66	0
Singapore	60.01	18.37	0	0.08	1.73	0	259.50	52.00	0	0.01	3.66	0
South Korea	448.5	7.15	0	0.12	8.80	0	83	35	0	0.05	1.12	0
Panel B: Financial sector												
All financial institutions	488.00	1.29	13	0.17	9.83	0	497.33	26.85	13	-0.04	3.21	0
China	415.00	5.27	1	0.14	7.41	0	475.00	50.00	2	-0.03	3.15	0
Japan	488.00	2.27	4	0.21	9.43	0	497.33	26.85	4	-0.05	3.69	0
Malaysia	369.75	11.32	0	0.03	5.69	0	470.00	67.00	0	-0.02	2.92	0
Singapore	132.00	4.13	1	0.10	7.37	0	200	35.00	1	-0.03	2.78	0
South Korea	684.13	1.29	7	0.36	19.24	0	740.00	46.45	7	-0.07	3.51	0
Panel C: Non-financial sector												
All non-financial firms	581.71	0.01	28	0.07	6.66	0	586.45	0.16	25	-0.03	3.23	0
China	371.25	8.32	2	0.01	4.99	0	525.00	28.00	3	-0.04	2.52	0
Japan	581.71	0.01	14	0.24	9.49	0	586.45	0.16	13	0.00	3.89	0
Malaysia	610.00	10.16	0	0.04	6.16	0	570.00	60.00	0	-0.01	3.65	0
Singapore	485.00	1.25	4	0.06	6.44	0	565	37.83	1	-0.05	2.32	0
South Korea	751.50	3.91	8	0.01	6.24	0	550.00	28.77	8	-0.05	3.78	0
Full sample	581.71	0.01	41	0.18	7.40	0	586.45	0.16	38	0.00	3.49	0

markets (Dooley and Hutchison, 2009; Edwards, 2010; Frank and Hesse, 2009; Wang and Moore, 2012).

Secondly, a closer inspection of the figure indicates a small peak of CDS spreads after Standard & Poor's downgraded Japan's credit rating to AA- in January 2011 due to the increasing concern over the country's high deficit and the threat of deflation; this emphasises the important impact of Japan's credit risk in Asia. Furthermore, the gaps among the CDS spreads in the sovereign, the financial and the non-financial sectors were decreasing in the beginning of 2014. In other words, a strong co-movement of credit risk among these three sectors is identified in terms of CDS data.

Tables 5.1 provides an overview of the summary statistics of 1-year and 5-year CDSs ranging from January 2009 to March 2014.[68] The first row of Table 5.1 lists the types of market participants associated with the sectors and five Asian countries. For example, Panel A reports the relative statistics of the sovereign sector, Panel B reports the statistics of the financial sector, while the associated statistics values of the non-financial sector are provided in Panel C. Data for these five Asian countries are included in the analysis: China, Japan, Malaysia, Singapore and South Korea. In particular, the cross-border values are presented in the first row of each individual panel. The left section of Table 5.1 reports the maximum CDS spreads, the minimum CDS spreads and the results of the Augmented Dickey- Fuller (ADF) test. In contrast, the right section of Table 5.1 reports the average values of the changes in the CDS spread, the standard deviation of the changes in the CDS spread and the results of the unit root test on the changes in the CDS spread. The unit root test is conducted for

[68] Due to the word count constraints of this current thesis, the summary statistics of individual CDS spreads can be provided to readers upon request.

each individual series of CDS spreads and changes in CDS spreads, thus the number of rejections of the null hypothesis is reported according to different sectors and maturities.

Beginning with 1-year CDSs, a visual inspection of the CDS spreads in Table 5.1 highlights that there is a striking difference between the minimum and maximum values of daily CDS spreads in 2009-2014. For example, daily sovereign CDS spreads range from 0.02bps to 448.5bps. The minimum CDS spreads are identified for the Japanese sovereign debtor, while the South Korean sovereign debtor has the maximum CDS spreads. It is worth noting that the Japanese sovereign CDS spreads in the analysed dataset are tiny compared with those of other Asian countries because of the small possibility of developed countries, such as Japan, not meeting their debt obligations.[69] In addition, a small dispersion of Asian sovereign CDS spreads compared to the corporate counterparties in the analysed period indicates a lower market assessment of sovereign default risk than the likelihood of default in the corporate sectors. This may be due to the unlikely occurrence of government default events, which until recently were relatively rare.[70] Even though some authors, such as David and Jeffery (2014), claimed that the incidence of government default had increased since the global financial crisis of 2008, the default risk of a Government is still lower than that of the corporate sector (Arnold and Lemmen, 2001). Furthermore, the results of the unit root tests from the ADF constructions suggest that most daily

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[69] In particular, the reason why the value of the Japanese sovereign CDS spread is tiny is twofold. First, Japan is a developed country and has a mature debt market; market investors expected less probability of default in the case of the Japanese sovereign debtor. Second, unlike other Asian economies, Japan has its own CDS market and most Japanese CDS contacts are written in Japanese Yen, therefore, a foreign exchange rate risk may also be entailed when converting Japanese Yen dominated CDS spreads to USD. However, the aim of the current thesis is to investigate the potential credit risk spillover effects among Asian CDS contracts and not to analyse the risk of dual-currency listing.

[70] A sovereign default occurs when a country cannot repay its debts, and typically takes the forms of bonds; a recent example is the Greek bailout agreement dated May 2010. The Greek economy was hit by the 2008 global financial crisis and on the 1st of May 2010, the Greek government requested a first bailout, thus exacerbating the Eurozone debt crisis from early 2009.

CDS spreads are not stationary series. Therefore, a transformed series of first-differenced data is necessary.

A visual inspection of Table 5.1 also highlights a number of interesting insights into the 5-year CDSs. First, the range of 5-year CDS spreads is wider than their 1-year counterparties. For example, the maximum average value of 5-year CDS spreads in the sovereign sector is 299.02bps in the short term but is 465.00bps in the long term. This finding implies a positive relationship between the credit risk of an entity and the time horizon of its debt; as suggested by Hull and White (2000b), the uncertainty of credit risk increases as a function of time. However, the negative mean of the changes in the CDS spread as well as its small standard deviation indicate the fact that long-term CDS spreads tended to tighten, while short-term CDS spreads tended to be more volatile during the sample period. The results of the stationary tests of changes in the CDS spreads strongly reject the null hypothesis of a unit root in the changes of CDS spreads. Thus, the analysis of the current chapter employs the changes of CDS spreads instead of CDS spreads because the latter are I(1).

Taken together, the preliminary analysis of the sample data in this chapter suggests that the market expectation of a default on long-term debts is higher than on short-term debts, as investors require a default risk premium to compensate for the potential default by the firm in the future (Chan-La, 2006; Calice *et al.* 2013). The findings also indicate that the level of credit risk in the sovereign sector is lower than that of the financial and non-financial sectors, but a high level of volatility regarding the changes of sovereign CDS spreads indicates an increase in the fluctuation of credit risk in Asian countries.

5.3.2 Research methods

A detailed examination of the sample CDS spreads has been provided in the previous section of the chapter; daily CDS spreads and the changes in the daily CDS spreads are described. The results of the unit root tests are indicative of the fact that unit roots are present in the daily CDS spreads; hence, the changes in the daily CDS spreads are used. Thus, the next step in fitting a VAR model is to determine whether autoregressive (AR) or moving average (MA) terms are needed to correct any autocorrelation that remains in the changes of CDS spreads. By looking at the autocorrelation function (ACF) and partial autocorrelation plots (PACF) of the changes of CDS spreads, the number of AR and/or MA terms can be identified. The analysis of this chapter in the thesis is based on a VAR(1) specification for two reasons. First, the PACF plot has a significant spike only at lag 1 for the vast majority of the sample (i.e., 85%). Second, the findings of previous studies have documented that a VAR(1) model is adequate to capture any interdependence among the changes in CDS spreads. Thus, a VAR research approach is applied to the analysis of spillover effects regarding the mean spread changes. Furthermore, one aim of this thesis is to examine whether there are any significant transmissions of shocks and volatilities spillovers between the credit risks of different firms. Hence, the Lagrange Multiplier (LM) test is used to test whether there are significant ARCH effects in the residuals. Initially, an autoregressive model is fitted to the residuals and tested for the presence of ARCH effects. The results from the LM tests rejected the null hypothesis of no ARCH effects for 97% of the estimates, which thus supports the decision to employ a GARCH modelling approach when examining volatility transmission between CDS spread changes. Due to the word constraint in the chapter, the results of the LM tests are not shown, the detailed results of ARCH effects tests can be provided upon request.

In the analysis of this chapter, a vector of daily CDS spread changes follows a simple VAR(1) dependency structure, which is given by equation (5.1):

$$\begin{bmatrix} \Delta CDS_{i,t}^{SOV,C} \\ \Delta CDS_{j,t}^{F,C} \\ \Delta CDS_{k,t}^{NF,C} \end{bmatrix} = \begin{bmatrix} \gamma_{i,0} \\ \gamma_{j,0} \\ \gamma_{k,0} \end{bmatrix} + \begin{bmatrix} \gamma_{ii} & \gamma_{ij} & \gamma_{ik} \\ \gamma_{ji} & \gamma_{jj} & \gamma_{jk} \\ \gamma_{ki} & \gamma_{kj} & \gamma_{kk} \end{bmatrix} \begin{bmatrix} \Delta CDS_{i,t-1}^{SOV,C} \\ \Delta CDS_{j,t-1}^{F,C} \\ \Delta CDS_{k,t-1}^{NF,C} \end{bmatrix} + \begin{bmatrix} \varepsilon_{i,t} \\ \varepsilon_{j,t} \\ \varepsilon_{k,t} \end{bmatrix} \qquad (5.1)$$

$$\begin{bmatrix} \varepsilon_{i,t} \\ \varepsilon_{j,t} \\ \varepsilon_{k,t} \end{bmatrix} \sim N(0, H_t) \qquad (5.2)$$

where, $\Delta CDS_{i,t}^{SOV,C}$ represents the daily changes in the CDS spread of a nation's sovereign debtor at time *t*. $\Delta CDS_{j,t}^{F,C}$ and $\Delta CDS_{k,t}^{NF,C}$ are the daily changes in the CDS spreads of the nation's financial institutions and non-financial firms. In particular, $C \in$ {China, Japan, Malaysia, Singapore, South Korea} which takes one country a time. $\gamma_{i,0}$, $\gamma_{j,0}$ and $\gamma_{k,0}$ are intercepts. The diagonal elements, γ_{ii}, γ_{jj} and γ_{kk}, measure an entity's own spillover effects of changes in the CDS spread while the off-diagonal elements capture the cross-sectoral spillover effects of changes in the CDS spread simultaneously. $\varepsilon_{i,t}$, $\varepsilon_{j,t}$ and $\varepsilon_{k,t}$ are error terms, which are considered to be a multivariate normal conditional distribution. For the error term, equation (5.2) assumes that the conditional mean is zero and the conditional covariance matrix is given by the positive definite 3×3 matrix, H_t, according to the specification of a full-BEKK model discussed by Engle and Kroner (1995):

$$H_t = C'C + A'\varepsilon_{t-1}A + G'H_{t-1}G \qquad (5.3)$$

where, the full-BEKK model provides a measurement of the cross-effect in the variance equation parsimoniously and also guarantees positive semi-definiteness by working with quadratic forms. *C* is a 3×3 lower triangular matrix of constants, whereas *A* and *G* are 3×3 parameter matrices in the variance and covariance matrices. In the analysis of this chapter, equation (5.3) can be expanded as follows:

$$\begin{bmatrix} h_{ii,t} & h_{ij,t} & h_{ik,t} \\ h_{ji,t} & h_{jj,t} & h_{jk,t} \\ h_{ki,t} & h_{kj,t} & h_{kk,t} \end{bmatrix} = \begin{bmatrix} c_{ii} & 0 & 0 \\ c_{ji} & c_{jj} & 0 \\ c_{ki} & c_{kj} & c_{kk} \end{bmatrix}' \begin{bmatrix} c_{ii} & 0 & 0 \\ c_{ji} & c_{jj} & 0 \\ c_{ki} & c_{kj} & c_{kk} \end{bmatrix} +$$

$$\begin{bmatrix} a_{ii} & a_{ij} & a_{ik} \\ a_{ji} & a_{jj} & a_{jk} \\ a_{ki} & a_{kj} & a_{kk} \end{bmatrix}' \begin{bmatrix} \varepsilon_{i,t-1}^2 & \varepsilon_{i,t-1}\varepsilon_{j,t-1} & \varepsilon_{i,t-1}\varepsilon_{k,t-1} \\ \varepsilon_{j,t-1}\varepsilon_{i,t-1} & \varepsilon_{j,t-1}^2 & \varepsilon_{j,t-1}\varepsilon_{k,t-1} \\ \varepsilon_{k,t-1}\varepsilon_{i,t-1} & \varepsilon_{k,t-1}\varepsilon_{j,t-1} & \varepsilon_{k,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{ii} & a_{ij} & a_{ik} \\ a_{ji} & a_{jj} & a_{jk} \\ a_{ki} & a_{kj} & a_{kk} \end{bmatrix} +$$

$$\begin{bmatrix} g_{ii} & g_{ij} & g_{ik} \\ g_{ji} & g_{jj} & g_{jk} \\ g_{ki} & g_{kj} & g_{kk} \end{bmatrix}' \begin{bmatrix} h_{ii,t-1} & h_{ij,t-1} & h_{ik,t-1} \\ h_{ji,t-1} & h_{jj,t-1} & h_{jk,t-1} \\ h_{ki,t-1} & h_{kj,t-1} & h_{kk,t-1} \end{bmatrix} \begin{bmatrix} g_{ii} & g_{ij} & g_{ik} \\ g_{ji} & g_{jj} & g_{jk} \\ g_{ki} & g_{kj} & g_{kk} \end{bmatrix} \quad (5.4)$$

where, the diagonal parameters a_{ii} (g_{ii}), $a_{jj}(g_{jj})$ and a_{kk} (g_{kk}) measure the effects of entities' own past shocks (volatility) on a CDS's own conditional variance. In contrast, other elements in the matrix measure the cross-sectoral effects that past shocks (volatility) in the CDS spread changes have on the variance and co-variance of the other sector and vice-versa. $h_{ii,t}$ is the variance of changes in CDS spreads from entity i, $h_{ij,t}$ is the covariance of changes in CDS spreads from both entity i and entity j. The elements of equation (5.4) can be further expanded as:

$$H_{ii,t} = C_{ii}^2 + \sum_{m=1}^3 \sum_{n=1}^3 a_{ni} a_{mi} \varepsilon_{m,t-1} \varepsilon_{n,t-1} + \sum_{m=1}^3 \sum_{n=1}^3 g_{ni} g_{mi} h_{nm,t-1} \quad (5.5)$$

$$H_{ij,t} = C_{ii} C_{12} + \sum_{m=1}^3 \sum_{n=1}^3 a_{ni} a_{mj} \varepsilon_{m,t-1} \varepsilon_{n,t-1} + \sum_{m=1}^3 \sum_{n=1}^3 g_{ni} g_{mj} h_{nm,t-1} \quad (5.6)$$

$$H_{ik,t} = C_{ii} C_{13} + \sum_{m=1}^3 \sum_{n=1}^3 a_{ni} a_{mj} \varepsilon_{m,t-1} \varepsilon_{n,t-1} + \sum_{m=1}^3 \sum_{n=1}^3 g_{ni} g_{mk} h_{nm,t-1} \quad (5.7)$$

$$H_{jj,t} = \sum_{n=1}^2 C_{n2}^2 + \sum_{m=1}^3 \sum_{n=1}^3 a_{nj} a_{mj} \varepsilon_{m,t-1} \varepsilon_{n,t-1} + \sum_{m=1}^3 \sum_{n=1}^3 g_{nj} g_{mj} h_{nm,t-1} \quad (5.8)$$

$$H_{jk,t} = \sum_{n=1}^2 C_{n2} C_{n3} + \sum_{m=1}^3 \sum_{n=1}^3 a_{nj} a_{mk} \varepsilon_{m,t-1} \varepsilon_{n,t-1} + \sum_{m=1}^3 \sum_{n=1}^3 g_{nj} g_{mk} h_{nm,t-1} \quad (5.9)$$

$$H_{kk,t} = \sum_{n=1}^3 C_{n3}^2 + \sum_{m=1}^3 \sum_{n=1}^3 a_{nk} a_{mk} \varepsilon_{m,t-1} \varepsilon_{n,t-1} + \sum_{m=1}^3 \sum_{n=1}^3 g_{nk} g_{mk} h_{nm,t-1} \quad (5.10)$$

Furthermore, under the assumption of conditional normality, the parameters of a multivariate GARCH model can be estimated by maximising:

$$l\,(\theta) = -\frac{TN}{2} log 2\pi - \frac{1}{2} \sum_{t=1}^T (log|H_t| + I_t' H_t^{-1} I_t) \quad (5.11)$$

where, θ denoted all the unknown parameters to be estimated, N is the number of CDSs (i.e., N equals to 3 in the analysis of this chapter) and T is the number of observations (i.e., it equals to 1,368 observations). The maximum-likelihood estimate for θ is asymptotically normal, thus traditional procedures for statistical inference are applicable. Kroner and Ng (1998) provided a detailed discussion on this.

5.4 Empirical findings

The findings from this current chapter should help to answer the first and the second research questions regarding the *domestic cross-sectoral* credit risk spillovers. In order to examine the cross-sectoral credit risk spillover effects within each of the five Asian countries, VAR(1)-trivariate-GARCH(1,1) frameworks are estimated by adopting a full-BEKK representation. One trivariate GARCH model incorporates the CDS data of three series from three different sectors (i.e., one series from the sovereign sector, one series from the financial sector and one series from the non-financial sector) for each individual country. For each of the 1-year and 5-year CDSs, this leads to a total of 63 models for China, 378 models for Japan, 15 models for Malaysia, 15 models for Singapore and 180 models for South Korea. This model makes it possible to test whether direct and indirect credit risk spillovers are present in both the mean and the variance of the changes in CDS spreads. As introduced before, the five Asian countries are classified into two geographic regions: East Asia and Southeast Asia. China, Japan and South Korea are grouped into East Asia while Southeast Asian countries include Malaysia and Singapore.

The findings are reported in terms of the percentages of significant coefficients, the percentages of negative significant coefficients and the averaged values of the coefficients, respectively. For instance, in order to calculate the percentages of significant coefficients, the number of significant coefficients is divided by the total number of the models and then multiplied by 100. They identify the quantities of significant credit risk spillovers from the standpoints of both the mean and the variance of changes in CDS spreads. In order to calculate the percentages of significant negative coefficients, the number of negative significant coefficients is divided by the number of significant coefficients and then multiplied by 100. They help to measure the sign of significant credit risk spillovers. The averaged values of the coefficients are calculated by summing up the value of each significant coefficient and then dividing the sum by the total number of the models. Such a procedure sets the values of the insignificant coefficients to be zero.

Tables 5.2 to 5.7 report the findings from 1-year CDSs; the findings for East Asia are presented in the tables with an even table number (i.e., Table 5.2, Table 5.4 and Table 5.6), while the tables with an odd table number (i.e., Table 5.3, Table 5.5 and Table 5.7) report the findings for Southeast Asia. A brief discussion of the robustness tests from 5-year CDSs is also provided in this section, yet because of word count limitations, the tables (i.e., Tables A.5.1 to A.5.6) are included in the appendix of this current thesis.

Each table is structured in the same fashion both for the sake of simplicity and in order to facilitate a visual inspection of the results. The first row of each table lists the names of the sample countries, while the independent variables are presented in the first column of the table. In each table, three groups of CDS entities are included: (i) the sovereign sector (i.e., *SOV*), (ii) the financial sector (i.e., *F*) and (iii) the non-financial sector (i.e., *NF*). Furthermore, each table is divided into two panels; Panel A displays the results of the credit risk spillover effects from the mean spread changes while Panel B shows the shock (B_1) and the volatility (B_2) spillovers. The diagonal and the off-diagonal coefficients in equation (5.1) are presented in the remainder of Panel A. The diagonal coefficients measure the credit risk spillovers from an entity's own lagged changes in the CDS spread to its current changes in the CDS spread, while the off-diagonal parameters show the cross-sectoral spillover effects. Moreover, Panel B presents the coefficients in equation (5.5) to equation (5.10); the coefficients are calculated by expanding the variance-covariance matrix from the full-BEKK model. For instance, the shock spillovers from both an entity's own and other entities' past shocks via the square of an entity's own past shocks and the cross-product of the past shocks of an entity's own and other entities are presented in section B_1. The second half of Panel B (i.e., B_2) shows the volatility spillover effects of both an entity's own and other entities' past volatilities. The number of models in each individual country is presented in the last row of each table.

5.4.1 Estimates from 1-year CDSs

Tables 5.2 to 5.7 present the findings pertaining to the credit risk spillover effects from 1-year Asian name CDSs. A number of findings emerge from a visual inspection of the first panel from Tables 5.2 to 5.7. First, the insignificant diagonal coefficients of the sovereign sector from Panel A of Table 5.2 indicate that the changes of the East Asian sovereign CDS spreads do not depend on their respective own lags; in Table 5.2, the percentage of significant γ_{ii} is zero. In contrast, a different picture emerges from Table 5.3 regarding the individual spread changes spillover effects of Southeast Asian sovereign debtors; for instance, the percentages of significant γ_{ii} are 60.00% in Malaysia and 13.33% in Singapore, respectively. Moreover, the associated figures in Table 5.5 indicate that all of the significant γ_{ii} are negative and the negative values reported in Table 5.7 evidence the oscillatory movement of CDS spread changes in these two Southeast Asian countries; the averaged values of γ_{ii} are -0.033 in Malaysia and -0.011 in Singapore, respectively.

Secondly, with the exception of Japanese financial sectors, the significant firms' own credit risk spillovers are found in all of the five countries, as only the

Japanese financial sector has zero significant γ_{ii} in Table 5.2. The percentages of the significant firm's own spread changes spillovers range from 1.67% in South Korea to 60.00% in Malaysia. In particular, more than half of those significant coefficients in Malaysian financial sectors (i.e., 55.55%) are significant negative, while none of its non-financial firms have significant negative firm's own past spread changes spillovers. The findings evidence the difference of firm's own credit risk transmission regarding different sectors within a nation; thus, an analysis of the spillover effects with reference to the sector-level credit risk is required. Taking the findings from Tables 5.6 and 5.7 together, the size of individual credit risk spillover effects (i.e., the average value of the coefficients) is relatively smaller in Japan; for example, the average values of γ_{kk} range from 0.008 in the Japanese non-financial sector (in Table 5.6) to 0.057 in the Malaysian non-financial sector (in Table 5.7). Hence, the findings of significance related to the individual credit risk spillover effects from past CDS spread changes indicate that there are sector- and country-level variations in the transmission of credit risk with reference to 1-year Asian CDS spread changes.

Thirdly, an analysis of the off-diagonal elements of Panel A from Tables 5.2 to 5.7 suggests that there are significant cross-sectoral credit risk spillover effects in both East Asian and Southeast Asian countries. For example, a one-way transmission of credit risk from the Chinese financial sector to its sovereign debtor is found, and the percentage of significant γ_{ij} is 14.29% in Table 5.2. In particular, the negative average value of the coefficient (i.e., γ_{ij} = -0.016 in Table 5.6) indicates that a previous CDS spread change in the Chinese financial sector is negatively associated with the CDS spread changes in the Chinese sovereign debtor on the next day. In other words, a positive change in the CDS spread of the Chinese financial sector leads to a mean reverse in the changes of the CDS spread of its sovereign debtor. Moreover, a bidirectional transmission of the credit risk spillover effects between the Japanese sovereign and financial sectors is found; in Table 5.2, the off-diagonal parameters (i.e., γ_{ij} and γ_{ji}) are both statistically significant at the 5% level of significance. The associated average values of the coefficients in Table 5.6 show the opposite signs of credit risk transmission; the average size of the credit risk spillover effects from the Japanese financial sector to its sovereign debtor is 0.0001, and -0.580 in the other direction. In contrast, a unidirectional transmission of the credit risk spillover effects is present from the Japanese non-financial sector to its sovereign sector; the percentages of significant γ_{ki} are 7.14% in Table 5.2 with an average value of 0.001 in Table 5.6. Therefore, the changes of the CDS spread in the Japanese sovereign sector did not depend on its own past lags but indirectly received the past information from both domestic financial and non-financial firms in 2009-2014. This linkage reflects the important role of firms over the sovereign sector in Japan regarding short-term credit risk transmission, although their impact is tiny.

In South Korea, bidirectional linkages are found between the sovereign debtor and its non-financial sector (i.e., in Table 5.2, the percentage of significant γ_{ki} is 1.67% and that of significant γ_{ik} is 21.11%), and the financial and non-financial sectors (i.e., the percentage of significant γ_{kj} is 21.11% and 2.22% for γ_{jk} in Table 5.2). This finding implies that the non-financial sector in South Korea plays an intermediary role in the credit risk transmission from the financial sector to the sovereign sector during the analysed sample period. In particular, an opposite transmission of the credit risk between the sovereign sector and the non-financial sector is evidenced; a positive change in the 1-year CDS spread from the non-financial sector leads to a mean reverse movement of the changes in the South Korean sovereign debtor's CDS spread, while the sign of the cross-sectoral credit risk transmission is opposite in the other direction.

Compared with the magnitudes of the size of the spillover effects, the cross-sectoral credit risk spillover effects from the sovereign sector to its non-financial firms are stronger than in the other direction (i.e., in Table 5.6, 0.014 for γ_{ki} and -0.002 for γ_{ik}).

Turning to the findings from Southeast Asian countries, bidirectional credit risk spillover effects exist among the three sectors in Malaysia, while no significant cross-sectoral credit risk spillover effects are found in Singapore. This implies a strong co-movement of 1-year CDS spread changes among different sectors in Malaysia, which may create a potential channel of financial contagion, while the CDS spread changes of Singaporean entities are less interdependent.

The results from Panel A of Tables 5.2 to 5.7 provide convincing evidence of short-term direct and indirect credit risk spillover effects with reference to the CDS spread changes in the sample set. The points of interest from Panel A in Tables 5.2 to 5.7 have also indicated that the credit spreads of 1-year CDSs written on Asian entities are predictable from individual historical CDS recordings, as well as from cross-sectoral spread changes. This calls the weak form of the EMH into question; for example, Harris and Pisedtasalasai (2006) stated that ‘the finding that there are spillover effects in returns implies the existence of an exploitable trading strategy and, if trading profits exceed transaction costs, potentially represents evidence against market efficiency’ (p.1556). In addition, with the exception of Singapore, the remaining four Asian countries are affected by cross-sectoral credit risk spillover effects in the view of CDS spread changes.

The results for the conditional variance-covariance equations are reported in Panel B of each table; B_1 reports the transmission of credit shocks and B_2 reports the transmission of the volatility spillover effects. For example, the upper section of Panel B (i.e., B_1) shows the shock spillover effects in the variance and covariance of changes in the CDS spread; the coefficients associated with $\varepsilon_{i,t-1}^2$, $\varepsilon_{j,t-1}^2$ and $\varepsilon_{k,t-1}^2$ show the impact of a sector's own past shock and the coefficients associated with $\varepsilon_{i,t-1}\varepsilon_{j,t-1}$, $\varepsilon_{i,t-1}\varepsilon_{k,t-1}$ and $\varepsilon_{j,t-1}\varepsilon_{k,t-1}$ show the impact of cross-sectoral shocks. Meanwhile, the lower section of Panel B (i.e., B_2) indicates the spillover effects of past volatility. A number of interesting findings emerged. First, the diagonal elements in B_1 (or B_2) capture the firm's own shock (or volatility) credit risk spillover effects. It is clear that with the exception of the Singaporean sovereign sector, the diagonal elements in B_1 and B_2 are consistently significant across all sectors in each country; the conditional variance of Singaporean sovereign CDS spread changes is not affected by firm's own past shocks, as the coefficients in the upper section of Panel B on $h_{ii,t}$ are insignificant in Table 5.3. The significant diagonal elements indicate a strong GARCH (1, 1) process driving the conditional variances of CDS spread changes for most Asian entities in 2009-2014. It is particularly true in the case of Malaysia, as the percentage of the significant credit risk transmission of a sector's own past volatility is 100%. The sum of the coefficients regarding the GARCH (1, 1) process on each variance equation measures the volatility persistence. The sum of the coefficients on the GARCH effects from Table 5.6 and Table 5.7 tends to unity, therefore there is a high degree of volatility persistence in Asia.

Secondly, the off-diagonal elements in Panel B across Tables 5.2 to 5.7 capture the cross-sectoral shock and volatility spillover effects. In general, the effects of past volatility are wider and stronger than those of past shocks. Beginning with the transmission of shocks and volatility spillovers in China, in the second part of Panel B in Table 5.2, the impact of past cross-sectoral volatility between the sovereign and the financial sectors as well as that between the sovereign and the non-financial sectors have significant effects, as the percentages of the significant coefficients are 80.95%

and 85.71%, respectively. The associated figures in Table 5.6 further reveal that past information from the covariance of changes in the CDS spread between the Chinese sovereign debtor and its financial sector (i.e., $h_{ij,t-1}$) plays a more important role than their own past volatilities in explaining the volatility of changes in the Chinese sovereign CDS spread (i.e., $h_{ij,t}$). In other words, the size of the spillover effects from $h_{ij,t-1}$ (i.e., 0.5283) is greater than that from $h_{ii,t-1}$ (i.e., 0.2320) in Table 5.6. Indeed, as discussed before, a number of studies have indicated that systemic risk is often triggered by financial institutions that are too big to fail. Although Panel A reports that the CDS spread changes of financial institutions in China co-move negatively with those of the sovereign entity, the results in Panel B suggest that an increase in the covariance between the CDS spread changes of the Chinese financial and sovereign sector can lead to a higher volatility of the sovereign CDS spread changes.

Turning to the transmission of credit risk among Japanese sectors, a visual inspection of the off-diagonal elements in B1 and B2 reveals that the percentages of significant impact of the past shocks from the Japanese financial sector (i.e., $\varepsilon^2_{j,t-1}$) on the volatility of changes in Japanese CDS spreads are nearly half of the total number; in Table 5.2, they range from 35.98% in $h_{ik,t}$ to 45.24% in $h_{ii,t}$. Hence, the past shocks from the Japanese financial sector constitute one of the important factors in spilling over credit risk in Japan. Moreover, the past volatility from the Japanese financial sector is also highly correlated with the volatility of the changes in the Japanese CDS spread; the percentages of significant impact of $h_{jj,t-1}$ range from 37.30-93.92%. It is also noticeable that the percentages of significant impact of the past covariance between the changes in the Japanese financial and non-financial sectors' spreads (i.e., $h_{jk,t-1}$) are slightly higher than in the case of China. Therefore, the volatility of changes in the Japanese CDS spread is widely affected by the past correlated volatility from both domestic financial and non-financial sectors.

It is clear that the variance of the South Korean sovereign sector (i.e., $h_{ii,t}$) is not indirectly influenced by past cross-sectoral credit shocks, but there is a direct effect from past innovations; for example, the percentages of significant impact of $\varepsilon_{i,t-1}^2$ are 22.22% but zero with reference to $\varepsilon_{i,t-1}\varepsilon_{j,t-1}$. In line with the previous findings from China and Japan, there are significant credit risk spillover effects from the past cross-sectoral volatilities of the sovereign and financial sectors, as well as from the sovereign and the non-financial sectors on the volatility of their respective sovereign sector. Furthermore, the past volatilities of the financial sector and of the non-financial sector (i.e., $h_{jj,t-1}$ and $h_{kk,t-1}$) as well as the past cross-sectoral volatilities (i.e., $h_{ij,t-1}, h_{ik,t-1}\ and\ h_{jk,t-1}$) have significant influence on the cross-sectoral volatility of the financial and non-financial sectors.

Panel B of Table 5.3 reports the percentages of significant coefficients with reference to Southeast Asian countries, namely Malaysia and Singapore. In general, there are significant past shock and volatility spillovers in Malaysia; significant volatility spillovers are found from the past information on the volatility of the Malaysian sovereign sector (i.e., $h_{ii,t-1}$) to the covariance between the sovereign and non-financial sectors (i.e., $h_{ik,t}$), as the percentages of significant effects are 93.33% in Table 5.3. Turning to the short-term credit risk transmission in Singapore, according to Table 5.3, the volatility of the changes in the Singaporean sovereign debtor's CDS spread only depends on the past variance of all three sectors. Thus, past information regarding the volatilities of the sovereign, the financial and the non-financial sectors spilled over to the volatility of changes in the Singaporean sovereign sector. Furthermore, it is interesting that the responses of $h_{ij,t}$ and $h_{ik,t}$ on past shocks are different; according to Table 5.7, the covariance between the changes in the Singaporean sovereign sectors and its financial sectors' CDS spread (i.e., $h_{ij,t}$) is positively correlated with all past shocks, but there is an opposite transmission direction on $h_{ik,t}$. The findings suggest a sectoral characteristic of the credit risk spillover effects in Singapore with reference to the 1-year CDS spread changes.

Table 5.2: The percentages of significant coefficients for 1-year CDSs: East Asia

Variables	China			Japan			South Korea		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread changes spillovers									
$\Delta CDS_{i,t-1}^{SOV}$	0.00	0.00	0.00	0.00	14.29	0.00	0.00	2.22	21.11
$\Delta CDS_{j,t-1}^{F}$	14.29	14.29	0.00	14.29	0.00	14.29	0.00	1.67	2.22
$\Delta CDS_{k,t-1}^{NF}$	0.00	0.00	14.29	7.14	7.14	7.14	1.67	21.11	1.67

Panel B: Shock and volatility Spillovers	China						Japan						South Korea					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B_1: Shock spillovers																		
$\varepsilon_{i,t-1}^2$	34.92	11.11	9.52	14.29	12.70	3.17	12.70	10.85	11.90	10.05	9.79	10.05	22.22	11.11	8.89	5.56	7.22	7.78
$\varepsilon_{j,t-1}^2$	28.57	28.57	15.87	11.11	7.94	6.35	45.24	45.24	40.21	42.59	35.98	37.83	25.56	25.56	10.56	6.67	5.56	6.67
$\varepsilon_{k,t-1}^2$	22.22	15.87	22.22	11.11	12.70	15.87	23.02	40.21	23.02	16.67	16.40	16.40	21.11	10.56	21.11	6.11	7.22	7.22
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	14.29	11.11	7.94	20.63	6.35	7.94	17.46	15.87	14.29	15.61	14.29	14.55	0.00	5.56	6.67	13.33	5.00	5.00
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	12.70	9.52	6.35	11.11	23.81	9.52	9.79	14.55	10.85	10.05	18.25	14.29	0.00	7.22	9.44	6.11	18.33	12.78
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	6.35	15.87	12.70	7.94	12.70	15.87	16.67	23.02	24.07	21.16	20.37	21.16	0.00	6.11	7.22	5.00	7.22	9.44
B_2: Volatility spillovers																		
$h_{ii,t-1}$	93.65	23.81	30.16	79.37	79.37	23.81	93.65	38.10	37.04	81.22	81.75	35.45	98.33	23.89	20.56	73.89	75.00	20.00
$h_{jj,t-1}$	33.33	93.65	30.16	80.95	31.75	73.02	40.48	93.92	39.68	83.60	37.30	82.01	28.89	97.78	26.11	77.22	23.89	74.44
$h_{kk,t-1}$	38.10	28.57	93.65	26.98	82.54	79.37	42.86	45.50	93.65	42.33	80.42	80.16	29.44	25.56	98.33	26.67	77.78	76.11
$h_{ij,t-1}$	80.95	79.37	25.40	93.65	69.84	73.02	81.48	82.28	37.30	93.39	76.72	75.93	75.56	76.67	21.11	97.78	63.89	63.33
$h_{ik,t-1}$	85.71	19.05	80.95	73.02	93.65	73.02	80.42	39.68	79.63	76.19	93.12	74.34	80.56	20.00	74.44	69.44	98.33	67.22
$h_{jk,t-1}$	36.51	76.19	76.19	79.37	77.78	93.65	40.48	82.54	82.01	77.25	75.13	93.39	24.44	76.67	73.33	71.67	64.44	97.22
No. of models	63						378						180					

Note: This summary table shows the percentages of significant coefficients at 5% significance level for 1-year CDS contracts reference entities in China, Japan and South Korea. SOV (i=1), F (i=2) and NF (i=3) are the abbreviation of sovereign debtor, financial institutions and non-financial firms.

Table 5.3: The percentages of significant coefficients for 1-year CDSs: Southeast Asia

Variables	Malaysia						Singapore					
	$\Delta CDS_{i,t}^{SOV}$		$\Delta CDS_{j,t}^{F}$		$\Delta CDS_{k,t}^{NF}$		$\Delta CDS_{i,t}^{SOV}$		$\Delta CDS_{j,t}^{F}$		$\Delta CDS_{k,t}^{NF}$	
Panel A: Spread changes spillovers												
$\Delta CDS_{i,t-1}^{SOV}$	60.00		13.33		60.00		13.33		0.00		0.00	
$\Delta CDS_{j,t-1}^{F}$	13.33		60.00		60.00		0.00		13.33		0.00	
$\Delta CDS_{k,t-1}^{NF}$	13.33		60.00		60.00		0.00		0.00		13.33	
Panel B: Shock and volatility Spillovers												
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B₁: Shock spillovers												
$\varepsilon_{i,t-1}^2$	46.67	13.33	40.00	20.00	13.33	33.33	0.00	20.00	33.33	13.33	20.00	13.33
$\varepsilon_{j,t-1}^2$	26.67	26.67	6.67	6.67	6.67	6.67	0.00	40.00	26.67	26.67	26.67	33.33
$\varepsilon_{k,t-1}^2$	13.33	6.67	13.33	6.67	6.67	6.67	0.00	26.67	26.67	20.00	20.00	20.00
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	6.67	13.33	6.67	20.00	6.67	6.67	0.00	20.00	26.67	26.67	33.33	26.67
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	13.33	6.67	6.67	6.67	20.00	6.67	0.00	20.00	20.00	26.67	26.67	26.67
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	20.00	6.67	6.67	6.67	6.67	6.67	0.00	33.33	20.00	26.67	26.67	26.67
B₂: Volatility spillovers												
$h_{ii,t-1}$	100.00	13.33	53.33	80.00	93.33	20.00	100.00	46.67	46.67	66.67	73.33	46.67
$h_{jj,t-1}$	33.33	100.00	33.33	80.00	26.67	80.00	33.33	93.33	46.67	66.67	46.67	66.67
$h_{kk,t-1}$	26.67	13.33	100.00	6.67	80.00	80.00	46.67	40.00	86.67	53.33	66.67	60.00
$h_{ij,t-1}$	86.67	80.00	33.33	100.00	73.33	80.00	0.00	66.67	46.67	86.67	66.67	66.67
$h_{ik,t-1}$	80.00	13.33	86.67	66.67	100.00	80.00	0.00	40.00	73.33	53.33	86.67	66.67
$h_{jk,t-1}$	26.67	73.33	80.00	80.00	80.00	100.00	0.00	60.00	66.67	60.00	66.67	86.67
No. of models	15						15					

Note: This summary table shows the percentages of significant coefficients at 5% significance level for one-year CDS contracts reference entities in Malaysia and Singapore.

Table 5.4: The percentages of significant negative coefficients for 1-year CDSs: East Asia

Variables	China			Japan			South Korea		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread changes spillovers									
$\Delta CDS_{i,t-1}^{SOV}$	N/A	N/A	N/A	N/A	100.00	N/A	N/A	100.00	26.34
$\Delta CDS_{j,t-1}^{F}$	100.00	0.00	N/A	0.00	N/A	51.85	N/A	0.00	100.00
$\Delta CDS_{k,t-1}^{NF}$	N/A	N/A	22.18	0.00	7.42	7.42	100.00	92.09	0.00

Panel B: Shock and volatility Spillovers	China						Japan						South Korea					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B₁: Shock spillovers																		
$\varepsilon_{i,t-1}^{2}$	0.00	0.00	0.00	33.33	37.50	50.00	0.00	0.00	0.00	26.32	59.46	42.11	0.00	0.00	0.00	60.00	38.46	35.71
$\varepsilon_{j,t-1}^{2}$	0.00	0.00	0.00	42.86	60.00	50.00	0.00	0.00	0.00	44.72	48.53	44.76	0.00	0.00	0.00	50.00	40.00	58.33
$\varepsilon_{k,t-1}^{2}$	0.00	0.00	0.00	14.29	62.50	60.00	0.00	0.00	0.00	42.86	51.61	51.61	0.00	0.00	0.00	63.64	46.15	38.46
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	11.11	57.14	80.00	38.46	50.00	20.00	34.85	40.00	51.85	52.54	38.89	40.00	N/A	50.00	50.00	20.83	44.44	55.56
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	0.00	33.33	25.00	42.86	26.67	66.67	59.46	34.55	36.59	39.47	55.07	53.70	N/A	61.54	58.82	54.55	24.24	60.87
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	50.00	20.00	62.50	40.00	75.00	60.00	52.38	50.57	46.15	50.00	45.45	53.75	N/A	63.64	61.54	44.44	46.15	11.76
B₂: Volatility spillovers																		
$h_{ii,t-1}$	0.00	0.00	0.00	44.00	50.00	20.00	0.00	0.00	0.00	51.47	47.25	41.04	0.00	0.00	0.00	39.10	38.52	27.78
$h_{jj,t-1}$	0.00	0.00	0.00	60.78	20.00	45.65	0.00	0.00	0.00	47.47	31.91	43.55	0.00	0.00	0.00	59.71	34.88	45.52
$h_{kk,t-1}$	0.00	0.00	0.00	23.53	61.54	48.00	0.00	0.00	0.00	32.50	48.36	52.81	0.00	0.00	0.00	33.33	63.57	48.91
$h_{ij,t-1}$	13.73	48.00	50.00	0.00	50.00	52.17	46.10	52.41	39.01	0.00	44.14	47.39	58.82	38.41	39.47	0.00	44.35	37.72
$h_{ik,t-1}$	12.96	25.00	49.02	47.83	0.00	47.83	49.67	37.33	47.51	51.74	0.00	53.38	63.45	44.44	40.30	51.20	0.00	37.19
$h_{jk,t-1}$	0.00	52.08	52.08	64.00	61.22	0.00	42.48	53.53	44.19	50.68	45.77	0.00	36.36	50.00	48.48	64.34	62.93	0.00

Table 5.5: The percentages of significant negative coefficients for 1-year CDSs: Southeast Asia

Variables	Malaysia						Singapore					
	$\Delta CDS_{i,t}^{SOV}$		$\Delta CDS_{j,t}^{F}$		$\Delta CDS_{k,t}^{NF}$		$\Delta CDS_{i,t}^{SOV}$		$\Delta CDS_{j,t}^{F}$		$\Delta CDS_{k,t}^{NF}$	
Panel A: Spread Changes Spillovers												
$\Delta CDS_{i,t-1}^{SOV}$	100.00		0.00		0.00		100.00		N/A		N/A	
$\Delta CDS_{j,t-1}^{F}$	0.00		55.55		11.12		N/A		0.00		N/A	
$\Delta CDS_{k,t-1}^{NF}$	0.00		0.00		0.00		N/A		N/A		0.00	
Panel B: Shocks and Volatility Spillovers												
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B₁: Shock Spillovers												
$\varepsilon_{i,t-1}^2$	0.00	0.00	0.00	66.67	100.00	0.00	N/A	0.00	0.00	0.00	66.67	100.00
$\varepsilon_{j,t-1}^2$	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	0.00	25.00	75.00	100.00
$\varepsilon_{k,t-1}^2$	0.00	0.00	0.00	0.00	100.00	100.00	N/A	0.00	0.00	0.00	33.33	0.00
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	0.00	50.00	0.00	0.00	100.00	0.00	N/A	66.67	0.00	25.00	60.00	50.00
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	100.00	0.00	100.00	100.00	66.67	100.00	N/A	33.33	33.33	25.00	75.00	75.00
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	66.67	0.00	100.00	100.00	0.00	0.00	N/A	0.00	66.67	25.00	100.00	50.00
	0.00	0.00	0.00	66.67	100.00	0.00	N/A	0.00	0.00	0.00	66.67	100.00
B₂: Volatility spillovers												
$h_{ii,t-1}$	0.00	0.00	0.00	66.67	57.14	0.00	0.00	0.00	0.00	20.00	45.45	28.57
$h_{jj,t-1}$	0.00	0.00	0.00	50.00	75.00	66.67	0.00	0.00	0.00	90.00	42.86	50.00
$h_{kk,t-1}$	0.00	0.00	0.00	100.00	58.33	41.67	0.00	0.00	0.00	37.50	70.00	66.67
$h_{ij,t-1}$	46.15	66.67	60.00	0.00	45.45	58.33	N/A	20.00	28.57	0.00	50.00	50.00
$h_{ik,t-1}$	50.00	100.00	53.85	40.00	0.00	66.67	N/A	66.67	45.45	75.00	0.00	20.00
$h_{jk,t-1}$	50.00	36.36	58.33	58.33	50.00	0.00	N/A	66.67	50.00	66.67	90.00	0.00

Table 5.6: The averaged coefficients for 1-year CDSs: East Asia

Variables	China			Japan			South Korea		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread Changes Spillovers									
$\Delta CDS_{i,t-1}^{SOV}$	0.00	0.00	0.00	0.00	-0.580	0.00	0.00	-0.002	0.014
$\Delta CDS_{j,t-1}^{F}$	-0.016	0.013	0.00	0.0001	0.00	0.237	0.00	0.002	-0.009
$\Delta CDS_{k,t-1}^{NF}$	0.00	0.00	0.011	0.001	0.188	0.008	-0.002	-0.018	0.003

Panel B: Shocks and Volatility Spillovers	China						Japan						South Korea					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B_1: Shock Spillovers																		
$\varepsilon_{i,t-1}^2$	0.0110	0.0010	0.0018	-0.0005	-0.0003	-0.0006	0.0018	0.0011	0.0016	0.0002	-0.0001	0.0001	0.0085	0.0012	0.0014	-0.0001	0.0000	0.0001
$\varepsilon_{j,t-1}^2$	0.0057	0.0101	0.0018	0.0004	-0.0002	0.0000	0.0062	0.0062	0.0049	-0.0006	-0.0002	-0.0005	0.0100	0.0100	0.0013	0.0003	-0.0001	-0.0002
$\varepsilon_{k,t-1}^2$	0.0019	0.0023	0.0049	0.0011	-0.0005	-0.0007	0.0044	0.0049	0.0044	0.0005	-0.0003	-0.0001	0.0066	0.0013	0.0066	-0.0001	0.0000	0.0003
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	0.0011	-0.0021	-0.0013	0.0048	0.0003	0.0006	0.0004	0.0000	-0.0005	-0.0003	-0.0002	-0.0004	0.0000	0.0001	0.0003	0.0044	0.0002	0.0000
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	0.0015	0.0011	0.0004	-0.0004	0.0035	-0.0003	-0.0002	-0.0004	0.0002	0.0000	0.0002	0.0003	0.0000	-0.0004	-0.0007	-0.0004	0.0028	-0.0003
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	0.0000	0.0012	-0.0008	0.0006	-0.0008	0.0006	-0.0005	-0.0008	-0.0004	-0.0002	0.0000	0.0002	0.0000	-0.0002	-0.0002	0.0001	0.0003	0.0030
B_2: Volatility Spillovers																		
$h_{ii,t-1}$	0.2320	0.0011	0.0012	0.0005	0.0130	0.0000	0.8476	0.0024	0.0022	-0.0046	0.0050	-0.0004	0.8643	0.0015	0.0013	0.0092	0.0055	0.0004
$h_{jj,t-1}$	0.0018	0.8412	0.0013	-0.0105	0.0005	-0.0054	0.0015	0.8584	0.0025	-0.0013	0.0000	0.0052	0.0016	0.8623	0.0017	-0.0101	0.0005	-0.0015
$h_{kk,t-1}$	0.0033	0.0018	0.8464	0.0001	-0.0070	-0.0034	0.0022	0.0036	0.8532	-0.0002	0.0005	-0.0005	0.0010	0.0010	0.8709	0.0003	-0.0066	-0.0023
$h_{ij,t-1}$	0.5283	0.0025	0.0006	0.8434	-0.0060	0.0111	-0.0021	-0.0085	0.0000	0.8462	0.0055	0.0065	-0.0189	0.0213	-0.0005	0.8594	-0.0024	0.0058
$h_{ik,t-1}$	-0.0007	0.0001	0.0246	-0.0031	0.8474	-0.0003	0.0027	0.0003	0.0109	-0.0004	0.8439	-0.0042	-0.0144	0.0002	0.0090	-0.0026	0.8663	0.0094
$h_{jk,t-1}$	0.0012	-0.0061	-0.0072	-0.0082	-0.0100	0.8439	-0.0005	-0.0013	0.0123	-0.0003	-0.0012	0.8504	0.0003	-0.0058	-0.0026	-0.0067	-0.0098	0.8586

Table 5.7: The averaged coefficients for 1-year CDSs: Southeast Asia

Variables	Malaysia			Singapore		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread Changes Spillovers						
$\Delta CDS_{i,t-1}^{SOV}$	-0.033	0.010	0.012	-0.011	0.000	0.000
$\Delta CDS_{j,t-1}^{F}$	0.007	-0.023	0.038	0.000	0.012	0.000
$\Delta CDS_{k,t-1}^{NF}$	0.054	0.127	0.057	0.000	0.000	0.007

Panel B: Shocks and Volatility Spillovers	Malaysia						Singapore					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B_1: Shock Spillovers												
$\varepsilon_{i,t-1}^2$	0.0119	0.0003	0.0037	-0.0007	-0.0005	0.0023	0.0000	0.0017	0.0038	0.0016	-0.0021	-0.0011
$\varepsilon_{j,t-1}^2$	0.0002	0.0073	0.0001	0.0000	0.0000	0.0000	0.0000	0.0013	0.0021	0.0015	-0.0035	-0.0010
$\varepsilon_{k,t-1}^2$	0.0006	0.0001	0.0009	0.0001	-0.0005	-0.0001	0.0000	0.0021	0.0004	0.0007	-0.0001	0.0002
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	0.0001	-0.0010	0.0002	0.0053	-0.0002	0.0000	0.0000	-0.0001	0.0051	0.0006	-0.0061	-0.0013
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	-0.0011	0.0000	-0.0004	-0.0001	-0.0013	-0.0001	0.0000	-0.0017	0.0001	0.0021	-0.0002	-0.0003
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	-0.0071	0.0000	-0.0004	-0.0001	0.0003	0.0001	0.0000	0.0007	0.0001	0.0009	-0.0020	-0.0007
B2: Volatility spillovers												
$h_{ii,t-1}$	0.9039	0.0018	0.0005	-0.0211	-0.0109	0.0004	0.9111	0.0005	0.0009	0.0114	-0.0037	-0.0002
$h_{jj,t-1}$	0.0010	0.9025	0.0005	0.0018	-0.0004	-0.0055	0.0027	0.8266	0.0007	-0.0226	-0.0001	0.0070
$h_{kk,t-1}$	0.0013	0.0003	0.9167	-0.0001	0.0098	0.0059	0.0029	0.0007	0.7801	-0.0002	-0.0189	0.0030
$h_{ij,t-1}$	0.0032	-0.0425	0.0003	0.9025	-0.0013	-0.0101	0.0000	0.0228	-0.0005	0.7773	0.0075	-0.0058
$h_{ik,t-1}$	0.0221	-0.0012	-0.0203	0.0059	0.9099	-0.0217	0.0000	-0.0005	-0.0078	0.0029	0.7843	0.0114
$h_{jk,t-1}$	-0.0017	0.0119	-0.0051	0.0095	0.0021	0.9093	0.0000	0.0061	0.0149	-0.0155	-0.0222	0.7727

From previous discussions, it is clear that credit risk spillovers affect both the changes and the volatility of the CDS spread. In particular, the credit risk spillover effects display both country and sector specific features during the period 2009 to 2014. In terms of spread changes spillovers, a bidirectional credit risk spillover effect is identified between the sovereign and the financial sectors in both Japan and Malaysia, while a bidirectional credit risk spillover effect exists between the sovereign and the non-financial sectors in Japan, South Korea and Malaysia. According to the shock and volatility spillovers, a GARCH(1,1) process exists in the changes of the CDS spreads for a variety of sample entities, including both sovereign debtors and firms in the five Asian countries. Moreover, the transmission of credit risk predominantly occurs through volatility spillovers while shocks have a reduced impact on volatility changes.

5.4.2 Robustness tests using 5-year CDSs

The previous discussion has outlined the main findings from 1-year CDS data. Thus, this subsection reports the summary results of the 5-year CDSs. The results of the credit risk spillover effects by using 5-year CDSs are displayed in Tables 5.1A to 5.6A in the appendices of this thesis due to the word count restrictions of this current chapter. The results for East Asia in terms of the percentages of significant coefficients, percentages of significant negative coefficients, and the averaged values of the coefficients are reported in Table 5.1A, Table 5.3A and Table 5.5A, respectively. The results for Southeast Asia are displayed in tables of even numbers. Similar to the reporting fashion of short-term spillover effects, Panel A of each table illustrates the spread changes spillovers, while the shock and volatility spillovers are displayed in Panel B.

Beginning with spread changes spillovers reported in Panel A from Table 5.1A to Table 5.6A, Table 5.1A demonstrates that past information from the non-financial sector plays an intermediary role in the transmission of credit risk among the three different sectors in South Korea in both the short and long term. Moreover, the findings from Table 5.2A confirm the presence of firm's own and cross-sectoral credit risk spillovers in Malaysia, although the percentages of significant coefficients are higher in the long than in the short term. In line with the findings from the changes in the 1-year CDS spread, there are no cross-sectoral linkages among sectors in Singapore by using 5-year CDSs. Furthermore, similar to the findings from the 1-year CDS spread changes, Table 5.5A confirms that the non-financial sector in South Korea plays an intermediary role in spilling over the credit risk among its sovereign and financial sectors. Panel B of Tables 5.1A to 5.6A show the results on shocks and volatility spillovers regarding the long-term credit risk spillover effects. Consistent with the previous findings on 1-year CDSs, a strong GARCH (1, 1) effect drives the credit risk in the vast majority of 5-year CDSs, although this effect is weak in Japan. Furthermore, the cross-sectoral credit risk spillovers of shocks are found in each country; for example, according to Table 5.6 and Table 5.5A, the impact of correlated past shocks between the financial and the non-financial sectors (i.e., $\varepsilon_{j,t-1}\varepsilon_{k,t-1}$) is consistently and negatively linked with the volatilities of CDS spread changes in the Japanese sovereign, financial and non-financial sectors (i.e., $h_{ii,t}$, $h_{jj,t}$ and $h_{kk,t}$) in both the short and long term. Moreover, a large number of significant coefficients regarding the past covariance of the sovereign and the financial sectors and that of the sovereign and the non-financial sectors are evidenced to exert an impact on the volatility of changes in the sovereign debtor's CDS spread in China, Japan, South Korea and Malaysia.

A comparison of the results from 1-year and 5-year CDSs also reveals that the credit risk spillover effects from firm's own past spread changes differ according to the maturity of the instruments. This finding is in line with Calice *et al.* (2013), who found that the transmission of credit risk varies with maturity and sector, as the attitudes of market participants differ between short-term and long-term credit risk. For example, according to Panel A of Table 5.1A, the insignificant γ_{jj} and γ_{kk} indicate that firm's own spillover disappears when considering the 5-year CDSs of Chinese financial and non-financial sectors, respectively. In other words, past changes in the credit risk of the financial and non-financial sectors in China no longer affect the current credit risk level once a long-term risk perspective is adopted. In addition, the impact of past changes in the Singaporean sovereign sector's CDS spread on its current status changes from -0.011 to 0.029 when using 5-year CDS data; in Singapore, the spillover effects of sovereign credit risk increase as a function of time. In terms of the off-diagonal coefficients in Panel A, bidirectional linkages are found across all three sectors in Japan and Malaysia, respectively. The results from Panel B of Table 5.5A and Table 5.6A show that both shocks and volatility spillovers in 5-year South Korean and Singaporean sovereign CDSs are more pronounced than those in 1-year CDSs, because the volatilities of changes in their sovereign CDS spreads turn to depend on the impact of both past direct and indirect shocks and volatilities in the credit risk of the domestic sovereign sector and its associated financial and non-financial sectors.

5.5 Conclusion

This chapter investigates the credit risk spillover effects within a nation's sovereign debtor and its financial and non-financial sectors using daily CDS spread changes from January 2009 to March 2014. Credit risk spillover effects from past changes in CDS spreads, from past shocks and volatilities are illustrated by employing the VAR(1)-trivariate-GARCH(1,1)-full-BEKK models proposed by Engle and Kroner (1995). In particular, 651 sets of CDS data are computed once by choosing three series of CDS data including one from the sovereign sector, one from the financial sector and one from the non-financial sector for each of the five Asian countries (China, Japan, Malaysia, Singapore and South Korea). Percentages of significant coefficients, percentages of significant negative coefficients and the averaged values of the coefficients are reported to identify the quantities of credit risk spillovers, the signs and the magnitudes of the effects. In particular, the analysis of this chapter uses 1-year CDS data to examine the presence of short-term credit risk spillovers 5-year CDS data to conduct robustness tests for the same set of sample firms.

A number of findings can be derived from this current chapter. First, the findings evidence the existence of both firm’s own- and cross-sectoral domestic credit risk spillover effects in Asian CDS reference entities; they are observed in the changes in the CDS spread, the shock and the volatility of credit risk. The significant firm’s own credit risk spillover effects imply a rejection of the weak form of the EMH and indicate a strong GARCH (1, 1) process appearing to characterise the Asian CDSs; in particular, volatility spillover effects are more pronounced than the effects of shocks. Thirdly, the significance impact of the past cross-sectoral volatility from the sovereign and the financial sectors on the current volatility of the sovereign debtor credit risk indicates the presence of strong cross-sectoral credit risk spillover effects regarding the volatility of credit risk. The results are in line with the findings from prior studies, such as Acharya *et al.* (2014), Alter and Beyer (2014) and Alter and Schüler (2012), who have evidenced the strong interdependence between the credit risk of the sovereign and the financial sectors. Last but not the last, the significant impact of the past cross-sectoral volatility from the financial and non-financial sectors on the current credit risk volatilities of different sectors implies the important role of the past correlated information from the volatilities and credit risk spillovers in the financial and non-financial sectors in transmitting credit risk in Asia. Thirdly, the credit risk spillover effects vary in different sectors and countries.

Since the analysis of this current chapter has identified significant domestic credit risk spillover effects within each Asian country, the next chapter of this current thesis moves on to the investigation of credit risk spillover effects by adopting a more comprehensive view

Chapter 6: Cross-firm credit risk interdependence of Asian CDSs

6.1 Introduction

A growing number of academic studies have started to analyse firms' credit risk by using information from CDS contracts, which have gradually grown in popularity as a risk management tool over the past decade. While the role of these products in risk management has been highlighted, their impact on the credit risk transmission between different firms remains poorly understood (Culp *et al.*, 2016). As introduced before, substantial research on this topic has focused on the analysis of credit risk interdependence between developed economies by using composite CDS indices (Calice *et al.*, 2012; Miquel *et al.*, 2012; Tamakoshi and Hamori, 2013a; Zoli, 2013). In order to aid our understanding of the scenario of credit risk transmission between firms in Asia from the standpoint of the CDSs, the framework of analysis in this chapter is conveyed by the significance findings from the previous chapter, which have evidenced the presence of credit risk spillovers between firms in different sectors within an Asian economy. According to the findings of the previous chapter, there are strong *domestic cross-sectoral* spillover effects between firms' credit risk in Asian economies regarding their CDS spread changes, as well as the volatilities of their CDS spread changes, but the respective directions and magnitudes of transmission differed. Moreover, the questions seeking to determine which firms give rise to the presence of credit risk spillover effects and how strong the impact of this transmission is are yet to be answered. Hence, the analysis of this current chapter helps to address these aforementioned questions.

This current chapter attempts to examine the manner in which credit risk is propagated across firms from the same sector or from different sectors both within the same economy and across countries. Therefore, this chapter complements the analysis undertaken in the previous chapter by testing spillover effects between any two Asian firms' credit risk using a VAR-bivariate-GARCH model with a full-BEKK specification;

it makes it possible to determine the persistence of shock innovations and the magnitudes of their effects over time.[71] Specifically, this chapter considers the credit risk spillover effects in the following four dimensions: 1) *domestic intra-sectoral* credit risk spillovers, 2) *domestic cross-sectoral* credit risk spillovers, 3) *regional intra-sectoral* credit risk spillovers, and 4) *regional cross-sectoral* credit risk spillovers. These spillovers are compared to indicate: (i) the sector or firm that is relatively more important in any spillover relations, (ii) the sector or firm that exerts a strong impact on the changes of other entities' credit risk and (iii) the sector or firm that is relatively sensitive to the credit risk information from other entities.

The remainder of this chapter is organised as follows. Section 6.2 explains the framework of the basic models employed in this chapter. Section 6.3 explains the research method adopted in this chapter. A detailed description of the study results is provided in section 6.4; there are four sub-sections in section 6.4; these sub-sections relate to: (i) *domestic intra-sectoral* credit risk spillover effects (i.e., sub-section 6.4.1), (ii) *domestic cross-sectoral* credit risk spillovers (i.e., sub-section 6.4.2), (iii) *regional intra-sectoral* credit risk spillovers (i.e., sub-section 6.4.3) and (iv) *regional cross-sectoral* credit risk spillovers (i.e., sub-section 6.4.4). Section 6.5 summarises the main findings of this chapter.

6.2 Framework of analysis

Unlike the previous chapter, the analysis of this chapter relies on a pairwise interdependence between two firms' credit risk. In other words, a firm's CDS spread changes are incorporated with another firm's CDS spread changes in order to enable an

[71] Nevertheless, in some respects, the analysis of this current chapter is less sophisticated than that of the previous chapter as only pairwise CDSs are considered in a bivariate setting. However, it is assumed to be a more comprehensive investigation of credit risk spillover effects because it detects the scenario of transmissions on the basis of different aspects.

investigation of firm-level pairwise interdependence, whereby a pairwise interdependence is applied to a sequence of firms. Therefore, the findings in this chapter should offer useful insights from a risk management perspective in terms of understanding how credit risk is interrelated between firms. Such an understanding would facilitate the development of effective strategies for the awareness of credit risk and of hedging strategies against shocks that are propagated across firms' CDS spread changes. Furthermore, a heightened awareness of the nature of volatility transmission between firms across sectors and countries is also of importance to economic policy-makers (Grammatikos and Vermeulen, 2012). Knowledge about such a volatility transmission between firms can allow policy-makers to take account of possible spillovers from one market segment to another and from one nation to another when making their policy decisions. Such an awareness about spillovers would be important from a financial stability perspective since any extreme volatility transmission could be detected and in consequence steps could be taken to mitigate the adverse impact of credit risk shocks in Asia.

As introduced before, this chapter distinguishes four different dimensions of credit risk interdependence between firms by sectors and economies. Specifically, it firstly considers the transmission of credit risk between two firms operating within the same sector and economy (i.e., *domestic intra-sectoral* credit risk spillover effects). For example, in each domestic sector, a firm's CDS spread changes are studied together with another firm's credit CDS spread changes. This setting makes it possible to examine the transmission of credit risk for any given pairs of Asian firms within a respective sector in their home country, thus the firms that are more important in spilling over credit risk in the sector of an economy are identifiable. Moreover, under this framework, the firms which are less affected by the credit risk shocks from other firms in the respective sector are also detectable. In particular, for this level of analysis, each nation has only one sovereign debtor in the sovereign sector, therefore it is impossible to construct a pairwise study within the sovereign sector of a given country. Thus, the analysis focuses on a nation's financial and non-financial sectors, respectively.

According to the previous discussion in the literature review chapter of this thesis, studies on the topic of the impact of interconnectedness between firms have mostly concentrated on examining the 'too-big-to-fail' hypothesis based on the effects of the collapse of Lehman Brothers on a number of large US banks. In contrast, only a limited number of studies have investigated the spillover effects of credit shock in an Asian nation's financial sector. One of the first published studies on this topic was reported by Baba and Inada (2009). Baba and Inada's analysis focused on the CDS spreads of four Japanese megabanks between the 2nd of April 2004 and the 30th of December 2005; these are the Bank of Tokyo-Mitsubishi, the Sumitomo Mitsui Banking Corporation, the MIZUHO Corporate Bank and the UFJ Bank. The findings suggested that the CDS spreads of the four Japanese megabanks were cointegrated in the period and the CDS spreads correlated substantially with the information of financial markets and the banks' balance sheet. Their results also emphasised the leading role of a Japanese bank's CDS spreads over the respective bond spreads, thus the CDS spreads of Asian financial institutions are an important tool to measure their credit risk.[72] It is noticeable that these four Japanese banks are also included in the data sample of this thesis, therefore the findings of this part of the analysis will not only add to our understanding of this topic in a region of the world where investigations are scarce, but also help to enhance our knowledge about the interdependence between Asian financial institutions after the 2008

[72] In particular, a significant amount of volatility spillover effects between the Japanese bond spreads and CDS spreads were identified in 2004-2005 using a bivariate GARCH model.

global financial crisis. In particular, to the best of my knowledge, the part related to the exploration of credit risk transmission between firms in the non-financial sector in each Asian economy by using the CDS data from this thesis is one of the first attempts in the field. Hence, the findings associated with the domestic credit risk transmission between firms within an Asian nation's non-financial sector should help extend our knowledge on the exposure of credit risk transmission between Asian non-financial firms.

The second dimension examines the credit risk spillovers for a pair of firms from different sectors but within the same nation (i.e., *domestic cross-sectoral* credit risk spillover effects). In this vein, the findings of Fratzscher (2002) and Kaltenhaeuser (2003) evidenced that when the level of integration with respect to the sectors within a country is higher, credit risk will depend more strongly on domestic market shocks. This part of this chapter's analysis provides a supplement to the results of the previous chapter by examining the transmission directions between firms on the basis of a pairwise investigation. As might be expected, the analysis of the previous chapter will be stronger since the relationships between CDS spread changes are estimated simultaneously for the respective reference entities across the sovereign, the financial and the non-financial sectors. Nevertheless, the pairwise investigation is reported here for the sake of completeness and in order to identify which pairs might be driving the results of Chapter 5 of this thesis; for instance, the findings from the previous chapter suggest a strong impact of the covariance between the financial and non-financial sectors' CDS spread changes on the transmission of volatility spillovers. Hence, the objective of identifying the firms which exert a strong impact on credit risk spillover between firms across different sectors can be achieved in this chapter.

The third dimension investigates the transmission of credit risk between the changes in CDS spreads for any given pairs of firms which are in the same sector but located in different states (i.e., *regional intra-sectoral* credit risk spillovers). This setting makes it possible to examine the cross-country impact of the changes in a firm's CDS spreads. For instance, the CDS spread changes of a financial institution from an Asian economy can be paired with each financial institution from the remaining four Asian countries by taking one of them at a time. The findings of previous studies, such as Black *et al.* (2016), Calice *et al.* (2012) and Degryse *et al.* (2010), evidenced the presence of such linkages across the banking system in advanced economies. The work of Alter and Beyer (2014) and Alter and Schüler (2012) also provided adequate evidence on the credit risk spillover effects between European countries during and after the 2010 Euro debt crisis. Their findings suggested that the initial shocks from troubled countries, such as Ireland and Greece, had a reduced impact on the creditworthiness of 'core' European countries, such as the UK and Germany. Hence, it is curious to examine which Asian country has a greater impact on the credit risk level of other economies in the sample. Since Japan and Singapore are the two economically important countries in Asia, their roles in the transmission of credit risk spillover effects are of interest.

Previous studies that have focused on the cross-country credit risk transmission between Asian nations are scarce, yet some attempts have still been made in this area. For example, Kim *et al.* (2010) are among the first researchers to have studied Asian CDS data with the purpose of investigating the risk of contagion. They used a number of *iTraxx* CDS indices, such as the *iTraxx* Japan and *iTraxx* Europe indices, in order to explain the changes in the CDS spreads of 38 non-sovereign Asian firms (i.e., 8 financial institutions and 30 non-financial firms).[73] They found significant and positive interdependence between them and argued that the risk of contagion is substantially explained by global

[73] In particular, there are 10 South Korean CDS reference entities, 6 Singaporean entities, 5 Indian entities, 8 Chinese entities (including 3 from Hong Kong and 1 from Taiwan), 4 Malaysian entities, 3 from Thailand and one entity from Indonesia and the Philippines, respectively.

effects, as risk appetites have changed after the 2008 global financial crisis. Their findings explicitly imply that there are significant interdependence between the CDS spread changes of Asian non-sovereign CDS reference entities, which may potentially create credit shock transmission channels. Furthermore, since the findings of Kim *et al.* (2010) rely on the CDS data ranging from January 2005 to 2009, the findings derived from using CDS data spanning from 2009 to 2014 in this thesis should help identify any shifts in credit risk transmission in Asia after the 2008 crisis. The findings should also help to identify the potential transmission of credit risk spillovers via credit shock and volatility by using the GARCH model.

The last dimension makes it possible to measure the credit risk spillover effects at a *regional cross-sectoral* level; it focuses on credit risk spillovers that are external to each sector and country. For instance, this setting allows the researcher to examine the cross-sectoral credit risk transmission between the Japanese sovereign debtor and the Chinese financial institutions, as well as the cross-sectoral transmission between the Chinese sovereign debtor and the Japanese financial institutions. This part of the analysis will facilitate an investigation of the argument that some shocks are regional (or global) in nature such that spillovers will exist for different sectors in different countries. In such circumstances, the analysis of this part of the chapter will shed light on the possible transmission mechanisms for such regional and global shocks as their impact reverberates across various sectors in different countries. Substantial studies have investigated the impact of the 2008 global financial crisis and the 2010 Euro debt crisis between the sovereigns and banks, their findings indicating that shocks which either related to a nation’s sovereign debtor or its banks can widely transmit to the adjacent economies by means of various transmission channels such as trade linkages. For example, one might speculate that spillovers may occur from the financial sector of the largest country to the non-financial sector of the smaller nations as equity investors in financial institutions may be the first to respond to any global shock which may have occurred.[74]

6.3 Research methods

This chapter uses the same dataset as that employed in the Chapter 5 of this thesis: 1-year and 5-year daily CDSs spread changes of (i) 121 firms drawn from the financial and non-financial sectors and (ii) 5 sovereign debtors. The sample includes data for CDSs from five Asian countries (i.e., China, Japan, Malaysia, Singapore and South Korea) ranging from January 2009 to March 2014. The pair-wised credit risk relationships between the changes of any two CDS spread series are estimated using a VAR-bivariate-GARCH-full-BEKK representation.[75] Thus, the CDS spread changes of one entity are jointly modelled with all of the other entities by taking one of them at a time. In order to model the full sample data in this manner, each CDS contract reference entity is labelled according to its respective sector and country. For example, let $\Delta CDS_{i,t}^{S,C}$ be the daily changes in CDS spread for firm *i* with its respective sector and country at time *t*. The superscript *S* represents different sectors and C refers to country. In line with the classification and notations of sectors in the previous chapter, *SOV* is for the sovereign debtor, *F* is for financial institutions and *NF* is for non-financial firms. Moreover, the five Asian countries are labelled as follows, where *CN* is for China, *JP* is for Japan, *MY* is for

[74] US financial institutions' credit problem in 2008 indirectly led to many Chinese textile companies' closures and the slowdown of China's steel industry (Fidrmuc and Korhonen, 2010).

[75] In line with Chapter 5 of this thesis, Engle's ARCH effect test is applied to the residuals to assess the significance of ARCH effects. The large critical values for these tests indicate a rejection of the null hypothesis in favour of the alternative. In addition, the Engle and Ng tests for asymmetries in volatility are employed to detect any presence of leverage effects in the transmission of shocks. Owing to the large number of pair-wise combinations included in this chapter, a first-step analysis of the leverage effect is conducted by selecting the largest two firms (based on total assets) in each sector from each country for testing. Thus, this allows us to test the possibility of asymmetries in volatility for the purpose of a small sample analysis. The results show limited significant leverage effects regarding the presence of sign and size bias. In addition, the large set of estimates also contributes to the difficulties of reporting the findings; as the leverage effects may cancel out at the aggregate level. Thus, a decision was made to employ the general bivariate GARCH model with the full-BEKK specification in this chapter to maintain a consistency with the remainder of this thesis. Nevertheless, a set of F-tests are applied to test for the asymmetric transmission of credit risk regarding the mean spread changes, the shocks and the volatilities.

Malaysia, *SG* is for Singapore and *SK* is for South Korea. As introduced before, this chapter will investigate the transmission of credit risk across sector and countries, thus, there are three different groups to each of the combination of sectors and countries. For example, the three groups of the combination of sectors are: (i) the sovereign entity with financial entities (*SOV:F*), (ii) the sovereign entity with non-financial entities (*SOV:NF*), and (iii) financial entities with non-financial entities (*F:NF*). This grouping was used in the previous chapter and is employed in the current empirical analysis in order to maintain a level of consistency throughout the thesis.

In its most general specification, the mean equation of the VAR(1)-bivariate-GARCH (1,1) process takes the following form:

$$\begin{bmatrix} \Delta CDS_{i,t}^{S,C} \\ \Delta CDS_{j,t}^{S,C} \end{bmatrix} = \begin{bmatrix} \gamma_{i,0} \\ \gamma_{j,0} \end{bmatrix} + \begin{bmatrix} \gamma_{ii} & \gamma_{ij} \\ \gamma_{ji} & \gamma_{jj} \end{bmatrix} \begin{bmatrix} \Delta CDS_{i,t-1}^{S,C} \\ \Delta CDS_{j,t-1}^{S,C} \end{bmatrix} + \begin{bmatrix} \varepsilon_{i,t} \\ \varepsilon_{j,t} \end{bmatrix} \qquad (6.1)$$

where, $\Delta CDS_{i,t}^{S,C}$ (or $\Delta CDS_{j,t}^{S,C}$) is the first differences of daily changes in CDS spread of the reference entity *i (*or *j)*. The parameters of the autoregressive terms, γ_{ij} and γ_{ji}, measure the credit risk spillover effects between the daily CDS spread changes of entity *i* and entity *j*; for example, γ_{ij} measures the impact of the past CDS spread changes of entity *i* on the current CDS spread changes of entity *j*. In other words, a one-way credit risk spillover effects present between entities *i* and *j* when any of these two parameters is statistically significant, while a bidirectional linkage of credit risk spillover effects exist when both of these two parameters are statistically significant. $\varepsilon_{i,t}$ and $\varepsilon_{j,t}$ are residual vectors; residuals are assumed to be conditional normally distributed with conditional mean values of zero and their corresponding conditional variance and covariance matrix H_t. In the bivariate GARCH (1,1)-full-BEKK representation proposed by Engle and Kroner (1995), H_t takes the following form:

$$\begin{bmatrix} h_{ii,t} & h_{ij,t} \\ h_{ji,t} & h_{jj,t} \end{bmatrix} = \begin{bmatrix} m_{ii,t} & m_{ij,t} \\ 0 & m_{jj,t} \end{bmatrix}' \begin{bmatrix} m_{ii,t} & m_{ij,t} \\ 0 & m_{jj,t} \end{bmatrix} + \begin{bmatrix} a_{ii} & a_{ij} \\ a_{ji} & a_{jj} \end{bmatrix}' \begin{bmatrix} \varepsilon_{i,t-1}^2 & \varepsilon_{j,t-1}\varepsilon_{i,t-1} \\ \varepsilon_{j,t-1}\varepsilon_{i,t-1} & \varepsilon_{j,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{ii} & a_{ij} \\ a_{ji} & a_{jj} \end{bmatrix} + \begin{bmatrix} g_{ii} & g_{ij} \\ g_{ji} & g_{jj} \end{bmatrix}' \begin{bmatrix} h_{ii,t-1} & h_{ji,t-1} \\ h_{ji,t-1} & h_{jj,t-1} \end{bmatrix} \begin{bmatrix} g_{ii} & g_{ij} \\ g_{ji} & g_{jj} \end{bmatrix} \quad (6.2)$$

where $h_{ii,t}$ *and* $h_{jj,t}$ are the conditional variances for entities i and j at time t, $h_{ji,t}$ describes the conditional covariance between them. Equation (6.2) models the dynamic process of H_t as a function of its own past values H_{t-1} and of past values of innovations ($\varepsilon_{i,t-1}$ *and* $\varepsilon_{j,t-1}$), which allows for firm's own and cross influences in the conditional variances. Using the BEKK modeling procedure, the estimates can show the extent to which shocks will have significant impacts on the variance of CDS spread changes. The BEKK parameterization is selected over other multivariate GARCH specifications because it guarantees that the covariance matrix is positive-definite, it also allows the estimated correlations between the changes of CDS spreads to be time-varying.

However, tracking the impact of shocks in CDS spread changes is not straight forward due to the non-linearity of the GARCH models; the impact of a shock depends on all other variables in the system, past shocks in entity *i* and entity *j* and their interactions, as well as past variance and covariance. Thus, equation (6.2) can be rewritten as:

$$h_{ii,t} = m_{ii}^2 + a_{ii}^2\varepsilon_{i,t-1}^2 + 2a_{ii}a_{ji}\varepsilon_{j,t-1}\varepsilon_{i,t-1} + a_{ji}^2\varepsilon_{j,t-1}^2 + g_{ii}^2 h_{ii,t-1} + 2g_{ii}g_{ji}h_{ji,t-1} + g_{ji}^2 h_{jj,t-1} \quad (6.3)$$

$$h_{ij,t} = m_{ii}m_{ij} + a_{ii}a_{ij}\varepsilon_{i,t-1}^2 + (a_{ii}a_{jj} + a_{ji}a_{ij})\varepsilon_{j,t-1}\varepsilon_{i,t-1} + a_{ji}a_{jj}\varepsilon_{j,t-1}^2 + g_{ii}g_{ij}h_{ii,t-1} + (g_{ii}g_{jj} + g_{ji}g_{ij})h_{ij,t-1} + g_{ji}g_{jj}h_{jj,t-1} \quad (6.4)$$

$$h_{jj,t} = m_{ji}^2 + m_{jj}^2 + a_{ij}^2\varepsilon_{i,t-1}^2 + 2a_{jj}a_{ij}\varepsilon_{j,t-1}\varepsilon_{i,t-1} + a_{jj}^2\varepsilon_{j,t-1}^2 + g_{ij}^2 h_{ii,t-1} + 2g_{ij}g_{jj}h_{ji,t-1} + g_{jj}^2 h_{jj,t-1} \quad (6.5)$$

In the variance-covariance equation, the credit shocks to entity j can affect the variance of CDS spread changes for entity i through: (i) the direct effect of past shocks in entity j and (ii) the indirect effect through the interactions between credit shocks to entity i and entity j. In addition, the volatility of CDS spread changes in entity i can vary with past variances of CDS spread changes in entity j and the covariance between the spread changes of both entities. Therefore, a_{ji} and g_{ji} in equation (6.3) measure the cross transmission of past squared errors ($\varepsilon_{i,t-1}^2$) and conditional variances ($h_{jj,t-1}$) from entity j to entity i, while a_{ij} and g_{ij} in equation (6.5) measure the cross linkage in the other direction.[76] In the bivariate case, the log likelihood function $l\,(\theta) = -\frac{TN}{2} log 2\pi - \frac{1}{2}\sum_{t=1}^{T}(log|H_t| + I_t' H_t^{-1} I_t)$ is maximised using the procedure of Berndt *et al.* (1974) in order to obtain the estimates of equations (6.1) and (6.2).[77] In this function θ denotes all the 11 unknown parameters to be estimated (m_{ii}, m_{ij}, m_{jj}, a_{ii}, a_{ij}, a_{ji}, a_{jj}, g_{ii}, g_{ij}, g_{ji},

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[76] Apart from the multivariate GARCH models, Diebold and Yilmaz' (2012) spillover index model has become increasing popularity in academic research. As introduced in Chapter 3 of this thesis, Alter and Beyer (2012) is one of the first researchers, who applied Diebold-Yilmaz' (2012) spillover index model to quantify the credit risk spillover effects using CDS data. Specifically, Diebold and Yilmaz' (2012) model builds on a VAR model and a variance decomposition approach; their model allows the user to incorporate the information set of the process of variance decompositions into one single value. Although this model simplifies estimates, a multivariate GARCH model framework is used in this thesis since one aim of this thesis is to detect whether a GARCH (1,1) process exists in driving the changes in CDS spreads; it facilitates test of the weak-form of EMH. Past studies such as Alomari *et al.* (2018) used a multivariate GARCH model and found significant return and volatility spillovers in Jordan's Amman Stock Exchange. Thus a full set of parameters from a multivariate GARCH model makes it possible to achieve this goal. In addition, the GARCH model with a full-BEKK specification also helps to identify the difference between the features of the cross-transmission of shock and volatility spillovers. Even though this thesis does not utilise the Diebold-Yilmaz' (2012) spillover index model, it has been widely applied in examining the spillover effects between various financial markets. For example, prior studies such as Bajo-Rubio *et al.* (2017), have used this model to examine spillover effects in Turkish stock market and found significant mean and volatility spillovers; in particular, a greater degree of interdependence was uncovered after the 2008 global financial crisis. Moreover, an analysis of the interdependence of macroeconomic conditions and stock prices, McMillan and Tiwari (2016) used a 200-year period of US data to examine the spillover effects between output and stock prices; the findings suggested that output is a strong explanatory factor in relation to the variation of stock prices.

[77] The BHHH algorithm is often used to maximize the log-likelihood function. Previous studies on multivariate GARCH models such as Li (2007) have employed this algorithm. McFadden and Train (1995) highlighted that the BHHH method is 'a more practical procedure for estimating time series' (p.8). Furthermore, McCullough and Renfro (1998) advised the use of a method such as the BHHH 'to avoid calculation of second derivative' (p.67). Carling and Soderberg (1998) agreed about the advantages of using the BHHH algorithm that other methods (e.g., the Newton method) arguing that these other methods 'performed poorly compared with the Gauss method (BHHH)' (p.83).

g_{jj}) for each pair of entities analysed and *N* is equal to two which refers to the number of CDS series in pairing.

Moreover, in order to present the dynamic correlations between the changes in two CDS reference entities' CDS spreads, the variance-covariance equations (i.e., equation (6.2)) from the estimate of each pair of firms is utilised to compute the dynamic correlations of each pair of firms from 2009 to 2014. The dynamic correlations calculated as follows:

$$\rho_{ij,t} = \frac{h_{ij,t}}{\sqrt{h_{ii,t}}\sqrt{h_{jj,t}}} \tag{6.6}$$

where $\rho_{ij,t}$ is the correlation between the CDS reference entities *i* and *j* at a point of time *t*. The numerator of equation (6.6) is the conditional covariance in equation (6.2), while the denominator is the product of the conditional standard deviations. In particular, as one of the important aims of this chapter is to identify the firms and sectors which has the strongest influence in the transmission of credit risk along four dimensions. However, due to the words constraints in this chapter, the firm names for pairs of firms which have strong cross-firm spillover effects are reported in the Appendices 6.1.

6.4 Empirical Findings

This chapter uses a VAR(1)-bivariate-GARCH(1,1)-full-BEKK model in order to investigate the credit risk spillover effects of the changes in the 1-year and 5-year CDS spreads for a total number of 20,760 pairs of entities.[78] In order to provide a structural discussion of the results, the findings regarding various transmission of credit risk are reported separately for the 1-year and 5-year CDSs. Section 6.4.1 presents the estimates

[78] For each maturity, there are 1,733 pairs of firms in the analysis of spillovers within the same sector of a given country, while 4,540 pairs of entities are considered when examining credit spillovers within the same sector but across countries. The analysis of transmission between sectors in a given country examines spillovers in 772 pairs of entities while the last construction involves 3,335 pairs of entities in the analysis of credit spillovers between different sectors and countries.

from the 1-year CDSs, while the estimates from the 5-year CDSs are reported in section 6.4.2. In order to facilitate our understanding of the findings from this chapter, each of the two sections has four sub-sections, respectively. According to the estimates from 1-year CDSs, the first sub-section of section 6.4.1 focuses on credit risk spillovers within the same sector in a nation, while the cross-sectoral linkages within a nation are studied in the second sub-section. The third sub-section of section 6.4.1 examines transmission within a given sector but across different countries taken one at a time, while the last sub-section focuses on the spillover effects of credit risk across different sectors and countries. In the same vein, an overview of the estimates of robustness tests that are based on the 5-year CDSs is reported following.

Given that this chapter is looking at the credit risk transmission between entities for a total number of 10,380 pairs for each CDS contract maturity, it is difficult to show the results in great detail. Consistent with the approach adopted in Chapter 5 of this thesis, it was decided to report (i) the percentages of significant cross-effect parameters, (ii) the percentages of negative significant cross-effect parameters and (iii) the averaged values of those parameters given in the tables.[79] However, the tables reported in this chapter are not identical to those constructed for Chapter 5. Specifically, only the cross-effects of entities' credit risk spillovers are reported in each table, as the effects of a firm's past own credit spread changes have already been discussed in the previous chapter. In addition, restriction tests on cross-spillovers are conducted in order to verify whether any transmission between the two CDS spread changes in each pair is symmetrical or asymmetrical in nature. According to Allen and Gale (2000), a significant increase in

[79] The methods used for calculating the percentages of negative significant coefficients and average values in the current chapter are consistent with those of Chapter 5; the percentage of significant and negative parameters is found by dividing the number of negative significant parameters by the total number of the given statistically significant parameters. To calculate the average values, the insignificant values are treated as zero.

cross-market linkages after a shock to an individual country or a group of countries is defined as contagion. Therefore, in order to provide a more granular view of contagion over time, the average values of the time-varying correlations between two different CDS spread changes for each year are also reported.[80]

Tables 6.1 to 6.12 illustrate the main findings of the 1-year CDSs from the chapter; the findings of 5-year CDSs are reported in Appendices 6.1. Each table is structured in a similar fashion both for simplicity and in order to facilitate a visual inspection of the results. The first main column on the left-hand side of each table displays the parameters for the cross-effects of the credit risk spillovers that were estimated. In particular, the cross-effects derived from mean spread changes are presented in Panel A of each table, while shocks and volatility spillovers are presented in Panel, respectively. Panel C of those tables with an even table number reports the percentages of cases where the cross-transmission between any two different CDS series is asymmetrical. That is, it shows the percentages of rejection of the null hypothesis of a symmetric transmission of credit risk spillovers. The asymmetry of spillover effects is tested by conducting F-tests for each analysed pair. Panel C of those tables with an odd number shows the average annual correlation between the CDS spread changes of two entities in each sector from 2009 to 2014.

6.4.1 Estimates from 1-year CDSs

6.4.1.1 Domestic intra-sectoral spillover effects

This subsection presents the findings regarding the credit risk spillover effects across two sectors: (i) spillovers within a nation's financial sector and (ii) spillovers

[80] The correlation between any given pair of CDS spread change series at each point in time is constructed by dividing the conditional covariance by the product of the conditional standard deviations. These changes to the tables in Chapter 6 were decided upon because of the different analysis being conducted. Furthermore, in order to avoid any problem with information overload, a decision was taken to focus on the key coefficients; of course all results are available from the author upon request.

within a nation's non-financial sector. The percentages of significant parameters and the percentages of significant negative parameters are reported in Table 6.1. The associated average values of the parameters are shown in Table 6.2. In line with the classification of the five Asian countries in the previous chapter, China, Japan and South Korea are grouped in the East Asian region, while the two Southeast Asian countries are Malaysia and Singapore.

A number of points emerge from an analysis of these tables. Starting with Panel A of Tables 6.1 and 6.2, bidirectional linkages associated with changes in CDS spreads between a pair of firms are observed in each of the two sectors in the three East Asian countries, as well as in Malaysia.[81] In contrast, the interactions between Singaporean firms are weaker from the standpoints of the percentages of significant parameters in the mean equations. In addition, the associated small percentages of significant negative parameters indicate the significant and positive impact of changes in the CDS spreads for a given sector within a nation; in other words, the mean reversion of a firm's CDS spreads is likely to be associated with the mean reversion of other firms in the same sector and country. Particularly, the credit risk of Japanese financial institutions exhibited a higher degree of interdependence since nearly half of the cross-firm credit risk transmission is significant (i.e., in Table 6.1, the percentage of significant coefficient, $\gamma_{ji}^{F,JP}$, is 47.62%). This finding is in line with Gross and Kok (2013), who identified strong inter-bank linkages in the Japanese banking system. A further inspection of the averaged values of the parameters in Panel A of Table 6.2 documents the mean reversion co-movement of the changes in the firm's CDS spreads; these parameters are non-zero positive values. This bidirectional linkage is particularly strong in the Japanese non-financial sector, as

[81] For example, there was a spillover of credit risk from two firms, IOI Corporation Berhad from the manufacturing sector and Miscellaneous Berhad from the transportation sector to all non-financial firms in Malaysia between 2009 and 2014. Detailed results about individual firms can be provided upon request.

the average values of both cross-firm spillover effects are larger than half of a unit (i.e., $\gamma_{ij}^{NF,JP}$ = 0.7443 and $\gamma_{ji}^{NF,JP}$ = 0.5106). This finding suggests a strong spillover effect of the changes in CDS spreads between Japanese non-financial firms in the short run. In contrast, the averaged cross-firm credit risk spillover effects of the Japanese financial sector are weaker than in the case of the non-financial sector, however, this impact is still significant compared with the results of other nations' financial sectors; the averaged value of $\gamma_{ji}^{X,C}$ ranges from 0.0030 for the Chinese financial sector to 0.1212 for the Japanese financial sector. In general, the averaged credit spillover effects associated with γ_{ji} and γ_{ji} for the non-financial sectors in China, Japan and Malaysia are positive and larger than in the case of the non-financial sector, suggesting stronger credit linkages among the non-financial firms in these countries. Hence, the transmission of credit risk between Asian CDS reference entities in a given sector of a country varies as a function of the variation of both sectors and countries from the standpoints of CDS spread changes spillovers. Furthermore, the aforementioned findings from Panel A of Tables 6.1 and 6.2 provide some evidence of predictability in 1-year CDS spread changes in Asian reference entities over time. The findings reinforce the conclusions of some recent studies in the area about the weak-form information inefficiency of CDS spreads in emerging markets (Packer *et al.,* 2003; Williams *et al.,* 2013).

Secondly, Panel B in Tables 6.1 and 6.2 displays the results of the off-diagonal elements of the ARCH and GARCH matrix from the variance-covariance equations under the full BEKK approach in equation (6.2). The first half of Panel B captures the cross-transmission of shocks (i.e.,$a_{ij}^{S,C}$ and $a_{ji}^{S,C}$), while the second half reports the volatility spillovers (i.e., $g_{ij}^{S,C}$ and $g_{ji}^{S,C}$) between the analysed pairs of CDS series.[82] From this

[82] In line with the results reported in the previous chapter, strong GARCH (1,1) processes are found for the vast majority (90%) of the sample firms.

panel in Table 6.1, it is clear that some of the parameters are statistically significant for both the financial and non-financial sectors in the three East Asian countries. This finding is especially true in the Japanese financial sector, as nearly half of the volatility spillovers are statistically significant at the 5% level of significance. Therefore, the strong interdependence between Japanese financial institutions are not only found in the changes in their CDS spreads but are also evidenced in the spillover effects in terms of volatility. Contrasting findings are observed in the case of South Korea; slightly more shock and volatility spillovers are found in the non-financial sector than in the financial sector for South Korea (i.e., the percentages of significant $a_{ji}^{NF,SK}$ is 13.07 %).[83] A possible explanation here may be that there are large family conglomerates within the South Korean non-financial sector, such that internal finance may create a potential channel of credit transmission (Claessens *et al.*, 2000).[84]

In contrast, Malaysian and Singaporean firms (including both financial and non-financial firms) are less interdependent due to the small number of percentages of significant coefficients in Table 6.1; the percentages of significant coefficients range from zero to 33.33% and none of the significant coefficients have a negative value. Taking the number of pairs reported in the last row of Table 6.1, it is clear that only one pair of CDS reference entities for each of the Malaysian financial and non-financial sector has significant shock and volatility spillovers. More specifically, a one-way transmission of short-term credit risk shock from Oversea-Chinese Banking Corporation Limited in Singapore to DBS Bank Limited and Temasek Holdings (also in Singapore) was identified, while a bidirectional volatility spillover effect existed between Oversea-

[83] Taking the associated number of pairs in the South Korean non-financial sector into account, there are 20 out of 153 pairs exhibiting significant cross-firm shock spillovers. The estimation results suggest that the GS Caltex Corporation, Samsung Electronics Co., Ltd., SK Innovation Co., Ltd. and SK Telecom Co., Ltd. had a closer relationship to other non-financial firms.

[84] For instance, Claessens *et al.* (2000) found that the Kyuk Ho Shin family are the principal shareholders across a wide range of non-financial corporations in South Korea.

Chinese Banking Corporation Limited and Temasek Holdings. Therefore, in Singapore, Oversea-Chinese Banking Corporation Limited plays an important role in the banking industry in terms of credit risk volatility spillovers over the short term. Similarly, CIMB Bank Berhad from the banking sector is the only driver in the financial sector in Malaysia.

Thirdly, the values of the estimators in Panel B of Table 6.2 are large and positive; the large absolute values of $a_{ij}^{S,C}$ or $a_{ji}^{S,C}$ and $g_{ij}^{S,C}$ or $g_{ji}^{S,C}$ imply that shocks to the conditional variance will be highly persistent and a large negative or positive spread change will lead future variance forecasts to be relatively high for a protracted period. In addition, a visual inspection of the results shown in Panel C of Table 6.1 highlights that most cross-sectoral spillovers are asymmetric, especially in the financial sector. For example, all three pairs of financial institutions in Malaysia and Singapore have asymmetric spillovers in spread changes, shocks and variances. Furthermore, Panel C in Table 6.2 shows the averaged values of the time-varying correlations for each year from 2009 to 2014. It is worth highlighting that the analysis for the sample ends in March 2014; therefore, the average correlation shown for the year 2014 only involves a period of 3 months. From a visual inspection of these mean values, the smallest correlation ranges are observed for both the Japanese financial and non-financial sectors. Indeed, the values reported for Japan only vary from 0.02 for the financial sector in 2012 to a maximum of 0.06 for the non-financial sector in 2013 and 2014, respectively. By contrast, the non-financial sector in Malaysia and the financial sector in South Korea show a high degree of co-movement between credit spread changes from 2009 to 2014. In these two cases, the degrees of correlations are greater than 0.59 for the non-financial sector in Malaysia and greater than 0.50 for the financial sector in South Korea. Apart from these results, the findings indicate that the average correlations increased during 2012 for all countries,

Table 6.1: A summary of the significant parameters for 1-year CDSs: domestic intra-sectoral spillover effects

Parameters		**East Asia**						**Southeast Asia**			
		China		Japan		South Korea		Malaysia		Singapore	
		F	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*
Panel A: Mean spread changes spillovers											
$\gamma_{ij}^{S,C}$	$**$	14.29	27.78	28.57	13.07	33.33	21.57	33.33	30.00	0.00	10.00
	$**^{(-)}$	0.00	0.00	0.00	0.53	0.00	36.36	0.00	0.00	N/A	0.00
$\gamma_{ji}^{S,C}$	$**$	4.76	25.00	47.62	15.65	35.56	20.26	33.33	60.00	33.33	0.00
	$**^{(-)}$	0.00	0.00	0.00	4.46	0.00	6.45	0.00	0.00	0.00	N/A
Panel B: Shocks and volatility spillovers											
$a_{ij}^{S,C}$	$**$	19.05	11.11	19.05	33.05	20.00	20.92	33.33	20.00	33.33	10.00
	$**^{(-)}$	49.97	25.02	75.01	53.71	66.65	62.48	0.00	0.00	0.00	0.00
$a_{ji}^{S,C}$	$**$	28.57	22.22	33.33	31.38	11.11	13.07	0.00	20.00	33.33	0.00
	$**^{(-)}$	50.02	75.02	85.72	50.32	39.96	50.04	N/A	0.00	0.00	N/A
$g_{ij}^{S,C}$	$**$	19.05	19.44	47.62	42.98	13.33	32.68	33.33	0.00	33.33	20.00
	$**^{(-)}$	24.99	57.15	50.00	51.21	50.04	39.99	100.00	N/A	100.00	0.00
$g_{ji}^{S,C}$	$**$	38.10	19.44	66.67	46.75	11.11	35.29	0.00	0.00	33.33	10.00
	$**^{(-)}$	62.49	57.15	42.85	41.56	19.98	53.70	N/A	N/A	0.00	100.00
Panel C: Restriction tests											
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		100.00	91.67	95.24	99.86	97.78	99.35	100.00	100.00	100.00	100.00
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		95.24	83.33	90.48	65.55	91.11	90.20	100.00	90.00	100.00	90.00
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		100.00	97.22	95.24	99.44	93.33	99.35	100.00	100.00	100.00	100.00
Number of pairs		21	36	21	1431	45	153	3	10	3	10

Note: This tables reports the percentages of significant parameters and of significant negative parameters, respectively. An ** denotes significance at a 5% significant level, while an $**^{(-)}$ denoted significant but negative parameters at a 5% significant level. The results of restriction tests are shown in Panel D. The total numbers of pairs regarding the types of pairings are reported in the last row of the table. *F* is the abbreviation of financial institutions and *NF* is the abbreviation of non-financial firms.

Table 6.2: The averaged values of the parameters for 1-year CDSs: domestic intra-sectoral spillover effects

Parameters	East Asia						Southeast Asia			
	China		Japan		South Korea		Malaysia		Singapore	
	F	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*
Panel A: mean spread changes spillovers										
$\gamma_{ij}^{S,C}$	0.029	0.043	0.053	0.744	0.062	0.026	0.047	0.062	0.000	0.007
	(0.012)	(0.017)	(0.019)	(0.327)	(0.021)	(0.011)	(0.022)	(0.020)	(0.000)	(0.004)
$\gamma_{ji}^{S,C}$	0.003	0.030	0.121	0.511	0.087	0.048	0.031	0.166	0.041	0.000
	(0.001)	(0.013)	(0.047)	(0.238)	(0.022)	(0.017)	(0.011)	(0.067)	(0.014)	(0.000)
Panel B: Shocks and volatility spillovers										
$a_{ij}^{S,C}$	-0.001	-0.020	-0.079	0.001	0.010	-0.002	0.000	0.050	0.019	0.000
	(0.010)	(0.005)	(0.037)	(0.007)	(0.001)	(0.005)	(0.000)	(0.021)	(0.009)	(0.000)
$a_{ji}^{S,C}$	0.005	0.019	0.009	-0.004	-0.010	-0.008	0.044	0.008	0.075	0.021
	(0.010)	(0.009)	(0.013)	(0.008)	(0.003)	(0.013)	(0.022)	(0.004)	(0.029)	(0.000)
$g_{ij}^{S,C}$	-0.010	-0.004	0.007	0.003	0.001	0.003	0.000	0.000	0.008	-0.015
	(0.008)	(0.001)	(0.011)	(0.006)	(0.000)	(0.006)	(0.000)	(0.000)	(0.003)	(0.004)
$g_{ji}^{S,C}$	0.009	-0.002	-0.024	-0.001	0.002	0.015	-0.014	0.000	-0.012	0.005
	(0.006)	(0.003)	(0.010)	(0.004)	(0.002)	(0.009)	(0.003)	(0.000)	(0.001)	(0.002)
Panel C: Annual correlations										
2009	0.18	0.29	0.03	0.04	0.50	0.31	0.25	0.59	0.21	0.19
2010	0.16	0.28	0.05	0.05	0.58	0.31	0.20	0.61	0.32	0.22
2011	0.17	0.31	0.04	0.05	0.58	0.28	0.26	0.72	0.33	0.22
2012	0.15	0.29	0.02	0.05	0.51	0.27	0.25	0.67	0.34	0.23
2013	0.16	0.30	0.03	0.06	0.62	0.28	0.30	0.72	0.39	0.21
2014	0.18	0.33	0.04	0.06	0.64	0.27	0.30	0.71	0.43	0.27

Note: This tables presents the averaged values of the parameters and the annual correlations for 1-year CDSs regarding domestic intra-sectoral spillover effects.

especially in the financial sector. A possible reason here may be that merger and acquisition activities with Asian involvement in 2012 increased by 16.7-US$488.9 billion (Thomson Reuters, 2012). This acquisition activity may have led to increased linkages among credit risk for firms within this region.

Overall, the results discussed in this sub-section suggest that there are significant cross-firm credit risk spillovers for each of the respective sectors in the five Asian countries, in terms of both the mean and the volatility of spread changes. In particular, the Japanese financial institutions show a substantial number of significant cross-firm spillovers but with weaker credit risk spillover effects among them. In contrast, its non-financial sector shows a lower number of credit risk connections with each other but with significant effects. In terms of the co-movement of changes in CDS spreads, all of the five Asian countries seem to co-move from 2009 to 2014; the degree of co-movement in the non-financial sector is greater than in the financial sector for China and Malaysia, while it is in the other way around for Singapore and South Korea. Taken together, the results referring to domestic intra-sectoral credit risk spillover effects indicate that large and economically important firms seem to be the main drivers of cross-firm spillover effects in the domestic market. In particular, non-financial firms in China and South Korea were more connected with each other in terms of credit risk spillovers, while Japanese financial institutions were more affected by the credit risk spillovers derived from the volatility of changes in the associated CDS spreads in 2009-2014.

6.4.1.2 Domestic cross-sectoral spillover effects

As previous studies have indicated that there is a feedback loop between the credit risk of a sovereign debtor and its domestic financial institutions, it seems plausible that other cross-sectoral linkages may exists (i.e., between the sovereign sector and the non-financial sector and between the financial and non-financial sectors) (Acharya *et al.,* 2014;

Alter and Beyer, 2014). In addition, one important contribution of this thesis is its goal of enhancing our understanding of the credit risk linkages among a nation's sovereign debtor, its financial and non-financial sectors in order to analyse what a role the credit risk of a nation's non-financial firms play in spilling over credit risk in domestic market. Therefore, the analysis of the previous chapter and this sub-section of the current chapter aims to identify any presence of cross-sectoral credit risk interdependence each of the sample Asian countries.

Credit risk transmission across sectors within an Asian nation has been analysed via a trivariate-GARCH model in the Chapter 5 of this thesis. Nevertheless, by using a bivariate-GARCH setting, this sub-section provides a complementary study of the transmission of credit risk to identify which pairs of entities appear to driving the results arrived within the previous chapter. Although the transmission loop of credit risk between different sectors is also detectable by using the results from the previous chapter, its interpretation is not such straightforward applicable in this chapter because a bivariate setting is consistently utilised for various investigations throughout this current chapter. In other words, the bivariate analysis in this chapter not only help to identify systemic important CDS reference entities within a nation, but also help to track their roles in depth for a regional level. Thus, it was decided to proceed with the bivariate analysis of credit risk linkages among sectors within a country so that the results obtained could inform the previous chapter's findings.

Tables 6.3 to 6.4 report the results by using 1-year CDS spread changes in order to investigate the credit risk transmission between different sectors in their home-country. In line with Table 6.1 and Table 6.2, the first rows in Tables 6.3 and 6.4 list out country names. In addition, the abbreviations for three different combinations of CDS reference entities is shown in three sub-columns in the second row of the tables, respectively.

Namely, they are: (i) pairs between the sovereign debtor and the financial institutions (i.e., *SOV:F*), (ii) pairs between the sovereign debtor and the non-financial firms (i.e., *SOV:NF*) and (iii) pairs between the financial and non-financial firms (i.e., *F:NF*). That is, $S \in \{SOV\colon F, SOV\colon NF, F\colon NF\}$ in the analysis of domestic cross-sectoral spillover effects. Therefore, the coefficients, $\gamma_{ij}^{S,C}$ and $\gamma_{ji}^{S,C}$ reported in Panel A of Tables 6.3 and 6.4 measure the cross-sectoral credit risk spillover effects within a nation regarding the changes in CDS spreads for each combination and $a_{ij}^{S,C}$ or $g_{ij}^{S,C}$ and $a_{ji}^{S,C}$ or $g_{ji}^{S,C}$ reported in Panel B of the tables measure the cross-sectoral spillover effects from the past shock or volatility of firms' CDS spread changes. Moreover, the sovereign debtor ranked first based on the order of the process of pairings and the financial institutions ranked second, corresponding to the pair of *SOV:F*. Similarly with the pair of *SOV:F*, the financial institutions ranked first and the non-financial sector ranked second in the pair of *F:NF*. For instance, when the Chinese sovereign debtor is paired with its domestic financial institutions, the coefficient $\gamma_{ij}^{SOV:F,CN}$ captures the impact of past changes in CDS spread from the Chinese sovereign debtor to the current changes in its financial institutions' CDS spread and the coefficient $\gamma_{ji}^{SOV:F,CN}$ measures the impact of past changes in CDS spreads from Chinese financial institutions to its sovereign debtor's current changes in CDS spread.

Table 6.3 reports the percentages of estimated coefficients that were (i) significant and (ii) significant but negative at the 5% significance level and Table 6.4 documents the averaged values of the coefficients. A number of findings emerge from a visual inspection of Tables 6.3 and 6.4. Beginning with Panes A of Tables 6.3 and 6.4, the results show significant transmission of credit risk between sectors in an Asian nation, but the proportions of coefficients which are statistically significant differ between sectors and countries. For instance, bilateral credit risk spillover effects are found in the three different pairs for Japan CDS reference entities, while the effects is only significant in the pair of *SOV: F* in China and in the pair of *SOV:NF* in South Korea. In line with the findings from the Chapter 5 of this thesis, the Japanese sovereign debtor correlated more widely with its financial institutions than non-financial firms (i.e., the percentages of significant $\gamma_{ij}^{S,JP}$ and $\gamma_{ji}^{S,JP}$ for the pair of *SOV:F* are larger than *SOV:NF*).

In contrast, past changes in CDS spreads from the sovereign debtors in China and South Korea have a wide range of effects on the current CDS spread changes in their respective domestic non-sovereign (including both financial) firms. The percentage of significant spillovers from the past changes in the sovereign debtor's CDS spreads is 57.14% compared with 14.29 in the other direction from the investigation of China. In contrast, more than half pairs of firms received information from the past CDS spread changes of South Korean sovereign debtor but only 11.11% of the total 18 pairs in referencing of *SOV:NF* has significant cross-sectoral credit risk spillovers. This finding is further evidenced by the large and positive average values reported in Table 6.4; the impact of the South Korean sovereign debtor to its financial institutions is 0.1222 compared with 0.1331 to its non-financial firms. Thus, even though the sovereign debtors in China and South Korea dominated the process of credit risk transmission n domestic market, but their impacts differ in the financial and non-financial firms.

Secondly, a different picture emerges from the results of Southeast Asian CDS reference entities. The zero percentage of significant coefficients both to $\gamma_{ij}^{SOV:F,MY}$ and $\gamma_{ji}^{SOV:F,MY}$ are identified, while some of the coefficients $\gamma_{ij}^{S,MY}$ and $\gamma_{ji}^{S,MY}$ in referencing to the pairs of *SOV:NF* and *F:NF* are statistically significant. In other words, the Malaysian non-financial firms spilling over its credit risk both to its sovereign debtor and financial institutions in short run. This finding is in line with the results from the Chapter 5 of this thesis, hence, the non-financial firms in Malaysia play important roles in transmitting credit risk spillovers. In Singapore, bidirectional linkages between the financial and non-financial sectors are identified; the percentage of significant coefficient $\gamma_{ij}^{F:NF,SG}$ is 26.67% and is 13.33% for the coefficient: $\gamma_{ji}^{F:NF,SG}$. Hence, in these two Southeast Asian countries, the credit risk of non-sovereign firms spilled over from and to each other, while their respective sovereign debtors are less affected. In particular, the non-financial firms in Malaysia was more influential due to its large and significant effects on its sovereign debtor (i.e., $\gamma_{ji}^{SOV:NF,MY}$ = 0.2370).

Thirdly, from Panel B of Tables 6.3 and 6.4, there are significant cross-sectoral transmission in referencing to past shocks and volatilities from Panel B of Tables 6.3 and 6.4. Looking at Japan, the greater percentage of significant coefficients in Panel B compared with that in Panel A implies strong credit risk spillover effects between sectors via past volatility of CDS spread changes. In particular, 6 out of the 7 Japanese financial institutions (i.e., 85.71%) have strong influence on the volatility of changes in Japanese sovereign CDS spreads in short run, corresponding with an aggregate reversion effects (i.e., -0.0313 for the coefficient $g_{ji}^{SOV:F,JP}$ in Table 6.4). Moreover, nearly half of the 318 pairs of firms were affected by cross-sectoral credit risk volatility spillovers in Japanese financial and non-financial firms' pairings. This finding again documents the significance impact of the volatility transmission between the financial and non-financial firms. It is also true in China but opposite in South Korea because past changes in the South Korean financial institutions' CDS spread changes have great impact on the current status of its non-financial firms' credit risk; for example, in the aggregate level, 1bps CDS spread change in the financial institutions translates into a further 0.0885bps changes in its non-financial firms' CDS spreads on the next day.

Looking at the right parts of Tables 6.3 and 6.4 gives some interesting findings of credit risk spillover effects in Southeast Asian countries. In Malaysia, the magnitude of cross-sectoral credit risk spillovers effects from past shocks in its sovereign debtor to its non-sovereign firms decreased in the non-financial sector, from 33.33-20%. A weak unidirectional volatility spillover was uncovered from the Singaporean sovereign entity to its domestic financial sector ($g_{ij}^{SOV:F,SG}$= -0.0340); indeed, past credit risk information was only transmitted through volatility for Singapore.[85]

Fourthly, Panel C in Table 6.4 shows the average values of time-varying correlations between domestic sectors for each group. It is clear that the correlations of the Malaysian sovereign entity with its financial and non-financial sectors are both positive and high. The average annual correlation varied from 0.72 to 0.77 for *SOV:F*, from 0.82 to 0.71 for *SOV:NF* and from 0.41 to 0.46 for *F:NF*. An interesting finding here is that the average correlation for the *SOV:F* pairing in China was the only series where the credit risk linkages declined; it fell from 0.27 to 0.10. With the exception of the Singaporean pair of *F:NF*, the correlation between domestic financial and non-financial firms was smaller than that between the sovereign debtors and domestic firms. Thus, credit risk linkages between financial and non-financial firms were less pronounced than between financial firms and their sovereign entity. The negative correlation for *SOV:F* and *SOV:NF* in Singapore indicates a potential diversification gain for investors in the debt market. Pu and Zhao (2009) have suggested that correlation in credit risk is countercyclical; it is higher during economic downturns and lower during booms. They also argue that it is higher among firms with low credit ratings than among those with high credit ratings. Thus the negative correlations documented for the Singaporean pairings in the current analysis may have been due to the different stages of the cycle that each sector was experiencing.

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[85] The only pair with significant volatility spillovers is the pair between Temasek Holdings and Singaporean sovereign sector.

Table 6.3: A summary of the significant parameters for 1-year CDSs: domestic cross-sectoral spillover effects

Parameters		East Asia									Southeast Asia					
		China			Japan			South Korea			Malaysia			Singapore		
		SOV:F	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*
Panel A: Mean spread changes spillover effects																
$\gamma_{ij}^{X,C}$	$**$	57.14	33.33	7.94	14.29	1.85	19.58	60.00	61.11	45.56	0.00	40.00	33.33	0.00	0.00	26.67
	$**^{(-)}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	0.00	N/A	N/A	0.00
$\gamma_{ji}^{X,C}$	$**$	14.29	0.00	33.33	14.29	5.56	16.93	0.00	11.11	15.00	0.00	60.00	40.00	0.00	0.00	13.33
	$**^{(-)}$	100	N/A	0.00	0.00	0.00	1.56	N/A	100	51.85	N/A	0.00	0.00	N/A	N/A	0.00
Panel B: Shocks and volatility spillover effects																
$a_{ij}^{X,C}$	$**$	14.29	22.22	28.57	0.00	27.78	49.74	20.00	44.44	22.22	33.33	20.00	20.00	0.00	20.00	13.33
	$**^{(-)}$	100.00	100.00	55.56	N/A	60.00	48.40	100.00	75.00	62.50	100.00	0.00	66.67	N/A	0.00	50.00
$a_{ji}^{X,C}$	$**$	14.29	0.00	41.27	42.86	50.00	57.67	40.00	38.89	30.56	0.00	0.00	0.00	0.00	20.00	20.00
	$**^{(-)}$	0.00	N/A	25.00	100.00	40.91	48.08	100.00	25.00	45.00	N/A	N/A	N/A	N/A	0.00	66.67
$g_{ij}^{X,C}$	$**$	14.29	33.33	41.27	42.86	50.00	57.67	40.00	38.89	30.56	33.33	0.00	33.33	33.33	20.00	20.00
	$**^{(-)}$	100.00	0.00	61.54	100.00	37.04	50.92	25.00	42.86	52.73	100.00	N/A	20.00	100.00	100.00	33.33
$g_{ji}^{X,C}$	$**$	0.00	22.22	36.51	85.71	40.74	43.39	20.00	33.33	26.67	0.00	0.00	6.67	0.00	20.00	20.00
	$**^{(-)}$	N/A	100.00	60.87	33.33	50.00	46.95	100.00	83.33	52.08	N/A	N/A	0.00	N/A	0.00	66.67
Panel C: Restriction tests																
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		85.71	100.00	98.41	85.71	98.15	99.74	90.00	88.89	98.89	100.00	80.00	93.33	100.00	80.00	93.33
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		71.43	77.78	82.54	85.71	90.74	74.07	90.00	88.89	91.67	66.67	60.00	93.33	100.00	100.00	93.33
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		85.71	88.89	98.41	85.71	96.30	99.47	100.00	94.44	98.89	100.00	100.00	100.00	100.00	80.00	93.33
Number of pairs		7	9	63	7	54	378	10	18	180	3	5	15	3	5	15

Note: This tables shows the percentages of significant parameters and of significant negative parameters for 1-year CDSs, respectively. *SOV* is the abbreviation of sovereigns, *F* is the abbreviation of financial institutions and *NF* is the abbreviation of non-financial firms.

Table 6.4: The averaged values of the parameters for 1-year CDSs: domestic cross-sectoral spillover effects

Parameters	East Asia									Southeast Asia					
	China			Japan			South Korea			Malaysia			Singapore		
	SOV:F	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*
Panel A: Mean spread changes spillover effects															
$\gamma_{ij}^{X,C}$	0.074	0.040	0.005	2.222	0.002	0.024	0.122	0.133	0.089	0.000	0.056	0.072	0.000	0.000	0.017
	(0.028)	(0.016)	(0.002)	(0.945)	(0.001)	(0.009)	(0.048)	(0.043)	(0.029)	(0.000)	(0.027)	(0.032)	(0.000)	(0.000)	(0.007)
$\gamma_{ji}^{X,C}$	-0.015	0.000	0.052	0.000	0.002	1.331	0.000	-0.009	0.010	0.000	0.237	0.059	0.000	0.000	0.011
	(0.006)	(0.000)	(0.022)	(0.000)	(0.001)	(0.574)	(0.000)	(0.003)	(0.008)	(0.000)	(0.073)	(0.023)	(0.000)	(0.000)	(0.005)
Panel B: Shocks and volatility spillover effects															
$a_{ij}^{X,C}$	-0.024	-0.016	-0.001	0.000	0.007	-0.006	-0.019	-0.033	-0.011	-0.054	0.048	-0.037	0.000	0.007	-0.011
	(0.007)	(0.005)	(0.012)	(0.000)	(0.011)	(0.008)	(0.004)	(0.000)	(0.010)	(0.019)	(0.022)	(0.012)	(0.000)	(0.003)	(0.007)
$a_{ji}^{X,C}$	0.028	0.000	0.001	-0.037	0.013	0.004	-0.005	0.021	0.004	0.000	0.000	0.000	0.000	0.027	0.017
	(0.013)	(0.000)	(0.005)	(0.011)	(0.010)	(0.011)	(0.002)	(0.003)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.021)
$g_{ij}^{X,C}$	-0.001	0.015	-0.004	-0.042	-0.007	0.001	0.007	0.011	-0.001	-0.020	0.000	0.002	-0.034	-0.002	0.012
	(0.000)	(0.006)	(0.006)	(0.007)	(0.010)	(0.003)	(0.002)	(0.003)	(0.004)	(0.003)	(0.000)	(0.003)	(0.009)	(0.000)	(0.008)
$g_{ji}^{X,C}$	0.000	-0.012	0.008	-0.031	-0.009	-0.010	-0.012	-0.005	-0.003	0.000	0.000	0.005	0.000	0.007	0.013
	(0.000)	(0.002)	(0.006)	(0.021)	(0.005)	(0.010)	(0.001)	(0.001)	(0.005)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.008)
Panel C: Annual correlations															
2009	0.27	0.40	0.08	0.19	0.03	0.05	0.41	0.56	0.37	0.72	0.82	0.41	-0.25	-0.07	0.37
2010	0.19	0.41	0.07	0.29	0.05	0.04	0.43	0.61	0.38	0.66	0.71	0.43	-0.28	-0.01	0.38
2011	0.16	0.39	0.08	0.28	0.07	0.05	0.43	0.59	0.37	0.70	0.73	0.44	-0.29	-0.03	0.37
2012	0.14	0.40	0.07	0.30	0.08	0.05	0.43	0.60	0.36	0.77	0.72	0.45	-0.27	-0.02	0.36
2013	0.12	0.43	0.09	0.36	0.10	0.06	0.50	0.61	0.41	0.77	0.73	0.45	-0.28	-0.02	0.41
2014	0.10	0.43	0.09	0.39	0.09	0.06	0.52	0.62	0.42	0.77	0.71	0.46	-0.29	0.02	0.42

Taken the findings associated both with intra-sectoral and cross-sectoral credit risk spillover effects in the first two parts of this section, some interesting findings emerge in various aspects. First, the significance impact of past changes in CDS spreads and their past volatilities on the corresponding current level of credit risk presented between different CDS reference entities in 2009-2014. In China, the two Chinese financial institutions analysed are state owned so the credit risks of Chinese financial institutions are associated with that of the Chinese sovereign sector.

6.4.1.3 Regional intra-sectoral spillover effects

The concluding two sub-sections of this section analyse the credit risk spillover effects at the regional level on the basis of two dimensions: (i) regional intra-sectoral credit risk spillovers and (ii) regional cross-sectoral credit risk spillovers. Observing the co-movement of CDS spread changes for different countries can help policy-makers estimate the likelihood of default for an industry across a region and plan for a domino effect in terms of defaults for a specific sector (Brunnermeier, 2009; Moser, 2003).

In this sub-section, the credit risk spillover effects at the regional intra-sectoral level are reported, or more specifically the transmission of credit risk between firms within the same sector but from different Asian nations is incorporated in order to identify the firms that are more important in spilling over credit risk across different countries. Since a pair of countries can involve both an East Asian country and a Southeast Asian country, a decision is made to display the corresponding results alphabetically according to the initial of each country name; for example, the selection pairs choose China as the first input nation, while Japan is in the second order. Within the bivariate setting employed, the CDS reference entities operating with ten pairs of countries are studied; they are: China with Japan (*CN:JP*), China with Malaysia (*CN:MY*), China with Singapore (*CN:SG*), China with South Korea (*CN:SK*), Japan with Malaysia (*JP:MY*), Japan with Singapore (*JP:SG*), Japan with South Korea (*JP:SK*), Malaysia with Singapore (*MY:SG*), Malaysia with South Korea (*MY:SK*) and Singapore with South Korea (*SG:SK*).

Tables 6.5 and 6.6 illustrate the findings of the regional intra-sectoral credit risk spillover effects in the short run; Table 6.5 reports the percentages of significant parameters and the percentages of significant but negative parameters, while the average values of the parameters are illustrated in Table 6.5. Because of the large numbers of pairs of firms included in the cross-country analysis, each table is split into three parts – one for each sector. As introduced before, there is only one sovereign CDS series in each country, which produces only one pair of sovereign debtors for each country pairing, therefore a summary of the percentages of the significant and significant but negative parameters in relation to the sovereign sector will not be reported in Table 6.5. The interpretation of the pairwise interdependence between two firms' credit risk in relation to the regional intra-sectoral level is straightforward. For instance, when a financial institution in China is paired with a financial institution in Japan, the coefficient $\gamma_{ij}^{F,CN:JP}$ in equation (6.1) captures the impact of the former CDS spread changes of the Chinese financial institution on the current CDS spread changes of the Japanese financial institution, while $\gamma_{ji}^{F,CN:JP}$ measures these effects from an opposite perspective.

In order to discuss the findings of each sector in a coherent way, the remainder of this sub-section is divided into three parts. The first part presents the findings of the credit risk spillover effects between two financial institutions from two different countries; the findings of this part of the analysis should help to identify the financial institutions that are systemically important across Asian countries. The second part of this sub-section reports the results from the non-financial institutions; the findings should also help detect the 'core' non-financial firms in spilling over credit risk between countries. Similar with the first two parts, the final part of this sub-section presents the findings of the transmission of credit risk between Asian sovereign debtors, therefore, the analysis of this part should help identify the ‘core’ countries in Asia that may act as a sunspot of credit risk transmission in a period of financial distress.

6.4.1.3.1 Regional intra-sectoral spillover effects: the financial sector

Taking the results from Panel A of Tables 6.5 and 6.6 together reveals a number of findings. First, the non-zero percentages of the significant coefficients $\gamma_{ij}^{F,C}$ and $\gamma_{ji}^{F,C}$ regarding the type of pairing corresponding to the Japanese financial institutions imply the existence of bilateral credit risk spillover effects between the financial institutions in Japan and the remaining Asian countries. For example, the proportions of credit risk spillovers from the Japanese financial institutions to other nations’ financial institutions range from 9.52% for Malaysia to 20.41% for China. Thus, the credit risk of Japanese financial institutions bridged the credit risk of other Asian financial institutions in 2009-2014. Furthermore, a significant degree of influence of the South Korean financial institutions on the financial institutions in other nations emerged; the percentages of significant cross-firm credit risk spillovers ranged from 28.87% for Japan to 54.29% for China. Hence, the financial institutions in these two East Asian countries dominate the cross-transmission of credit risk through past mean spread changes.

In contrast, the financial institutions in Singapore only exhibit a bidirectional credit risk interdependence with the financial institutions in Japan. In other words, past changes in the CDS spreads of Singaporean financial institutions have no influence on the current CDS spread changes of the financial institutions in other Asian countries. A detailed inspection of the credit risk interdependence that includes Singaporean financial institutions further implies that the past CDS spread changes of the financial institutions in Malaysia and South Korea exert a significant degree of influence on the current CDS spread changes of Singaporean financial institutions; nearly half of the total pairs of firms (i.e., 44.44% for Malaysia and 50.00% for South Korea) affected the financial institutions in Singapore.

Secondly, the percentage of significant but negative parameters reports zero values in Table 6.5; in other words, the sign of the aggregate value of the credit risk spillover effects is positive for all ten pairs of countries. This finding is evidenced in Table 6.6 and it suggests that, on average, once a financial institution in the region has a higher CDS spread on a specific day, other financial institutions in the region will tend to have a higher CDS spread on the following day. Moreover, a significant impact of the South Korean financial institutions on the financial institutions in other Asian nations is identified, as estimates range from 0.0225 for Singapore to 0.0470 for China. In other words, 1bps aggregated changes in the CDS spreads of the South Korean financial institutions leads to 0.0470bps changes in the CDS spreads of the Chinese financial institutions on the following day. Therefore, one can conclude that the financial institutions in South Korea have a strong influence on the mean CDS spread changes of most Asian entities in the short run. In contrast, the past mean CDS spread changes of Singaporean financial institutions are affected by those in Malaysia to a greater extent, with an average value of 0.0249. Taken together, the range of significant values suggests that the spillovers of spread changes for the financial sector in the short term not only depend on the geographical location of the country, but also on the type of financial system present in the country. For example, where markets are geographically close or share a similar financial system, the impact of the spread changes in one country on the spread changes of another country is greater. This feature is especially pronounced for

Malaysia and Singapore, where Islamic financial markets are important and where the distance between the countries is small.[86]

Thirdly, the volatility spillover results are presented in Panel B of Tables 6.5 and 6.6. Bidirectional shock and volatility interdependence are identified for all country pairings with the exception of the Malaysia-Singapore pairing. A one-way credit risk transmission was identified across all financial institutions from Singapore to Malaysia; a total of 33.33% thereof are shock spillovers transmitting from Singaporean financial institutions to the Malaysian financial sector, with an average value of -0.0072.[87]

Fourthly, the time-varying correlations between the spread changes of each country pair for a specific sector are presented in Panel C of Table 6.6. It is noticeable from this panel that the average correlation reported in Table 6.6 is about the same as that shown in Table 6.2. This indicates that the transmission of credit risk in the financial sector is not more sensitive to domestic shocks and volatility than to information from the financial institutions of foreign countries. The spillovers among firms' CDS spread changes in the same sector across different countries are greater than that those within the same countries. These findings indicate that credit risk spillovers are not limited within the country so long as the firms belong to the same sector. While the credit standing of Malaysian financial firms co-moves with that of Singaporean and South Korean financial institutions, on average, it moves in the opposite direction to that of Chinese and Japanese financial firms. Negative correlations have been identified between the Chinese and Malaysian financial sectors (ranging from -0.07 in 2009 to -0.05 in 2014), as well as

[86] Singapore was accepted as a full member of the Islamic Financial Services Board (IFSB) in 2005. The IFSB is an international body based in Malaysia that defines the regulatory and supervisory standards governing Islamic financial services. In January 2009, Singapore launched its first Islamic bond programme worth SGD200 million (www.asianbondsonline.adb.org).

[87] This result is mainly due to the large amount of spillovers from the Oversea-Chinese Banking Corporation Limited in Singapore.

between the Japanese and Malaysian financial sectors (-0.02 for the year 2009 and -0.06 for the year 2014).[88]

6.4.1.3.2 Regional intra-sectoral spillover effects: the non-financial sector

Several interesting findings emerge when turning to the investigation of the credit risk transmission between non-financial firms in Tables 6.5 and 6.6. First, the bidirectional interdependence between the non-financial firms in the five Asian sample countries is evidenced, except for the pair Malaysia-Singapore. In relation to the credit risk transmission between the two Southeast Asian countries, a one-way credit risk linkage is identified in referencing the 16.00% significant coefficient of $\gamma_{ij}^{MY:SG,NF}$. This finding is in line with the results from the estimates corresponding to the transmission between the financial institutions in Malaysia and Singapore, but the magnitude of the impact from the Malaysian non-financial firms is smaller than the impact from its financial institutions to their Singaporean counterparts (i.e., 0.0137 compared with 0.0249). Moreover, the non-financial firms in Malaysia not only play an important role in bridging the credit risk of firms in Southeast Asia, but also exert a significant degree of influence on the changes in the credit risk of firms in East Asian countries. This finding is of particular interest, as one would expect the leadership of advanced economies, such as Japan and Singapore, in the credit risk transmission at the intra-regional level. However, in his book *Japanese Firms in Contemporary Singapore*, Shimizu (2008) identified that there has been a decline in Singapore's location-specific advantages because of the rising labour costs compared with other Asian countries, such as Malaysia and China. Moreover, he also found that the low-cost labour in Malaysia further attracted an increasing amount

[88] For the *JP:SG* pair, the correlation between the financial sectors in these two countries was flexed between positive and negative but turned to a moderate negative correlation from 2012 (-0.01) to 2014 (-0.05).

of FDI.[89] In particular, as introduced in the background chapter of this thesis, there is an uptrend of FDI in Malaysia in the current sample span. Hence, the dynamic shifts in the investment and trading linkages between these countries call for a reassessment of the cross-border credit risk interdependence between firms in Asia, which is also one of the main aims of this thesis.

Furthermore, over one third of the 45 pairs of non-financial firms in China and Malaysia were influenced by the past CDS spread changes of the Malaysian non-financial firms. This finding also holds in the Malaysia-South Korea pair. Compared with the percentages of significant intra-sectoral credit risk spillovers in referencing the Japan-Malaysia and Japan-Singapore pairs (i.e., 12.22% compared with 8.15%), the larger number of pairs of firms for the Japan-Malaysia pairing evidence the strong credit interdependence between the two countries. In addition, Malaysian non-financial firms also have different types of effects on the changes in the credit risk of non-financial firms in China and South Korea, 17 pairs and 33 pairs, respectively. Of the 972 pairs of non-financial firms located in Japan and South Korea, 8.15% of them indicated a significant transmission of credit risk from the Japanese non-financial sector, corresponding to 88 pairs of firms. In contrast, 149 pairs of firms (i.e., 15.33%) were affected by the previous changes in the CDS spreads of South Korean non-financial firms. Therefore, past changes in the CDS spreads of the non-financial firms in Asia were closely correlated in 2009-2015.

[89] For example, the Pokka Corporation was the first Japanese general beverage manufacturer who made FDI in Singapore, Malaysian and China. However, it moved the main investment country from Singapore to Malaysia in early 1990 in order to make use of the low-cost labour. This strategy has not only been adopted by Japanese firms, but has also been applied by some Singaporean firms, such as Yeo Hiap Seng and Fraser and Neave, who also make FDI in the lower-cost neighbouring countries. In addition, Shimizu (2008) argued that the FDI from Singaporean firms may also be partly due to the fact that these firms are interested in securing the local market.

Thirdly, the percentage of significant coefficients in referencing the shock and volatility spillovers in Panel B of Tables 6.5 and 6.6 indicate the significant role of the Japanese non-financial firms in spilling over their credit risk shocks to the non-financial firms in other Asian countries. For instance, approximately one half of the total pairs of firms were affected by previous short-term credit risk shocks (i.e., between 43.70 and 52.06%) and more than half of them received credit risk spillovers via the volatility of the past CDS spread changes of Japanese non-financial firms (i.e., between 47.94 and 64.07%). However, the associated aggregated effects reported in Panel B of Table 6.6 imply that the interdependence between non-financial firms was smaller than the financial institutions in 2009-2014. A possible explanatory reason could be that the sample size of the non-financial firms in this thesis is a derived mix of industries, which entails less homoscedasticity than the classification of financial institutions.

Nevertheless, the estimates of this part of the sub-section reveal the presence of cross-firm credit risk transmission between different Asian countries within the non-financial sector.

6.4.1.3.3 Regional intra-sectoral spillover effects: sovereigns

Substantial research have examined credit risk transmission between sovereigns by using CDS data in the US and European countries (Aizenman *et al.*, 2013b; Chiarella *et al.*, 2015; Dieckmann and Plank, 2012; Kalbaska and Gątkowski, 2012; Wang and Moore, 2012). The main findings imply the variation of transmission directions between 'core' European countries (i.e., the UK and Germany) and peripheral European countries. These 'core' countries were less affected by the credit shocks from the distress countries (such as Greece and Ireland) due to the strong economic fundamentals of the UK and Germany. Although studies that are relevant to the credit risk interdependence between emerging market countries are fewer, there are some. Ismailescu and Kazemi (2010) analysed the impact of credit rating announcements to emerging market countries including China, South Korea and Malaysia for the time from 2001 to 2009. The findings identified the significance impact of common creditors (such as Japan) to the credit risk spillover effects between the sovereigns in Asia. Since the sample span of this chapter of the current thesis ranges from January 2009 to March 2014, the analysis of this part should extend our knowledge about the credit risk spillover effects in Asia by using a more up-to-date CDS data set.

The estimates of regional intra-sectoral spillover effects between two Asian sovereigns are reported in the last part of Table 6.6. The results from Panel A of Table 6.6 indicate that there were only two pairs of Asian sovereigns (i.e., *JP:SK* and *MY:SK*) presenting direct spillover effects of credit risk in terms of past changes in CDS spreads in 2009-2014. In addition, the impacts of the bilateral transmission of credit risk from Japan and South Korea are strong; 1bps change in the South Korean sovereign debtor's CDS spread on today will result to a 0.001bps change in the Japan's on the next day and yield a 0.245bps change in the changes in Malaysia's, respectively. That is, past changes in the South Korean sovereign CDS spread are associated with the CDS spread changes in referencing the sovereigns of Japan and Malaysian, with weak effects on Japan. The findings are in line with Ismailescu and Kazemi (2010) who supporting the presence of common creditor transmission channel between the credit risk of sovereigns.

Nevertheless, estimates of the shock and volatility spillover effects in Panel B of the table imply that the credit risk of Asian sovereigns were associated indirectly via the Japan sovereign debtor. For instance, five of the ten pairs present transmission of past shocks; they are: China and Japan (*CN:JP*), Japan and Singapore (*JP:SG*), Japan and South Korea (*JP:SK*), Malaysian and Singapore (*MY:SG*), as well as Singapore and South Korea (*SG:SK*). Shocks and volatility from the Japanese sovereign CDS spread changes

Table 6.5: A summary of significant parameters for 1-year CDSs: regional intra-sectoral spillover effects

Parameters		**Regional pairings of financial institutions**									
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects											
$\gamma_{ij}^{F,C}$	$**$	20.41	19.05	19.05	0.00	9.52	19.05	12.86	44.44	13.33	0.00
	$**^{(-)}$	0.00	0.00	0.00	N/A	0.00	0.00	22.22	0.00	0.00	N/A
$\gamma_{ji}^{F,C}$	$**$	20.41	47.62	0.00	54.29	23.81	19.05	28.57	0.00	46.67	50.00
	$**^{(-)}$	0.00	0.00	N/A	0.00	0.00	0.00	0.00	N/A	0.00	0.00
Panel B: Shocks and volatility spillover effects											
$a_{ij}^{F,C}$	$**$	26.53	47.62	19.05	20.00	14.29	23.81	24.29	0.00	23.33	40.00
	$**^{(-)}$	61.55	50.00	0.00	42.85	66.62	80.01	35.28	N/A	42.86	66.68
$a_{ji}^{F,C}$	$**$	18.37	23.81	19.05	30.00	23.81	19.05	21.43	33.33	23.33	26.67
	$**^{(-)}$	33.32	19.99	100.00	38.10	80.01	24.99	46.66	66.67	57.14	25.01
$g_{ij}^{F,C}$	$**$	42.86	57.14	38.10	28.57	38.10	38.10	41.43	0.00	53.33	43.33
	$**^{(-)}$	47.62	58.33	74.99	54.99	37.51	87.48	41.37	N/A	31.26	38.47
$g_{ji}^{F,C}$	$**$	46.94	33.33	28.57	40.00	19.05	19.05	30.00	22.22	33.33	30.00
	$**^{(-)}$	60.86	42.87	16.66	50.00	49.97	0.00	66.67	50.00	70.00	66.67
Panel C: Restriction tests											
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		100.00	95.24	100.00	97.14	100.00	100.00	30.00	88.89	93.33	96.67
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		79.59	76.19	80.95	85.71	76.19	76.19	90.00	77.78	93.33	90.00
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		97.96	95.24	95.24	98.57	95.24	95.24	98.57	100.00	96.67	100
Number of pairs		49	21	21	70	21	21	70	9	30	30

Table 6.5: continued

Parameters		Regional pairings of non-financial firms									
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects											
$\gamma_{ij}^{NF,C}$	$**$	12.14	28.89	8.89	25.31	12.22	8.15	9.05	16.00	36.67	2.22
	$**^{(-)}$	1.69	0.00	0.00	0.00	0.00	0.00	10.23	0.00	0.00	50.00
$\gamma_{ji}^{NF,C}$	$**$	5.35	37.78	2.22	14.20	9.63	9.63	15.33	0.00	23.33	14.44
	$**^{(-)}$	7.66	0.00	100.00	4.37	3.84	0.00	2.67	N/A	9.52	0.00
Panel B: Shocks and volatility spillover effects											
$a_{ij}^{NF,C}$	$**$	20.58	22.22	24.44	25.93	50.37	43.70	52.06	8.00	23.33	25.56
	$**^{(-)}$	60.01	40.01	63.67	38.10	48.52	48.31	45.66	100.00	57.14	65.22
$a_{ji}^{NF,C}$	$**$	46.50	15.56	20.00	12.96	25.56	21.48	24.18	32.00	24.44	11.11
	$**^{(-)}$	46.45	85.67	55.55	28.55	50.70	58.61	52.77	50.00	40.92	19.98
$g_{ij}^{NF,C}$	$**$	36.21	24.44	40.00	35.80	64.07	54.81	62.14	16.00	34.44	32.22
	$**^{(-)}$	56.84	54.54	50.00	43.10	41.05	43.24	46.03	50.00	61.30	41.37
$g_{ji}^{NF,C}$	$**$	47.94	11.11	35.56	27.16	42.96	35.93	35.29	0.00	25.56	25.56
	$**^{(-)}$	45.49	19.98	50.00	59.09	54.31	53.60	46.36	N/A	43.47	82.59
Panel C: Restriction tests											
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		99.79	97.78	97.78	99.38	100.00	100.00	99.90	96.00	97.78	98.89
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		93.83	93.33	88.89	96.91	98.15	98.52	98.15	100.00	94.44	95.56
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.89	100.00
Number of pairs		486	45	45	162	270	270	972	25	90	90

Table 6.6: The averaged value of parameters for 1-year CDSs: regional intra-sectoral spillover effects

Parameters	**Regional parings of financial institutions**									
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects										
$\gamma_{ij}^{F,C}$	0.012	0.011	0.012	0.000	0.011	0.006	0.010	0.025	0.022	0.000
	(0.005)	(0.005)	(0.005)	(0.000)	(0.005)	(0.002)	(0.006)	(0.010)	(0.010)	(0.000)
$\gamma_{ji}^{F,C}$	0.022	0.054	0.000	0.047	0.023	0.027	0.031	0.000	0.029	0.023
	(0.008)	(0.022)	(0.000)	(0.017)	(0.010)	(0.012)	(0.014)	(0.000)	(0.012)	(0.009)
Panel B: Shocks and volatility spillover effects										
$a_{ij}^{F,C}$	-0.008	-0.001	0.017	-0.001	-0.015	-0.016	0.012	0.000	0.003	-0.009
	(0.005)	(0.009)	(0.007)	(0.003)	(0.008)	(0.015)	(0.006)	(0.000)	(0.014)	(0.005)
$a_{ji}^{F,C}$	0.013	0.015	-0.013	0.017	-0.047	0.005	-0.014	-0.007	0.002	0.035
	(0.006)	(0.015)	(0.003)	(0.010)	(0.012)	(0.003)	(0.011)	(0.014)	(0.008)	(0.006)
$g_{ij}^{F,C}$	-0.008	0.003	-0.022	0.002	-0.003	-0.017	-0.005	0.000	0.001	-0.004
	(0.007)	(0.002)	(0.006)	(0.003)	(0.011)	(0.007)	(0.004)	(0.000)	(0.008)	(0.007)
$g_{ji}^{F,C}$	-0.004	0.004	0.009	0.004	0.002	0.015	-0.009	0.005	-0.002	-0.015
	(0.009)	(0.002)	(0.003)	(0.006)	(0.001)	(0.002)	(0.008)	(0.006)	(0.006)	(0.009)
Panel C: Annual correlations										
2009	0.13	-0.07	0.18	0.15	-0.02	0.03	0.07	0.21	0.38	0.14
2010	0.14	-0.08	0.13	0.17	-0.03	-0.01	0.10	0.22	0.37	0.12
2011	0.15	-0.10	0.10	0.17	-0.03	0.00	0.13	0.23	0.38	0.13
2012	0.13	-0.10	0.09	0.15	-0.07	-0.01	0.09	0.22	0.37	0.12
2013	0.12	-0.07	0.08	0.18	-0.06	-0.04	0.10	0.25	0.40	0.13
2014	0.13	-0.05	0.05	0.19	-0.06	-0.05	0.10	0.25	0.40	0.13

Table 6.6: continued

Parameters	Regional pairings of non-financial firms									
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects										
$\gamma_{ij}^{NF,C}$	0.022	0.055	0.004	0.052	0.508	0.269	0.471	0.014	0.109	-0.001
	(0.009)	(0.025)	(0.002)	(0.020)	(0.207)	(0.116)	(0.234)	(0.006)	(0.037)	(0.002)
$\gamma_{ji}^{NF,C}$	0.284	0.054	-0.001	0.011	0.018	0.007	0.013	0.000	0.035	0.010
	(0.126)	(0.020)	(0.000)	(0.005)	(0.007)	(0.003)	(0.005)	(0.000)	(0.015)	(0.004)
Panel B: Shocks and volatility spillover effects										
$a_{ij}^{NF,C}$	-0.004	0.002	-0.022	0.000	-0.003	0.009	0.005	-0.007	-0.008	-0.005
	(0.009)	(0.008)	(0.014)	(0.010)	(0.007)	(0.006)	(0.008)	(0.001)	(0.006)	(0.007)
$a_{ji}^{NF,C}$	0.006	-0.010	0.004	0.010	0.006	-0.001	-0.001	0.027	0.017	0.016
	(0.006)	(0.005)	(0.007)	(0.007)	(0.011)	(0.008)	(0.011)	(0.019)	(0.016)	(0.005)
$g_{ij}^{NF,C}$	-0.009	-0.001	-0.002	0.001	0.008	-0.001	-0.002	-0.001	-0.008	0.005
	(0.006)	(0.002)	(0.005)	(0.004)	(0.003)	(0.003)	(0.002)	(0.001)	(0.006)	(0.004)
$g_{ji}^{NF,C}$	-0.003	0.045	-0.003	-0.006	-0.005	0.008	0.000	0.000	0.010	-0.029
	(0.003)	(0.004)	(0.006)	(0.007)	(0.007)	(0.004)	(0.006)	(0.000)	(0.008)	(0.011)
Panel C: Annual correlations										
2009	0.00	0.25	0.05	0.13	0.00	0.01	0.03	0.10	0.21	0.04
2010	0.03	0.22	0.04	0.09	0.01	0.02	0.02	0.09	0.20	0.06
2011	0.03	0.23	0.05	0.12	0.02	0.02	0.02	0.09	0.25	0.06
2012	0.03	0.22	0.03	0.12	0.02	0.02	0.02	0.08	0.23	0.06
2013	0.04	0.24	0.03	0.13	0.02	0.03	0.02	0.10	0.24	0.06
2014	0.04	0.23	0.03	0.12	0.02	0.03	0.02	0.10	0.24	0.07

Table 6.6: continued

Parameters	Regional pairings of sovereigns									
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects										
$\gamma_{ij}^{sov,c}$	0.000	0.000	0.000	0.000	0.000	0.000	0.153	0.000	-0.079	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.069)	(0.000)
$\gamma_{ji}^{sov,c}$	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.245	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.069)	(0.000)
Panel B: Shocks and volatility spillover effects										
$a_{ij}^{sov,c}$	0.000	0.000	0.000	0.000	0.000	0.000	-0.028	-0.003	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)
$a_{ji}^{sov,c}$	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.080	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)
$g_{ij}^{sov,c}$	0.049	0.000	0.000	0.000	0.000	-0.189	0.009	0.216	0.000	0.008
	(0.011)	(0.000)	(0.000)	(0.000)	(0.000)	(0.036)	(0.001)	(0.001)	(0.000)	(0.003)
$g_{ji}^{sov,c}$	-0.002	0.000	0.000	0.000	0.000	0.008	-0.055	-0.072	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)	(0.000)	(0.000)	(0.000)
Panel C: Annual correlations										
2009	-0.04	0.67	0.32	0.53	-0.83	-0.80	0.25	-0.66	0.74	0.58
2010	-0.04	0.83	0.34	0.70	-0.86	-0.80	0.36	-0.67	0.76	0.49
2011	-0.13	0.84	0.37	0.73	-0.86	-0.81	0.37	-0.67	0.78	0.47
2012	-0.07	0.86	0.35	0.73	-0.86	-0.80	0.47	-0.67	0.73	0.46
2013	0.09	0.83	0.31	0.66	-0.86	-0.80	0.54	-0.67	0.75	0.44
2014	0.01	0.83	0.32	0.63	-0.86	-0.80	0.64	-0.67	0.77	0.42

spilled directly to other East Asian countries (i.e., China and South Korea), while spillovers from the sovereign sector in Japan were transmitted via Singapore to Malaysia.

In particular, bidirectional credit risk linkages are shown both in Panel A and B of the table for the pair of Japan and South Korea. A possible explanation of this direct link of credit risk can be the economic partnership between Japan and South Korea via

6.4.1.4 Regional cross-sectoral spillover effects

Globalisation has promoted a large amount of studies on multinational financial linkages. However, these studies have mainly focused on European Union countries, the degree of integration between large advanced economies, and the transmission of financial shocks among Eurozone nations, the UK and the US after the 2008 global financial crisis and during the 2010 Euro debt crisis. As one would expect, they have a high level of documented regional integration inside of the Western European countries and between these nations and the US. Clearly, past studies have confirmed the important role played by a large economy both in their region and more globally. In Asia, Japan is obviously the leading economy within the region, and China's growing role in global trade and increasing presence in Asian financial markets has affected their regional neighbours (Glick and Hutchison, 2013). Jang (2011) evidenced that Asian countries have made remarkable progress in terms of economic integration over the last decade.[90] As a result, a study of credit risk linkages among East Asian and Southeast Asian countries should yield interesting insights.

The results presented in this sub-section should shed light on *regional cross-sectoral* credit risk transmission from three standpoints; they are: (i) the cross-country

[90] The degree of financial integration significantly behind the degree of trade and real economy, such as the openness and restrictiveness in trade, financial transactions and cross-border movement of capital, output and consumption correlations. In addition, the funded of Asian Infrastructure Investment Bank which has its headquarter in Beijing China, aims to provide financial supporting to member countries, included in China, Malaysia, Singapore and South Korea.

spillover effects between sovereigns and financial institutions, (ii) the cross-country spillover effects between sovereigns and non-financial firms and (iii) the cross-country spillover effects between financial institutions and non-financial firms. In other words, the combination of five Asian countries and three sectors together leads to twenty categories of pairings in each of the three groups; one nation is paired with the remaining fours and this process is repeated for each country. Tables 6.7 to 6.12 report the findings of regional cross-sectoral credit risk spillover effects; the tables labelled with odd number display percentages of significant parameters and that are significant but negative, while tables labelled with even number display the averaged values of the parameters.

6.4.1.4.1 Regional cross-sectoral spillover effects: sovereigns and financial institutions

Tables 6.7 and 6.8 report the findings of cross-country credit risk spillover effects between sovereigns and financial institutions; the first main part of each table displays the results from the pairings of East Asian sovereigns and foreign countries' financial institutions, while those from the Southeast Asian sovereigns' pairings are discussed in the second part of the tables. In particular, the first and the second rows of each table show the respective nation of the CDS reference entities.

The results reported in Panel A of Tables 6.7 and 6.8 yield several insights. First, the cross-country transmission of credit risk between the home sovereign debtor and the foreign financial institutions is present across the East Asian countries and Malaysia although to varying degrees. For example, significant cross-county credit risk spillovers are found from East Asian sovereign debtors to the financial institutions in foreign countries; estimates of the percentage of significant coefficient, $\gamma_{ij}^{SOV:F,C}$, range 10.00-100.00%. This finding is not surprising as banks are more likely to hold both domestic and international government debt (IMF, 2010). In contrast, the Singaporean sovereign debtor seems to be immune to the credit risk from the financial institutions in other Asian countries in referencing the insignificant coefficients. While the Singaporean financial institutions are associated with the Chinese sovereign debtor; that is the Chinese Overseas Bank in Singapore. Moreover, past changes in the CDS spreads of the financial institutions in Japan affected the current CDS spreads changes of the South Korean and Malaysian sovereign debtors in 2009-2014, with 14.29% of pairings in South Korea and 28.57% in Malaysia. In particular, a wide influence of credit risk spillovers are found in the pairings that involve in the South Korean sovereign debtor; for example, Panel A of Table 6.7 shows that the percentage of significant values for $\gamma_{ij}^{SOV:F,C}$ for pairings involving the South Korean sovereign debtor and foreign financial institutions range from 66.67% regarding the Singaporean financial institutions to 100.00% with the Malaysian financial institutions.[91]

Secondly, an inspection of Panel A of Table 6.8 reveals that past short-term credit spread changes from the Japanese sovereign debtor can lead to large mean spread changes in the CDSs of the financial institutions in the remaining countries. Such a finding evidences a strong credit risk linkage cross country and sector credit risk spillovers between the sovereign sector in one country and financial institutions in another country. This finding further evidences the significant impact of common creditor (such as Japan) to the transmission of credit risk in Asia. In other words, when a bank faces a marked rise in non-performing loans of one country, it is forced to recapitalise, lend less and adjust to its lower level of equity. This may inevitably lead to a significant deterioration of the financial position of other countries that rely on the same lender.

Thirdly, a visual inspection of Panel B in Tables 6.7 and 6.8 indicates that the role of past shock and volatility in CDS spread changes was prominent in spilling over of

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[91] The number of pairs with significant cross credit risk transmission for China is 6, for Japan is 5, for Malaysia is 3 and 2 for Singapore.

Table 6.7: A summary of significant parameters of 1-year CDSs: home-country sovereigns and foreign financial institutions

Parameters		Sovereign debtors in East Asia and financial institutions in other countries											
		Chinese pairings				Japanese pairings				South Korean pairings			
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects													
$\gamma_{ij}^{SOV:F,C}$	$**$	14.29	33.33	66.67	20.00	71.43	33.33	33.33	10.00	85.71	71.43	100.00	66.67
	$**^{(-)}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\gamma_{ji}^{SOV:F,C}$	$**$	0.00	0.00	33.33	0.00	0.00	0.00	0.00	20.00	0.00	14.29	0.00	0.00
	$**^{(-)}$	N/A	N/A	100.00	N/A	N/A	N/A	N/A	0.00	N/A	0.00	N/A	N/A
Panel B: Shocks and volatility spillover effects													
$a_{ij}^{SOV:F,C}$	$**$	14.29	33.33	0.00	10.00	0.00	66.67	40.00	70.00	85.71	71.43	100.00	66.67
	$**^{(-)}$	100.00	100.00	N/A	0.00	N/A	50.00	0.00	71.43	0.00	0.00	0.00	0.00
$a_{ji}^{SOV:F,C}$	$**$	0.00	33.33	0.00	0.00	42.86	0.00	0.00	30.00	42.86	28.57	0.00	66.67
	$**^{(-)}$	N/A	100.00	N/A	N/A	33.33	N/A	N/A	0.00	66.67	50.00	N/A	50.00
$g_{ij}^{SOV:F,C}$	$**$	57.14	33.33	33.33	0.00	0.00	66.67	40.00	90.00	28.57	14.29	33.33	0.00
	$**^{(-)}$	0.00	0.00	100.00	N/A	N/A	0.00	0.00	22.22	50.00	100.00	0.00	N/A
$g_{ji}^{SOV:F,C}$	$**$	0.00	33.33	0.00	0.00	57.14	33.33	0.00	60.00	57.14	42.86	0.00	0.00
	$**^{(-)}$	N/A	0.00	N/A	N/A	0.00	0.00	N/A	83.33	0.00	0.00	N/A	N/A
Panel C: Restriction tests													
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.00	85.71	85.71	66.67	66.67
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		71.43	66.67	66.67	30.00	71.43	66.67	66.67	70.00	71.43	85.71	66.67	66.67
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		100.00	100.00	100.00	90.00	85.71	100.00	100.00	90.00	85.71	85.71	100.00	100.00
Number of pairs		7	3	3	10	7	3	3	10	7	7	3	3

Table 6.7: continued

Parameters		Sovereign debtors in Southeast Asian countries and financial institutions in other countries							
		Malaysian pairings				Singaporean pairings			
		MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects									
$\gamma_{ij}^{SOV:F,C}$	$**$	0.00	28.57	66.67	10.00	0.00	0.00	0.00	0.00
	$**^{(-)}$	N/A	0.00	0.00	100.00	N/A	N/A	N/A	N/A
$\gamma_{ji}^{SOV:F,C}$	$**$	0.00	28.57	0.00	70.00	0.00	0.00	0.00	0.00
	$**^{(-)}$	N/A	0.00	N/A	0.00	N/A	N/A	N/A	N/A
Panel B: Shocks and volatility spillover effects									
$a_{ij}^{SOV:F,C}$	$**$	42.86	0.00	0.00	30.00	0.00	14.29	0.00	60.00
	$**^{(-)}$	66.67	N/A	N/A	33.33	N/A	0.00	N/A	66.67
$a_{ji}^{SOV:F,C}$	$**$	0.00	0.00	66.67	50.00	28.57	42.86	14.29	10.00
	$**^{(-)}$	N/A	N/A	0.00	40.00	50.00	33.33	100.00	100.00
$g_{ij}^{SOV:F,C}$	$**$	14.29	0.00	0.00	40.00	28.57	14.29	0.00	50.00
	$**^{(-)}$	100.00	N/A	N/A	75.00	0.00	0.00	N/A	20.00
$g_{ji}^{SOV:F,C}$	$**$	0.00	14.29	0.00	50.00	28.57	57.14	14.29	10.00
	$**^{(-)}$	N/A	100.00	N/A	60.00	50.00	25.00	100.00	100.00
Panel C: Restriction tests									
H$_0$: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		85.71	100.00	100.00	100.00	100.00	85.71	100.00	90.00
H$_0$: $a_{ij}^{S,C} = a_{ji}^{S,C}$		71.43	71.43	66.67	80.00	71.43	57.14	66.67	80.00
H$_0$: $g_{ij}^{S,C} = g_{ji}^{S,C}$		100.00	100.00	100.00	100.00	100.00	90.00	100.00	100.00
Number of pairs		7	7	3	10	7	7	3	10

Table 6.8: The averaged values of parameters for 1-year CDSs: home-country sovereigns and foreign financial institutions

Parameters	**Sovereign debtors in East Asia and financial institutions in other countries**											
	Chinese pairings				Japanese pairings				South Korean pairings			
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects												
$\gamma_{ij}^{SOV:F,C}$	0.011	0.040	0.036	0.038	9.966	6.017	1.942	2.488	0.077	0.054	0.081	0.036
	(0.004)	(0.018)	(0.013)	(0.015)	(4.137)	(2.859)	(0.903)	(1.242)	(0.026)	(0.023)	(0.031)	(0.014)
$\gamma_{ji}^{SPV:F,C}$	0.000	0.000	-0.052	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000
	(0.000)	(0.000)	(0.026)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)	(0.000)	(0.000)
Panel B: Shocks and volatility spillover effects												
$a_{ij}^{SOV:F,C}$	-0.019	-0.013	0.000	0.013	0.000	-0.031	-0.047	-0.024	-0.012	-0.005	0.000	0.013
	(0.008)	(0.005)	(0.000)	(0.003)	(0.000)	(0.001)	(0.011)	(0.003)	(0.009)	(0.015)	(0.000)	(0.010)
$a_{ji}^{SOV:F,C}$	0.000	-0.033	0.000	0.000	0.029	0.000	0.000	0.029	0.003	-0.012	0.041	0.000
	(0.000)	(0.014)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.005)	(0.006)	(0.012)	(0.000)
$g_{ij}^{SOV:F,C}$	-0.015	0.009	-0.033	0.000	0.000	0.000	0.040	0.008	0.018	0.023	0.000	0.000
	(0.015)	(0.003)	(0.015)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.004)	(0.006)	(0.000)	(0.000)
$g_{ji}^{SOV:F,C}$	0.000	0.017	0.000	0.000	0.028	0.027	0.000	0.017	-0.071	-0.006	-0.007	0.000
	(0.000)	(0.008)	(0.000)	(0.000)	(0.009)	(0.001)	(0.000)	(0.018)	(0.014)	(0.001)	(0.003)	(0.000)
Panel C: Annual correlations												
2009	0.07	0.08	-0.03	0.40	0.20	0.10	-0.18	0.24	0.09	0.11	0.46	-0.09
2010	0.16	-0.03	-0.08	0.44	0.18	0.21	-0.29	0.29	0.03	0.07	0.28	-0.13
2011	0.22	-0.10	-0.02	0.41	0.17	0.23	-0.30	0.28	0.03	0.13	0.45	-0.13
2012	0.15	-0.09	-0.04	0.39	0.12	0.23	-0.26	0.31	-0.03	0.08	0.43	-0.14
2013	0.18	-0.08	-0.04	0.43	0.14	0.21	-0.26	0.27	-0.02	0.09	0.47	-0.15
2014	0.21	-0.04	-0.03	0.38	0.14	0.19	-0.29	0.25	-0.03	0.11	0.46	-0.15

Table 6.8: continued

Parameters	Sovereign debtors in Southeast Asian countries and financial institutions in other countries							
	Malaysian pairings				Singaporean pairings			
	MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects								
$\gamma_{ij}^{SOV:F,C}$	0.000	0.021	0.026	-0.013	0.000	0.000	0.000	0.000
	(0.000)	(0.008)	(0.012)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)
$\gamma_{ji}^{SOV:F,C}$	0.000	0.042	0.000	0.136	0.000	0.000	0.000	0.000
	(0.000)	(0.020)	(0.000)	(0.048)	(0.000)	(0.000)	(0.000)	(0.000)
Panel B: Shocks and volatility spillover effects								
$a_{ij}^{SOV:F,C}$	0.008	0.000	0.000	0.014	0.000	0.007	0.000	-0.008
	(0.010)	(0.000)	(0.000)	(0.005)	(0.000)	(0.001)	(0.000)	(0.003)
$a_{ji}^{SOV:F,C}$	0.000	0.000	-0.027	0.039	-0.005	0.010	-0.008	-0.003
	(0.000)	(0.000)	(0.026)	(0.015)	(0.002)	(0.012)	(0.003)	(0.000)
$g_{ij}^{SOV:F,C}$	-0.013	0.000	0.000	-0.003	0.063	0.014	0.000	0.008
	(0.006)	(0.000)	(0.000)	(0.003)	(0.025)	(0.004)	(0.000)	(0.001)
$g_{ji}^{SOV:F,C}$	0.000	-0.008	0.000	-0.010	-0.007	0.025	-0.012	0.000
	(0.000)	(0.004)	(0.000)	(0.004)	(0.015)	(0.016)	(0.005)	(0.000)
Panel C: Annual correlations								
2009	0.35	-0.08	-0.12	0.30	-0.29	0.12	0.11	0.14
2010	0.37	-0.15	-0.06	0.32	-0.27	0.08	0.11	0.17
2011	0.36	-0.14	-0.03	0.32	-0.25	0.10	0.07	0.22
2012	0.32	-0.18	-0.01	0.31	-0.27	0.12	0.08	0.14
2013	0.34	-0.17	-0.02	0.32	-0.28	0.11	0.09	0.12
2014	0.34	-0.19	0.00	0.33	-0.25	0.11	0.11	0.13

credit risk. For example, significant spillover effects are found including the Singaporean sovereign debtor, especially for the pair of Singapore and Japan and the pair of Singapore and South Korea. The findings also indicate that different cross-country spillover effects are present among Asian countries. That is, past shock from the Chinese financial institutions were directly transmitted to the Japanese sovereign debtor, while the opposite effect was uncovered when data for the South Korean sovereign debtor are analysed together with CDS spreads for Chinese financial institutions. Furthermore, the volatility of the changes in the CDS spreads of some financial institutions was more sensitive to a change in the CDS volatility of foreign sovereign debtors than to a change in the CDS volatility of the domestic sovereign entity. In comparison, the credit standing of Chinese sovereign debtor has less of a spillover effect on foreign financial institutions but its financial institutions play an intermediate role in transmitting credit risk to the sovereigns of its East Asian neighbour countries (i.e., Japan and South Korea).

Fourthly, the average annual correlations reported in panel C of Table 6.8 indicate evidence of a weak linkage between the home sovereign sector and foreign financial sectors in general. For instance, it is clear that a negative relationship exists between the Singaporean financial institutions and the sovereign CDSs of China, Japan, Malaysia and South Korea. The results indicate that the credit standing of financial institutions in Singapore changes in the opposite direction of the sovereign's credit standing in other countries as well as, from the previous section, the sovereign's credit standing in their own country.

6.4.1.4.2 Regional cross-sectoral spillover effects: sovereigns and non-financial firms

In the context of the interdependence of the credit risk between a home-country sovereign and the non-financial firms in a foreign nation, the effect thereof is twofold. First, according to the borrowing and lending channel, the non-financial firms seem to be more likely associated with the sovereigns who are their common creditors. As Ismailescu and Kazemi (2010) stated, 'an increase in the credit quality of a sovereign relieves the capital requirements of its lending centre making more capital available to other countries' (p.2862). In other words, there is a positive relation between the sovereigns and the non-financial firms at a cross-country level. However, it is also possible for a negative relation (i.e., competition relation) to exist; when a nation's credit quality improves, it will attract more FDI from global sources and it is more likely to reduce the capital flows to other countries and therefore increase the overall credit risk in these countries, especially in their non-financial firms. Hence, the analysis of this part aims to add to the literature by examining the credit risk connectedness of home-country sovereigns and foreign non-financial firms in Asia.

There are a number of findings according to Panel A of Tables 6.9 and 6.10. An interesting finding is that there were no direct significant spillover effects in terms of the changes in CDS spreads in relation to the Japanese sovereign debtor and the non-financial firms in Singapore. Nevertheless, a bidirectional linkage is emerging when taking the Singaporean sovereign debtor and the non-financial firms in Japan together. This finding can be partly explained by the fact that the Japanese non-financial firms are likely to have multinational business. As introduced before, these Japanese firms have distributed some of their producing activities in Singapore, which in turn resulted in increasing their sensitivities to the credit risk of the Singaporean sovereign debtor. For example, the non-financial firms with high statistically significant parameters in Japan are: the Itochu Corporation, the Nippon Telegraph and Telephone Corporation and the Sharp Corporation.

In general, the bidirectional transmission of the credit risk between the sovereigns and the non-financial firms was more limited, while the sovereign debtor exhibited a significant degree of influence on the non-financial firms in other Asian countries. Another interesting finding is that some non-financial firms in all of the three East Asian countries and Malaysia demonstrated their influence on a foreign Asian nation, but the changes in the CDS spreads of the Singaporean non-financial firms did not affect the levels of credit risk of the sovereign debtors in the remaining Asian countries. For example, according to the percentages of significant cross-sectoral transmission of credit risk, it is clear that no direct interdependence of the changes in the CDS spreads (i.e., $\gamma_{ij}^{SOV:NF,MY:SG}$ and $\gamma_{ji}^{SOV:NF,MY:SG}$) was found in the Malaysia-Singapore pair. However, the non-financial firms in these two Southeast Asian countries show strong credit risk linkages with the three East Asian countries, particularly with the South Korean sovereign debtor. For instance, all of the five non-financial firms in Malaysia and two of the five in Singapore were affected by the South Korean sovereign debtor between 2009 and 2014. Furthermore, the associated aggregated effects (i.e., $\gamma_{ij}^{SOV:NF,SK:SG}$ =0.0268) reported in Panel A of Table 6.10 imply the strong co-movement between the levels of credit risk in the South Korean sovereign debtor and in the Singaporean non-financial firms.

When these results are combined with previous findings, the credit standing of the Japanese sovereign debtor is important in connecting the credit risk of financial institutions and non-financial firms in other Asian nations between 2009 and 2014. In terms of the transmission of the past volatility spillovers, the transmission of past volatility is presented in the pair containing the Malaysian sovereign debtor and the South Korean non-financial firms.[92] Furthermore, negative correlations were identified for the China-Japan pairs, while positive high correlations existed in the pair containing

[92] It is noticeable that the credit risk spillovers were transmitted more via shocks between the Malaysian sovereign and the South Korean financial institutions.

Table 6.9: A summary of significant parameters for 1-year CDSs: home-country sovereigns and foreign non-financial firms

Parameters		Sovereign debtors in East Asia and non-financial firms in other countries											
		Chinese pairings				Japanese pairings				South Korean pairings			
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects													
$\gamma_{ij}^{SOV:NF,C}$	$**$	7.41	60.00	40.00	50.00	33.33	60.00	0.00	44.44	55.56	16.67	100.00	40.00
	$**^{(-)}$	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	0.00	0.00	0.00	0.00
$\gamma_{ji}^{SOV:NF,C}$	$**$	3.70	0.00	0.00	5.56	33.33	60.00	0.00	5.56	0.00	7.41	0.00	0.00
	$**^{(-)}$	50.00	N/A	N/A	100.00	0.00	0.00	N/A	0.00	N/A	0.00	N/A	N/A
Panel B: Shocks and volatility spillover effects													
$a_{ij}^{SOV:NF,C}$	$**$	25.93	0.00	0.00	27.78	11.11	60.00	60.00	61.11	11.11	66.67	20.00	20.00
	$**^{(-)}$	28.57	N/A	N/A	40.00	0.00	33.33	33.33	18.18	100.00	41.67	0.00	100.00
$a_{ji}^{SOV:NF,C}$	$**$	55.56	0.00	20.00	27.78	44.44	60.00	20.00	22.22	0.00	25.93	0.00	20.00
	$**^{(-)}$	46.67	N/A	0.00	80.00	75.00	66.67	0.00	25.00	N/A	42.86	N/A	0.00
$g_{ij}^{SOV:NF,C}$	$**$	51.85	0.00	0.00	44.44	11.11	100.00	80.00	72.22	11.11	68.52	0.00	40.00
	$**^{(-)}$	64.29	N/A	N/A	62.50	0.00	20.00	50.00	53.85	0.00	48.65	N/A	100.00
$g_{ji}^{SOV:NF,C}$	$**$	64.81	40.00	40.00	50.00	33.33	60.00	20.00	27.78	0.00	38.89	0.00	40.00
	$**^{(-)}$	34.29	100.00	100.00	33.33	0.00	66.67	100.00	40.00	N/A	61.90	N/A	50.00
Panel C: Restriction tests													
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		94.44	80.00	100.00	94.44	100.00	100.00	100.00	88.89	88.89	96.30	80.00	80.00
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		90.74	60.00	60.00	88.89	88.89	80.00	80.00	88.89	77.78	96.30	80.00	80.00
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		100.00	100.00	100.00	100.00	100.00	80.00	100.00	100.00	100.00	100.00	80.00	100.00
Number of pairs		54	5	5	18	9	5	5	18	9	54	5	5

Table 6.9: continued

Parameters		Sovereign debtors in Southeast Asian countries and non-financial firms in other countries							
		Malaysian pairings				Singaporean pairings			
		MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects									
$\gamma_{ij}^{SOV:NF,C}$	$**$	11.11	11.11	20.00	11.11	0.00	1.85	0.00	0.00
	$**^{(-)}$	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
$\gamma_{ji}^{SOV:NF,C}$	$**$	11.11	16.67	0.00	33.33	0.00	5.56	0.00	5.56
	$**^{(-)}$	0.00	0.00	N/A	16.67	N/A	0.00	N/A	100.00
Panel B: Shocks and volatility spillover effects									
$a_{ij}^{SOV:NF,C}$	$**$	33.33	64.81	40.00	5.56	0.00	25.93	20.00	33.33
	$**^{(-)}$	0.00	57.14	50.00	0.00	N/A	50.00	0.00	66.67
$a_{ji}^{SOV:NF,C}$	$**$	11.11	22.22	20.00	27.78	22.22	12.96	20.00	16.67
	$**^{(-)}$	100.00	58.33	0.00	60.00	50.00	57.14	0.00	66.67
$g_{ij}^{SOV:NF,C}$	$**$	11.11	48.15	40.00	16.67	0.00	16.67	20.00	55.56
	$**^{(-)}$	100.00	30.77	100.00	0.00	N/A	33.33	100.00	40.00
$g_{ji}^{SOV:NF,C}$	$**$	0.00	16.67	40.00	11.11	11.11	9.26	20.00	16.67
	$**^{(-)}$	N/A	55.56	100.00	100.00	100.00	40.00	100.00	33.33
Panel C: Restriction tests									
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		88.89	98.15	100.00	94.44	88.89	98.15	100.00	100.00
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		77.78	92.59	80.00	88.89	88.89	96.30	80.00	88.89
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		88.89	98.15	100.00	100.00	100.00	100.00	100.00	100.00
Number of pairs		9	54	5	18	9	54	5	18

Table 6.10: The averaged values of parameters for 1-year CDSs: home-country sovereigns and foreign non-financial firms

Parameters	Sovereign debtors in East Asia and non-financial firms in other countries											
	Chinese pairings				Japanese pairings				South Korean pairings			
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects												
$\gamma_{ij}^{SOV:NF,C}$	0.014	0.101	0.012	0.106	4.212	10.765	0.000	12.253	0.051	0.005	0.116	0.027
	(0.005)	(0.036)	(0.006)	(0.034)	(1.816)	(4.849)	(0.000)	(5.061)	(0.019)	(0.002)	(0.048)	(0.012)
$\gamma_{ji}^{SOV:NF,C}$	-0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.533	0.000	0.000
	(0.056)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.573)	(0.000)	(0.000)
Panel B: Shocks and volatility spillover effects												
$a_{ij}^{SOV:NF,C}$	-0.009	0.000	0.000	0.021	0.022	-0.013	-0.003	0.026	-0.010	0.022	0.021	-0.003
	(0.026)	(0.000)	(0.000)	(0.006)	(0.005)	(0.007)	(0.001)	(0.004)	(0.003)	(0.011)	(0.009)	(0.001)
$a_{ji}^{SOV:NF,C}$	-0.039	0.000	0.009	-0.022	-0.021	-0.055	0.022	0.010	0.000	0.001	0.000	0.005
	(0.005)	(0.000)	(0.004)	(0.011)	(0.005)	(0.026)	(0.008)	(0.009)	(0.000)	(0.007)	(0.000)	(0.002)
$g_{ij}^{SOV:NF,C}$	-0.016	0.000	0.000	-0.011	0.028	0.006	-0.002	-0.003	0.004	0.004	0.000	-0.013
	(0.010)	(0.000)	(0.000)	(0.005)	(0.007)	(0.003)	(0.000)	(0.003)	(0.002)	(0.003)	(0.000)	(0.003)
$g_{ji}^{SOV:NF,C}$	0.015	-0.016	-0.018	0.001	0.021	0.007	-0.007	0.003	0.000	-0.001	0.000	-0.033
	(0.004)	(0.005)	(0.006)	(0.012)	(0.007)	(0.001)	(0.001)	(0.004)	(0.000)	(0.005)	(0.000)	(0.037)
Panel C: Annual correlations												
2009	-0.05	0.62	-0.03	0.35	0.03	0.06	-0.54	-0.01	0.16	0.01	0.59	0.33
2010	-0.07	0.61	-0.02	0.31	-0.07	0.19	-0.60	0.03	0.12	0.02	0.56	0.26
2011	-0.06	0.63	-0.03	0.29	-0.01	0.20	-0.60	0.07	0.17	0.03	0.62	0.26
2012	-0.06	0.62	-0.04	0.27	-0.04	0.24	-0.56	0.07	0.16	0.02	0.59	0.24
2013	-0.07	0.62	-0.04	0.26	-0.06	0.21	-0.59	0.11	0.17	0.03	0.60	0.22
2014	-0.09	0.59	-0.03	0.21	-0.08	0.23	-0.62	0.13	0.20	0.04	0.59	0.19

Table 6.10: continued

Parameters	Sovereign debtors in Southeast Asian countries and non-financial firms in other countries							
	Malaysian pairings				Singaporean pairings			
	MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects								
$\gamma_{ij}^{SOV:NF,C}$	0.004	0.012	0.002	0.026	0.000	0.000	0.000	0.000
	(0.002)	(0.005)	(0.001)	(0.009)	(0.000)	(0.000)	(0.000)	(0.000)
$\gamma_{ji}^{SOV:NF,C}$	0.026	2.129	0.000	0.046	0.000	0.066	0.000	-0.001
	(0.009)	(0.946)	(0.000)	(0.017)	(0.000)	(0.031)	(0.000)	(0.000)
Panel B: Shocks and volatility spillover effects								
$a_{ij}^{SOV:NF,C}$	0.011	-0.007	-0.054	0.006	0.000	-0.002	0.003	-0.010
	(0.003)	(0.003)	(0.012)	(0.001)	(0.000)	(0.005)	(0.001)	(0.003)
$a_{ji}^{SOV:NF,C}$	-0.007	0.013	0.000	-0.014	-0.004	-0.002	0.001	-0.007
	(0.002)	(0.005)	(0.000)	(0.009)	(0.002)	(0.001)	(0.000)	(0.003)
$g_{ij}^{SOV:NF,C}$	-0.002	0.008	-0.010	0.047	0.000	0.002	-0.018	0.006
	(0.001)	(0.003)	(0.003)	(0.009)	(0.000)	(0.002)	(0.009)	(0.001)
$g_{ji}^{SOV:NF,C}$	0.000	0.004	-0.013	-0.023	-0.009	0.001	-0.013	0.028
	(0.000)	(0.005)	(0.005)	(0.009)	(0.002)	(0.001)	(0.001)	(0.005)
Panel C: Annual correlations								
2009	0.44	-0.01	0.03	0.49	0.01	-0.05	0.07	-0.07
2010	0.35	0.03	0.00	0.49	0.06	-0.05	0.12	0.01
2011	0.38	0.03	-0.02	0.47	0.06	-0.02	0.13	-0.04
2012	0.35	0.03	0.00	0.46	0.06	-0.08	0.13	0.01
2013	0.37	0.04	-0.01	0.43	0.06	-0.09	0.14	0.02
2014	0.37	0.05	-0.01	0.43	0.06	-0.09	0.14	0.05

Malaysian non-financial firms and the sovereign sectors of China and South Korea, respectively.[93]

6.4.1.4.3 Regional cross-sectoral spillover effects: financial institutions and non-financial firms

The results presented in Tables 6.11 and 6.12 imply a more prominent role of shock in the transmission of credit risk than past changes in CDS spreads. For example, credit risk among Southeast Asian countries (i.e., Malaysia and Singapore) did not appear to be transmitted directly through past mean spread changes. Instead, there was more of a spillover via shocks.[94] In addition, comparing the results in Tables 6.11 and 6.12 with the findings from the previous parts, the Singaporean non-financial firms showed a stronger connection with the Japanese financial institutions than with the Japanese sovereign debtor. Moreover, the significant value of $\gamma_{ij}^{F:NF,C}$(0.0425) further indicates that past information from the mean spread changes of the Singaporean non-financial sector has a greater impact. In the same vein, the Japanese non-financial sector exerts a significant impact on other Asian named financial institutions and this effect is pronounced in the transmission of shocks and volatility for 1-year CDS spread changes. Together with the findings from the previous discussion, therefore, the credit risk changes of the non-financial sector in Japan were not only linked with other Asian countries' sovereign sectors but there was also a strong connection with foreign financial institutions in the short run. This is particularly important for the financial institutions in China and South Korea, as this credit risk spillover effect was more pronounced than that among domestic linkages; the effect was 0.005 in Table 6.4 compared with 0.2510 in Table 6.12

[93] Comparing the correlations from Table 6.4 in relation to the domestic parings of sovereigns and non-financial firms in Table 6.10 with their counterparts, the findings suggest that Malaysian non-financial firms connected more within the domestic market.

[94] This pattern also existed when Chinese financial institutions were pairing with Singaporean non-financial firms.

Table 6.11: A summary of parameters for 1-year CDSs: home-country financial institutions and foreign non-financial firms

Parameters		**Financial institutions in East Asia and non-financial firms in other countries**											
		Chinese pairings				Japanese pairings				South Korean pairings			
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects													
$\gamma_{ij}^{F:NF,C}$	$**$	11.90	22.86	2.86	13.49	9.52	11.43	14.29	8.73	47.78	15.19	48.00	30.00
	$**^{(-)}$	24.44	0.00	0.00	11.76	0.00	0.00	0.00	0.00	0.00	6.10	0.00	0.00
$\gamma_{ji}^{F:NF,C}$	$**$	10.85	42.86	0.00	27.78	14.29	31.43	5.71	20.63	5.56	10.00	20.00	0.00
	$**^{(-)}$	9.76	0.00	N/A	17.14	11.11	0.00	0.00	7.69	0.00	5.56	0.00	N/A
Panel B: Shocks and volatility spillover effects													
$a_{ij}^{F:NF,C}$	$**$	26.19	17.14	17.14	21.43	30.16	20.00	17.14	19.84	25.56	23.33	18.00	52.00
	$**^{(-)}$	45.45	66.67	50.00	51.85	52.63	71.43	33.33	48.00	60.87	53.97	33.33	50.00
$a_{ji}^{F:NF,C}$	$**$	47.88	14.29	17.14	15.87	15.87	31.43	37.14	26.98	16.67	56.67	22.00	30.00
	$**^{(-)}$	51.38	100.00	33.33	60.00	50.00	81.82	46.15	55.88	46.67	48.37	36.36	33.33
$g_{ij}^{F:NF,C}$	$**$	44.44	31.43	25.71	35.71	33.33	28.57	31.43	39.68	36.67	41.30	18.00	54.00
	$**^{(-)}$	42.26	45.45	66.67	51.11	52.38	20.00	54.55	44.00	15.15	48.43	33.33	33.33
$g_{ji}^{F:NF,C}$	$**$	60.58	22.86	28.57	26.98	30.16	25.71	28.57	34.13	33.33	55.00	16.00	40.00
	$**^{(-)}$	51.09	50.00	40.00	44.12	42.11	66.67	60.00	58.14	70.00	53.54	37.50	75.00
Panel C: Restriction tests													
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		99.74	100.00	100.00	98.41	98.41	97.14	97.14	99.21	98.57	100.00	100.00	100.00
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		87.57	80.00	71.43	87.30	85.71	71.43	77.14	88.89	92.86	88.57	86.67	87.57
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		100.00	100.00	100.00	100.00	100.00	100.00	97.14	100.00	98.57	100.00	100.00	100.00
Number of pairs		378	35	35	126	63	35	35	126	70	70	30	30

Table 6.11: continued

Parameters		Financial institutions in Southeast Asian countries and non-financial firms in other countries							
		Malaysian pairings				Singaporean pairings			
		MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects									
$\gamma_{ij}^{F:NF,C}$	$**$	18.52	12.35	13.33	33.33	11.11	20.37	0.00	1.85
	$**^{(-)}$	0.00	0.00	0.00	0.00	0.00	3.03	N/A	0.00
$\gamma_{ji}^{F:NF,C}$	$**$	25.93	12.96	0.00	24.07	33.33	8.64	40.00	37.04
	$**^{(-)}$	0.00	4.76	N/A	7.69	0.00	0.00	0.00	0.00
Panel B: Shocks and volatility spillover effects									
$a_{ij}^{F:NF,C}$	$**$	22.22	59.26	20.00	24.07	18.52	39.51	13.33	37.04
	$**^{(-)}$	50.00	45.83	66.67	46.15	40.00	40.63	0.00	60.00
$a_{ji}^{F:NF,C}$	$**$	11.11	27.78	13.33	24.07	22.22	29.63	13.33	25.93
	$**^{(-)}$	66.67	60.00	50.00	46.15	50.00	41.67	100.00	21.43
$g_{ij}^{F:NF,C}$	$**$	29.63	61.73	26.67	38.89	18.52	56.17	33.33	35.19
	$**^{(-)}$	37.50	47.00	25.00	28.57	60.00	60.44	60.00	68.42
$g_{ji}^{F:NF,C}$	$**$	11.11	43.83	26.67	46.30	18.52	40.74	13.33	27.78
	$**^{(-)}$	66.67	67.61	75.00	72.00	40.00	50.00	0.00	26.67
Panel C: Restriction tests									
H_0: $\gamma_{ij}^{S,C} = \gamma_{ji}^{S,C}$		96.30	99.38	100.00	98.15	96.30	99.38	93.33	98.15
H_0: $a_{ij}^{S,C} = a_{ji}^{S,C}$		59.26	74.69	80.00	88.89	77.78	87.65	66.67	83.33
H_0: $g_{ij}^{S,C} = g_{ji}^{S,C}$		100.00	100.00	100.00	100.00	100.00	99.38	100.00	100.00
Number of pairs		27	162	15	54	27	162	15	54

Table 6.12: The averaged values of parameters for 1-year CDSs: home-country financial institutions and foreign non-financial firms

Parameters	**Financial institutions in East Asia and non-financial firms in other countries**											
	Chinese pairings				Japanese pairings				South Korean pairings			
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects												
$\gamma_{ij}^{F:NF,C}$	0.011	0.020	0.001	0.016	0.009	0.013	0.004	0.012	0.038	0.009	0.060	0.018
	(0.006)	(0.008)	(0.000)	(0.009)	(0.004)	(0.006)	(0.002)	(0.006)	(0.015)	(0.004)	(0.024)	(0.007)
$\gamma_{ji}^{F:NF,C}$	0.251	0.064	0.000	0.022	0.010	0.045	0.043	0.014	0.010	1.400	0.058	0.000
	(0.170)	(0.022)	(0.000)	(0.009)	(0.004)	(0.019)	(0.019)	(0.006)	(0.005)	(0.546)	(0.022)	(0.000)
Panel B: Shocks and volatility spillover effects												
$a_{ij}^{F:NF,C}$	0.013	-0.019	0.007	0.004	-0.005	-0.024	0.010	0.006	-0.003	0.000	0.004	-0.003
	(0.011)	(0.010)	(0.004)	(0.009)	(0.010)	(0.009)	(0.026)	(0.006)	(0.007)	(0.008)	(0.010)	(0.011)
$a_{ji}^{F:NF,C}$	0.007	-0.029	-0.015	-0.013	0.003	-0.033	0.005	-0.011	0.001	0.006	0.019	0.033
	(0.008)	(0.011)	(0.014)	(0.011)	(0.011)	(0.011)	(0.011)	(0.007)	(0.006)	(0.007)	(0.012)	(0.014)
$g_{ij}^{F:NF,C}$	0.004	0.005	-0.014	-0.002	-0.003	0.010	0.011	0.002	0.016	-0.004	0.001	0.016
	(0.006)	(0.005)	(0.003)	(0.005)	(0.003)	(0.002)	(0.010)	(0.005)	(0.004)	(0.009)	(0.002)	(0.006)
$g_{ji}^{F:NF,C}$	0.000	-0.008	0.004	-0.006	0.003	-0.009	-0.006	-0.003	-0.027	-0.002	0.008	-0.033
	(0.004)	(0.004)	(0.003)	(0.004)	(0.007)	(0.006)	(0.003)	(0.004)	(0.012)	(0.003)	(0.002)	(0.010)
Panel C: Annual correlations												
2009	0.00	0.33	0.13	0.20	0.03	0.16	0.00	-0.02	0.24	0.02	0.39	0.14
2010	0.01	0.27	0.12	0.20	0.04	0.17	-0.01	-0.04	0.26	0.02	0.38	0.16
2011	0.02	0.25	0.12	0.19	0.06	0.22	-0.01	-0.03	0.27	0.03	0.44	0.15
2012	0.01	0.24	0.13	0.17	0.09	0.21	0.02	-0.05	0.26	0.02	0.40	0.15
2013	0.02	0.27	0.12	0.17	0.12	0.24	0.05	-0.06	0.29	0.03	0.40	0.15
2014	0.03	0.24	0.14	0.18	0.12	0.23	0.05	-0.06	0.29	0.03	0.38	0.16

Table 6.12: continued

Parameters	Financial institutions in Southeast Asian countries and non-financial firms in other countries							
	Malaysian pairings				Singaporean pairings			
	MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects								
$\gamma_{ij}^{F:NF,C}$	0.019	0.017	0.004	0.070	0.033	0.027	0.000	0.011
	(0.008)	(0.007)	(0.002)	(0.026)	(0.015)	(0.011)	(0.000)	(0.005)
$\gamma_{ji}^{F:NF,C}$	0.020	0.605	0.000	0.014	0.020	0.275	0.033	0.018
	(0.009)	(0.252)	(0.000)	(0.006)	(0.008)	(0.120)	(0.012)	(0.007)
Panel B: Shock and volatility spillover effects								
$a_{ij}^{F:NF,C}$	0.005	0.012	-0.072	0.006	0.007	0.012	0.004	-0.009
	(0.007)	(0.008)	(0.008)	(0.006)	(0.004)	(0.005)	(0.000)	(0.010)
$a_{ji}^{F:NF,C}$	-0.005	-0.013	-0.003	0.009	-0.001	0.011	-0.006	0.034
	(0.006)	(0.010)	(0.000)	(0.014)	(0.003)	(0.009)	(0.000)	(0.019)
$g_{ij}^{F:NF,C}$	0.004	0.003	0.010	0.005	-0.003	-0.001	-0.002	-0.006
	(0.003)	(0.003)	(0.001)	(0.004)	(0.001)	(0.003)	(0.005)	(0.002)
$g_{ji}^{F:NF,C}$	0.000	-0.019	-0.002	-0.019	-0.005	0.007	0.008	0.008
	(0.001)	(0.006)	(0.002)	(0.007)	(0.001)	(0.004)	(0.000)	(0.006)
Panel C: Annual correlations								
2009	0.23	0.02	0.15	0.35	0.06	0.01	0.01	0.14
2010	0.24	0.02	0.23	0.37	0.09	0.02	0.03	0.14
2011	0.23	0.02	0.24	0.40	0.11	0.02	0.06	0.16
2012	0.22	0.03	0.24	0.39	0.10	0.00	0.04	0.16
2013	0.23	0.03	0.23	0.38	0.10	0.01	0.07	0.16
2014	0.23	0.03	0.27	0.40	0.10	0.01	0.06	0.17

for China, and 0.0000 compared to 0.0425 for Singapore. Furthermore, the transmission of shocks was more pronounced than the transmission of volatility from the non-financial firms in South Korea than from the non-financial sectors in other Asian countries; for example, the absolute values of $a_{ij}^{F:NF,C}$ are greater than those of $g_{ij}^{F:NF,C}$. An asymmetric transmission in relation to the mean spread changes is identified only for the South Korea-Singapore pair; the large and significant absolute values of $\gamma_{ij}^{F:NF,C}$ imply a greater impact of the Singaporean non-financial firms on the South Korean financial institutions rather than the other way around.

This analysis of 1-year CDS spread changes within the Asian region has highlighted several key points. First, the cross-country credit risk spillovers are more pronounced in terms of shocks and volatility transmission between different types of CDS reference entities; in particular, when home-country financial institutions were paired with foreign non-financial firms, a large number of bidirectional linkages inside the variance equation were uncovered. Second, strong credit risk linkages have been identified among the sovereign debtor, the financial institutions and non-financial firms for China, Japan and South Korea; past credit risk information from Chinese financial institutions and non-financial firms was transmitted to the Japanese sovereign debtor, while the credit standing of South Korean financial institutions was heavily dependent on the credit risk of the Japanese sovereign. Third, credit risk in the non-financial firms in Japan and South Korea spilled over to the financial institutions in China and the two Southeast Asian countries (i.e., Malaysia and Singapore), while these types of credit risk linkages were weaker for the pairings containing sovereigns and non-financial firms.

6.4.2 Robustness tests using 5-year CDSs

This section presents the results from the robustness tests by using 5-year CDS data; an overview of the results make it possible to conduct a comparison of the findings between short and long runs. Due to word count constraints, tables (i.e., Tables 6.1A to 6.12A) that report the findings of 5-year CDSs are shown in the appendices (i.e., Appendix 6.1) of this thesis. Moreover, the discussion of this part focuses on verifying any consistent or contrasting findings between the estimates from the 1-year and 5-year CDSs.

6.4.2.1 Domestic intra-sectoral spillover effects: 5-year CDSs

Compared with the estimates from the 1-year CDS spread changes, Panel A of Table 6.1A and Table 6.2A shows that the percentages of significant estimators and their average values are higher with the 5-year CDS dataset given that the spillover effects among the credit risk of Japanese non-financial firms are more persistent in the long than in the short run.[95] In line with the findings from the 1-year CDS data, the credit risk spillover effects between the financial institutions in Japan are stronger than in other Asian countries. Hence, the risk of contagion in Japan was high in both the short- and long-term horizon. Furthermore, firms in the financial sector in Japan (China and South Korea) show more evidence of contagion than their non-financial sector counterparts in terms of credit shock (volatility) spillovers.

The estimates of shocks and volatility spillovers from Panel B in Appendices 6.1 and 6.2 show some differences between the 1-year and 5-year CDSs. For example, information from past volatility did not spill over between the three Singaporean financial institutions, but via past shocks; the average values reported in Panel B of Table 6.2A indicate a higher degree of interdependence within the financial sector in Singapore on the basis of short-term shocks for 5-year CDSs (i.e., in absolute terms, -0.1157 compared with 0.0190).

[95] However, it is noticeable that their standard deviations reported in parentheses are more comparable than in the case of financial firms.

Panel C of Table 6.1A indicates the asymmetric transmission of credit risk among Asian entities. Compared to the 1-year estimates, the asymmetry is stronger in the case of the spillover effect between the spread changes for the financial sector of all countries (except for Singapore) and weaker in the case of the non-financial sector of all countries (except for China). For the variance equation, more (fewer) pairs in the Japanese (Chinese) financial sector show evidence of an asymmetric transmission of risk, and more pairs in the non-financial sector of China, Japan and Malaysia have an asymmetric transmission with the 5-year dataset. Panel C in Table 6.2A provides a more detailed description of the correlations between firms within the same sector and country for 5-year CDSs. It is noticeable that the positive correlation among the CDS spread changes of Japanese financial institutions for 1-year CDSs turns to negative when 5-year spreads are examined. The spread changes of CDSs for the pairs of entities within the financial sector varied between 2009 and 2012 (the correlation for this sector changes from 0.02 to 0.03 and from -0.09 to -0.01 for 5-year CDSs).[96] That is, while investors expected that the credit risk of these financial institutions would co-move over the short term, they forecasted that the credit risk of these institutions would be more divergent in the next five years. However, more recently, investors' beliefs seemed to have changed; the correlation of spread changes within the Japanese financial sector has become positive for both 1-year and 5-year CDSs, indicating that investors believe that the credit risk of these institutions will co-move in both the short and long term. Furthermore, the long-term credit risk correlations are obviously greater than their 1-year counterparties in all sectors except for

[96] A possible reason may be due to long-term market speculation. Japan raises significant amounts from the capital markets to finance government expenditures, mainly through the issuance of Japanese government bonds, financial fills and borrowing. These funding activities are supported by a large and diverse community of domestic and overseas investors and intermediaries. In particular, the local government is the largest issuer of bonds in the market, which includes quasi-government institutions and government-guaranteed local banks and corporations.

the Chinese and Singaporean non-financial sectors and the South Korean financial sector when Panel C of Table 6.1A and Table 6.2A is analysed in each case.

Overall, the results indicate a strong intra-sectoral interdependence in the three East Asian countries between 2009 and 2014. Over the course of the sample period, the spillover effects within the financial sector are more (less) prominent than in the non-financial sector in terms of volatility (mean) spillover in China. In South Korea, spillover within the financial sector is less (more) prominent than that within the non-financial sector in terms of volatility (mean) spillover. From both the 1-year and 5-year CDS data, the financial sectors of Japan and Singapore have a higher level of credit risk contagion than their non-financial sector counterparts in terms of both mean and volatility spillovers. By contrast, the credit risks of Malaysian non-financial firms are more contagious than those of Malaysian financial institutions.

6.4.2.2 Domestic cross-sectoral spillover effects: 5-year CDSs

Tables 6.3A and 6.4A report the spillover effects between two different sectors within the same country given that 5-year CDS spread changes were employed. A number of interesting findings have emerged. First, from a visual inspection of Table 6.3A, it is apparent that the number of significant parameters increased using longer-term CDS data; this finding once more confirms the significance impact of the time-horizon on the appetite of credit risk in Asia.

Moreover, different significant relationships are uncovered for the 5-year CDSs. For example, the bidirectional linkages between the South Korean sovereign and its domestic financial and non-financial firms disappear in the longer term. In contrast, significant bidirectional linkages among the mean spread changes are documented for the pair of sovereign and non-sovereign CDS reference entities (i.e., *SOV:F* and *SOV:NF*) in Singapore when data for 5-year contracts are studied; the DBS Bank Limited and the

Oversea-Chinese Banking Corporation Limited exert a strong influence on spilling over credit risk. The average coefficient values reported in Table 6.4A show strong and positive significant spillovers among long-term spread changes between the Japanese sovereign and non-sovereign firms; the financial institutions in Japan appear to play an intermediary role in transmitting credit risk in both short and long runs.[97]

Apart from the estimates from Panel A, the findings from Panel B of Table 6.3A and Table 6.4A show that the transmission of shocks and volatility is stronger among the 5-year data relative to the 1-year CDS contracts. For example, the unidirectional shocks and volatility linkages uncovered with the 1-year data for the pairing of sovereign and financial institutions in Malaysia as well as for the pairings of sovereign and non-financial firms for Singapore turn into bidirectional relations given that the 5-year CDSs are analysed. However, some findings remain the same; for example, the correlations between the sovereign and non-financial firms in Malaysia are high in both the short and long run, ranging from 0.77 to 0.81 between 2009 and 2014.

Overall, the estimates from 1-year and 5-year CDSs confirm the interdependence of credit risk between firms in the sovereigns, the financial institutions and the non-financial firms between 2009 and 2014. The Chinese sovereign debtor had extensive influence on the credit risk of the non-sovereign firms, especially on its financial institutions via volatility spillovers. In contrast, the financial institutions in Japan play an important role in influencing the credit risk of its sovereign debtor in both the short and long runs. Moreover, the transmission of shocks and volatility spillovers were more pronounced than the mean spread changes in South Korea in the long run. In the two Southeast Asian countries, the credit risk of the sovereign and firms was strongly

[97] This finding is in line with the estimation results from Chapter 5 for Japan when a trivariate-GARCH model was used.

connected in the case of Malaysia, while fewer credit risk interconnections were uncovered in Singapore.

6.4.2.3 Regional intra-sectoral spillover effects: 5-year CDSs

As introduced before, the estimates of the *regional intra-sectoral* spillover effects are reported for three sub-groups; they are: (i) a group of financial institutions, (ii) a group of non-financial firms and (iii) a group of sovereigns. In order to display the findings from the 1-year and 5-year CDSs in a similar vein, the findings from the group of financial institutions are discussed first in this sub-section, followed by a report of the findings from the non-financial firms and from the sovereigns.

6.4.2.3.1 Regional intra-sectoral spillover effects: financial institutions

The estimates of the cross-country spillover effects between the financial institutions are reported in Tables 6.5A and 6.6A. As for the estimates of $\gamma_{ij}^{S,C}$ and $\gamma_{ji}^{S,C}$ in Panel A of Table 6.5A, which capture the spillover effects of long-term credit risk. Common patterns are observed in the case of all pairs of firms across the different financial sectors; that is, a bidirectional spillover of spread changes existed between the financial sectors of the five Asian countries. The big and economically important financial institutions in Asia dominate spillovers among the CDS spread changes. The Malaysian and Singaporean financial sectors still show a strong linkage between each other. According to the results shown in Panel A of Table 6.5A and Table 6.6A, an asymmetric transmission exists, particularly between the JP:SG (-0.0020 with 0.0432), JP:SK (-0.0025 with 0.0471) and SG:SK (-0.0198 with 0.0228) pairs. Therefore, both short-term and long-term credit risk spillover effects exist for the pairings including Singapore and South Korea. The sensitivity of mean spread changes to past cross-CDS spreads differs when we move to 5-year instruments for the Japan-Singapore pair (e.g. the percentage of significant $\gamma_{ji}^{S,C}$ is 38.10%).[98]

Common patterns are observed for all pairs of financial firms; bidirectional past mean spread changes existed in all pairs. Similarly, the big and economically important financial institutions in Asia dominate the CDS spread changes spillovers and are the recipients of credit spillovers in the form of mean past changes. Malaysian and Singaporean financial sectors still show strong linkages between each other. According to the results shown in Panel A of Table 6.6A, an asymmetric transmission exists in the Japan and Singapore (-0.0020 with 0.0432), Japan and South Korea (-0.0025 with 0.0471) and Singapore and South Korea (-0.0198 with 0.0228) pairings. A comparison with the 1-year findings indicates that both short-term and long-term credit risk spillover effects exist for the pairings including Singapore and South Korea.[99]

The results in Panel B of Table 6.5A and Table 6.6A indicate that the bidirectional volatility linkages existed for all of the pairs studied. This finding is in line with the results from the 1-year CDS spread analysis. Therefore, financial institutions in Malaysia transmitted shocks to Singaporean financial institutions over both the short and long term. Panel C shows the correlation between domestic and foreign financial institutions. The average values of the short-term annual correlation for the China and Malaysia pairs, while that for the pair of Japan and Malaysia all turned from negative to positive signs; for example, the average values of the short-term correlation between the Chinese and Malaysian financial sectors are from -0.10 to -0.05 in Table 6.6 and that of the long-term correlation are from 0.12 to 0.06 in Table 6.6A.

[98] Out of the 21 parings, there are 3 pairs of financial institutions that have a significant impact in terms of past mean spread changes.
[99] It is noticeable that the Export-Import Bank of Korea is important in both the short and long run.

6.4.2.3.2 Regional intra-sectoral spillover effects: non-financial firms

Comparing the 5-year estimation results with the finding from 1-year CDS spread changes, it is clear that the percentages of significant spillovers for non-financial firms are greater; the only exceptions are the China and Singapore, Malaysian and Singapore, as well as Malaysia and South Korea pairings.[100] In particular, the credit spillover effects between the Japanese and South Korean non-financial firms are still strong and the percentage with significant parameters increased from 15.33% to 22.94% across the 972 pairs of firms studied.[101] The average values presented in Table 6.6A show a dramatic increase in the relationship between the spread changes of the non-financial firms in China and Japan; the mean value of $\gamma_{ij}^{NF,CNvsJP}$ has changed from 0.2844 for 1-year estimates to 1.0138 for 5-year estimates. This large and positive value indicates the important role of Japanese non-financial firms in affecting the credit risk of the Chinese non-financial sector.

From the variance analysis, the percentages of significant parameters are similar in both 1-year and 5-year CDSs. However, the percentages of negative significant parameters are less in the 5-year estimates; for example, the percentage of negative significant parameters for $\gamma_{ij}^{NF,CN:MY}$ is 2.22% for the 5-year instruments but it is 85.67% for the 1-year CDSs. Moreover, Panel C of the table shows that the correlation between the 5-year CDS spread changes of the non-financial sectors of Malaysia and South Korea was greater than that for the 1-year CDS spread changes. The correlation for the 1-year CDS spread changes flexed between 0.20 and 0.25 during 2009-2014, but the correlation for 5-year CDS spread changes fluctuated between 0.33 and 0.36. This finding is the

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[100] There are no significant spillover effects in relation to the credit spread changes between the non-financial firms in Malaysia and Singapore.

[101] There are 149 pairs of firms that have significant cross spillovers for 1-year CDS data and 223 pairs for 5-year CDS data.

opposite result to the pattern detected for the financial sectors of the same country pairing (the correlations for 1-year spread changes are between 0.37 and 0.40, but the correlations for the 5-year spread change are between 0.22 and 0.24).

6.4.2.3.3 Regional intra-sectoral spillover effects: sovereigns

The last section of Table 6.6A shows the estimation results of the credit spillover effects from 5-year CDS sovereign entities. It is easy to identify that the China-Malaysia, the China-Singapore, the Japan-Malaysia, the Japan Singapore, as well as the Malaysia and Singapore pairs have significant spillovers among their credit spread changes in the long term. Linkages in the mean spread changes between the Malaysian sovereign entity and the South Korean sovereign entity disappeared where a long-run perspective of 5 years was taken. By contrast, significant linkages appeared between the sovereigns in China and Malaysia; the values of $\gamma_{ji}^{SOV,CN:MY}$(0.4283) and $\gamma_{ij}^{SOV,CN:MY}$(-0.1436) further indicated that this long-term relationship was not symmetric; there was an asymmetric transmission between the information from past mean spread changes in the long run.

Taken together, the main findings regarding the intra-sectoral spillover effects are as follows. First, spillover effects presented between Asian CDS reference entities both in the changes in their CDS spreads and shocks and volatility, which provides clear evidence of the intra-sectoral credit risk interdependence both within a home-state and across different countries. In other words, the credit status of a firm can change in response to a change in the credit standing of both domestic and foreign firms in the same sector and in response to a domestic shock as much as to a foreign shock. The findings indicating significant cross-firm spillover effects of credit risk once more documented the reject of weak-form EMH.

Second, the magnitudes and directions of spillover effects vary across sectors and economies. According to the findings associated with domestic intra-sectoral spillover effects, Japanese financial institutions showed strong links in terms of credit risk, while the non-financial firms in China and Malaysia were more connected with their respective domestic counterparties in 2009-2014. Moreover, the financial institutions in Japan and South Korea displayed their significant effects on the connectedness of credit risk at a regional intra-sectoral level in 2009-2014. In terms of the credit risk interdependence of Asian sovereigns, spillover effects occurred through intermediaries such as the Japanese sovereign. Common creditors, such as Japan's banks and sovereign, linked the credit risk within the respective sector, while the non-financial firms in both Japan and South Korea spilled over credit risk in the region.

6.4.2.4 Regional cross-sectoral spillover effects: 5-year CDSs

The estimates of the long-term *regional cross-sectoral* spillover effects are presented in Tables 6.7A to 6.12A. For example, Tables 6.7A to 6.8A show the findings of cross-country spillover effects between an Asian sovereign debtor and the financial institutions in another Asian state in the long run. Tables 6.9A and 6.10A report the regional spillover effects between the sovereigns and the non-financial firms, while the cross-country spillover effects between the financial and non-financial firms are displayed in Tables 6.11A and 6.12A.

6.4.2.4.1 Regional cross-sectoral spillover effects: sovereigns and financial institutions

Tables 6.7A and 6.8A report the estimates of cross-country credit risk spillover effects between sovereigns and financial institutions by using 5-year CDS spread changes. A number of points emerge from the analysis. First, no evidence of credit spillovers is found when the South Korean sovereign debtor was paired with the financial institutions from the remaining countries (i.e., China, Japan, Malaysia and South Korea); thus the impact of the sovereign debtor in South Korea to the financial institutions in other states only presented in the short horizon. This is particularly noticeable for the pairing including the South Korean sovereign debtor and the Singaporean financial institutions given that no significant credit risk interdependence was documented in the 5-year CDS data. Another finding from the 5-year data is that the Singaporean financial institutions seemed to be less affected by the sovereigns in other countries via past mean spread changes. Nevertheless, strong credit risk linkages are uncovered when the Singaporean sovereign debtor is paired with the financial institutions in China (71.43%), Japan (42.86%) and Malaysia (28.57%).

Second, it is worth mentioning that the long-term credit risk linkages were weaker than their 1-year CDS counterparties when the Japanese sovereign debtor was pairing with the financial institutions in the remaining East Asian countries (i.e., China and South Korea); the value of $\gamma_{ij}^{SOV:F,JP:CN}$ fell to 0.7006 for Chinese financial institutions. It is surprising that 9 out of 10 financial institutions in South Korea were affected by the past spread changes of the sovereign entity in Malaysia according to the 5-year CDS data; this asymmetric transmission was surprising since there are no obvious institutional links or strong cultural ties between these two unless South Korean financial institutions are investors in Malaysian government bonds (e.g. $\gamma_{ij}^{SOV:F,MY:SK}$= -0.0155 and $\gamma_{ji}^{SOV:F,MY:SK}$ = 0.2147 in Table 6.8A).

Third, past shock and volatility credit risk spillovers were strongly transmitted from the Chinese sovereign debtor to a large number of financial institutions in the reaming countries in the long run, ranging from 50.00% for South Korea to 66.67% for Malaysia and Singapore. Furthermore, shock and volatility credit spillover effects were found from the Singapore financial institutions to the Chinese sovereign sector in the long run; the percentages of significance are 66.67% for parameters $a_{ji}^{SOV:F,CN:SG}$ and $g_{ji}^{SOV:F,CN:SG}$, respectively. Therefore, the Singaporean financial sector acted as a shock and volatility transmission channel to the sovereign sector of China, Japan and Malaysia in the long term. Panel C of Table 6.8A indicates that there were increasing correlations between the sovereign debtor in China and the financial institutions in Malaysia, ranging from 0.48 to 0.72 in the long run.[102]

6.4.2.4.2 Regional cross-sectoral spillover effects: sovereigns and non-financial firms

Estimates of the long-term credit risk transmission between Asian sovereigns and non-financial firms are presented in Tables 6.9A and 6.10A. Consistent with the previous findings from the 1-year CDS spread changes, a bidirectional relationship existed in the mean spread changes between the Chinese sovereign sector and the non-financial firms in Japan as well as South Korea; however, more spillovers were identified in the long-term to the findings for the 1-year CDS data; for example, the percentages of significant parameters increased from 3.70% to 11.11% for Japan, and from 5.56% to 11.11% for South Korea. An interesting finding here is that all of the 5 Malaysian non-financial firms have bidirectional linkages with the sovereign sectors in Japan and Singapore according to the mean spread changes; Table 6.1A0 indicates that past mean spread changes from the Japanese sovereign sector lead to a dramatic movement of credit risk in the Malaysian non-financial sector while a 1 bps increase in the spreads for Malaysian non-financial firms results in a 0.2918 bps change in the Singaporean sovereign sector's CDS in the long term.

Turning to the spillovers from shocks and volatility in Panel B of the Appendices, a number of key points emerge. For instance, the transmission of shocks and volatility is more pronounced in relation to the *CN:MY*, *CN:SG*, *JP:MY*, *JP:SG* and *JP:SK* pairs. This is especially true for the Japan-Malaysia pair; information related to past shocks and volatility in the Japanese sovereign sector was fully transmitted to the Malaysian non-

[102] The average annual correlation in the short run between the Chinese sovereign sector and the Malaysian financial sector was small and negative most of the time; from -0.1 to 0.08.

financial sector, while the average effects were greater in the opposite direction. In addition, the transmission of credit risk between the sovereign entity of South Korea and the non-financial sector of Singapore only occurred via past shocks from the non-financial sector in Singapore. The estimated averaged time-varying correlations between each sovereign sector and their foreign non-financial sectors shows that the non-financial sector in South Korea had strong relationships with the sovereign sector in China and Southeast Asian countries; the average correlations ranged from 0.49 to 0.57 for the China and South Korea pair, from 0.50 to 0.53 for the Malaysia and South Korea pair, and from 0.42 to 0.45 for the Singapore and South Korea pair.

6.4.2.4.3 Regional cross-sectoral spillover effects: financial institutions and non-financial firms

Tables 6.11A and 6.12A summarise the findings from *regional cross-sectoral* spillover effects by using the 5-year CDS spread changes between financial institutions and non-financial firms. In general, the aggregate interdependence of mean spread changes increased in the long run according to Panel A in Table 6.12A. In line with the findings from the 1-year CDS spread changes, the credit risk of the financial institutions and non-financial firms in both Japan and South Korea acted as a bridge in linking the credit risk of the non-sovereign sector in the remaining countries. Japanese financial institutions, which are the common creditors for major Asian countries, displayed a strong regional credit risk interdependence with the non-financial firms in other Asian countries; past changes in the CDS spreads of the non-financial firms in the remaining Asian countries strongly influenced the current level of credit risk in Japan in 2009-2014, ranging from 0.0202bps (in China) to 0.0565bps (in Malaysia).[103] Hence, the credit risk

[103] As introduced before, Malaysia has attacked the increasing FDI especially from Japan, whose non-financial corporations established overseas branches in Malaysia due to the low-cost labour.

of the Japanese economy was heavily integrated with the creditworthiness of the non-financial sector in Asia given the strong interconnectedness within the Japanese financial institutions. The long-term cross-sectoral transmission of volatility was pronounced in the 5-year data due to the great amount of significant parameters. Therefore, the role of shock and volatility in cross-sectoral credit risk transmission is confirmed in both the short and long run. The South Korea-Malaysia pair has the highest average annual correlations, with a range from 0.49 to 0.54 over the years 2009 to 2014.

6.5 Conclusion

This chapter presents an empirical analysis of credit risk spillover effects by using a VAR(1)-bivariate-GARCH(1,1)-full-BEKK model for 20,760 pairs of Asian CDS reference entities in relation to both short and long runs. In particular, the spillover effects proposed in this chapter are presented in four different groups; they are: (i) *domestic intra-sectoral* spillover effects, (ii) *domestic cross-sectoral* spillover effects, (iii) *regional intra-sectoral* spillover effects, and (iv) *regional cross-sectoral* spillover effects. The estimates of spillover effects in both the short and long run are done by employing 1-year and 5-year CDS data in this chapter. In each of the 1-year and 5-year CDS data sets, percentages of significant parameters, percentages of significant parameters with negative values and averaged values of parameters are reported in order to facilitate a comprehensive analysis of the significance, directions and magnitudes of the spillover effects in Asia for the period 2009-2014.

The findings can be summarised as follows. First, the main findings clearly indicate evidence of cross-firm credit risk interdependence between different sectors and countries both in relation to past mean spread changes, shocks and volatility. In particular, the transmission of shocks and volatility were more pronounced than the transmission of credit risk news from past mean spread changes in both the short and long run, although the magnitudes of shocks and the nature of the spillovers vary significantly as a consequence of the differences in the financial structure of each country. For example, there is no evidence of cross-sectoral transmission either in terms of past mean spread changes or shocks and volatility between the South Korean sovereign debtor and the Singaporean financial institutions in the long run. Second, it is noticeable that the credit risk of the Japanese sovereign plays an important role in spilling over credit risk to other Asian countries. This finding is in line with Eichengreen and Luengnaruemitchai (2004), who identified the core position of Japanese debt markets in Asia. In China, the credit standing of the Chinese sovereign was leading the credit statues of domestic financial and non-financial firms. Third, according to the findings of the credit risk spillover effects between the financial institutions, Chinese overseas banks have a strong network with both the home country and the financial institutions in other Asian nations, which may act as a sunspot source in a weak financial condition.

Taken together, there is a trade-off in terms of the propagation of contagion between completeness and interconnectedness. As Allen and Gale (2000) suggested, market completeness and market interconnectedness are two characterises of the structural market affecting the financial contagion. In conclusion, the findings in this chapter suggest that the CDS market for Asian entities is immature and the potential of contagious credit risk is quite substantial.

Chapter 7: The effects of corporate and markets factors on credit risk correlations

7.1 Introduction

Analyses in previous chapters have identified sizable credit risk spillovers between Asian name CDSs spread changes. Spillover effects are found both within and across sectors or between countries in the region; for example, credit risk in the non-financial sector in Japan spills over both to the financial sector in China and the non-financial sector in Malaysia. These results point to the possibility of credit risk contagion and raise questions about how contagious any credit risk is between entities or whether a financial system is resilient to a rise in the credit risk of one entity. Findings in previous chapters also indicate that there may be a number of factors which potentially determine or explain credit interdependence between Asian firms. Such interdependence can be examined using correlations between CDS spread changes and may have important implications for the transmission of credit risk across companies as well as for the stability of financial systems in the region. For example, higher credit risk correlation among firms can increase the risk levels of banks which lend to such companies[104] and endanger the stability of the whole financial system leading to an economic downturn.

Understanding the phenomenon of credit risk correlation is crucial for many areas in finance: when setting capital requirements for banks; constructing as well as managing a portfolio involving CDSs; and pricing structured credit products that are heavily exposed to credit risk.[105] The current chapter attempts to enhance our knowledge of this area by identifying the factors which potentially determine or explain credit

[104] For example, a rise in the correlated default among the individual borrowers within a bank's loan portfolio may reduce any diversification advantage that might have been available from lending to a large number of firms with uncorrelated default risk.

[105] A number of capital requirements have been set (for banks) in the event of default by an entity on its obligations; for example, the first Basle Accord (Basel I) published in 1988 established a uniform capital requirement for banks' credit risk. The second Basel Accord in 2004 and Basel III in 2010 have strengthened bank capital requirements by increasing the liquidity levels and decreasing the leverage levels permitted for banks (Angelini *et al.*, 2015; Dermine, 2015; King, 2013; Krug *et al.*, 2015). In addition, Basel III also strengthened the capital requirements for counterpart risk; for instance, an extra counterpart credit valuation adjustment (CVA) capital charge is required in additional to the traditional default capital charge (Sayah, 2016).

interdependences (and specifically, correlations between CDS spread changes) among entities in the same country or in different nations.

A number of academic studies (Gupton, 1997; Li, 2000; Vassalou and Xing, 2004) have attempted to explore credit risk correlation by investigating linkages between the equity returns or between the bond spreads of pairs of entities. Practitioners have adopted a similar approach when examining this topic. For example, J.P. Morgan's CreditMetrics model evaluates the linkages between two firms' credit risks by studying the correlation between their equity returns[106]. Other academics (Arellano and Ramanarayanan, 2012; Barnhill and Maxwell, 2002; Li, 2000) have studied correlations between the bond spreads of different entities. However, a number of factors have called the findings using this bond-spread approach into question; issues such as bond market illiquidity and variations in coupon conversion payments at the time of a default hamper the use of correlations between bond spreads when estimating credit risk interdependence. In addition, equity returns may be correlated for reasons other than credit risk linkages. As a result, Collin-Dufresne *et al.* (2001) have suggested that analyses of default risk correlation using linkages between equity returns or bond spreads have been relatively unsuccessful; variables which should, in theory, determine credit risk only exhibit limited explanatory power when equity returns and bond spreads are studied. Furthermore, research on this subject has mainly focused on comparing the ability of a limited number of macroeconomic variables to explain credit risk correlations in developed Western countries – especially the US. Very few investigations have analysed the power of regional- and global-level factors to explain credit risk linkages in Asia. In addition, there is little or no evidence about the ability of cross-country factors as well as regional and

[106] A further disadvantage of this approach is that equity returns are not unavailable for sovereign entities. Thus, this approach cannot be used when examining credit risk correlations involving CDSs for bonds issued by nation states.

global variables to explain credit risk correlation within a nation. The current chapter attempts to fill these gaps in the literature.

The analysis in this chapter of the thesis aims to contribute to the literature in four main ways. First, it is particularly interested in the characteristics of credit networks that have emerged in Asian CDS markets; results about these characteristics should facilitate a comparison with findings from previous studies on this topic in other regions. Furthermore, to the best of the author's knowledge, there is, apart from findings in the previous chapter, no detailed description of credit risk interdependences focusing particularly on Asian non-financial institutions. To fill this gap, the current chapter examines credit risk correlations for two different categories of borrowers: F and NF entities. Findings about the non-financial sector and the correlation of its credit risk with that of financial firms should offer interesting insights. Third, credit risk correlations are studied in order to investigate the internal structures of Asian credit networks across both sectors and countries; to date, most previous investigations have focussed on a single sector or a specific country. Finally, this chapter also identifies the factors which explain credit risk correlation from a comprehensive range of corporate and market variables covering firm-, country-, regional- and global-level indicators; this setting will enable the determinants of credit risk correlation to be evaluated in terms of a comprehensive set of observable factors.

The remainder of the chapter is organised as follows. The next section details the evidence from the existing literature on the relationship between observable variables and credit risk correlations; in addition, it illustrates how network theories have been applied in the finance area. Section 7.3 describes the dataset and outlines the research approach employed. Section 7.4 outlines the empirical findings of the chapter while Section 7.5 concludes.

7.2 Related literature

7.2.1 Determinants of credit risk correlations and transmission channels

The academic literature has concentrated on two main approaches when investigating the factors which influence credit risk correlation: (i) the structural models approach as exemplified by the work of Merton (1974) and (ii) the reduced-form approach which has been adopted by researchers such as Li (2000) and Brigo and Chourdakis (2009). The classical Merton (1974) model allows credit risk correlations to be estimated by assuming that the relationship between firms' assets follows a stochastic process. Specifically, the Merton model assumes that a firm's total assets are equal to the sum of the firm's equity and debt. From the perspective of the Merton model, holding risky debt is equivalent to going long in a risk free bond and shorting a put option on the firm's assets. This assumption makes it possible to identify how different underlying factors relate to correlated credit risk among different firms. Further analysis by Zhou (2001b) has provided insights about the default correlation between two firms whenever their asset values fall below a certain level. More recently, Hull and White (2000a, 2000b) have focused on the importance of firm-specific variables when determining CDS spreads and the pricing of correlated default for a basket of CDS contracts. According to their analysis, the joint default probability of any two firms depends on the cumulative probability of default for both firms (Hull and White, 2000b). This implies that information relating to underlying factors such as firm value, firm volatility, and firm leverage that affect this joint probability may play an important role in determining credit risk correlations.

Firm-level factors thought to influence credit risk correlations in terms of CDS spreads have been explored in a small number of studies. This small number of investigations have emphasised that changes in firms' financial conditions affect their credit risk correlation. For example, Hull and White (2000b) were one of the first to study default correlations using a CDS dataset and concluded that firm-specific factors such as changes in a company's volatility and leverage contributed to linkages between default probabilities. More recent studies such as Tang and Yan (2010) and Pu and Zhao (2012) have identified a positive relationship between information on firm leverage (or equity volatility) and credit risk correlations. Results from Pu and Zhao (2012) suggest that the average pair-wise residual correlation is typically reduced by adding in information relating to both firms' leverage and volatility; as these authors have stated: 'It is clear that co-movements in the firm-level variables among different firms can partially explain the correlation in the changes in CDS spreads' (p.1099).

The reduced-form approach (Duffie and Singleton, 1999; Jarrow and Turnbull, 1995; Van Landschoot, 2004) suggested that credit risk correlation varies as macroeconomic conditions change. According to this approach, changes in macroeconomic conditions may cause the default risk of all bonds to vary thereby increasing any correlations that may be present. For example, Collin-Dufresne *et al.* (2001) studied whether variations in corporate bond yield spreads are associated with S&P500 returns, corporate leverage ratios, the 10-year Treasury bond yield, the term structure and the implied volatility of the S&P 500 (VIX). Their results indicated that higher stock market volatility, lower S&P500 returns, decreases in 10-year Treasury bond yield changes and a flatter yield curve are associated with higher credit risk among firms.

In a subsequent study of this topic, Carling and Colleagues (2007) identified a different set of macroeconomic variables that were important in explaining credit risk. Specifically, their study investigated the effects of different macroeconomic conditions on business defaults in order to explain the 'survival time to default' for the loan portfolio of a major Swedish bank's business borrowers over the period 1994 to 2000. Their findings suggested that macroeconomic variables such as the output gap, the yield curve, and consumers' expectations of future economic developments could help explain the default risk of firms in this loan portfolio.

By employing a longer time span of data from 1980 to 2004 for a sample of US industrial firms, Duffie *et al.* (2007) argue that the three-month Treasury bill rate and the trailing 1-year return on the S&P 500 index could predict default intensity.[107] They found that default intensity among firms had a significantly negative relationship with changes in the short-term interest rate but was positively associated with movements in the S&P 500 index, consistent with Lando and Nielsen (2010).[108] The latter finding is interesting as it conflicts with the expectation that default risk among firms should be lower in a booming market (Claußen *et al.*, 2017; Gilchrist *et al.*, 2009; Tang and Yan, 2010). They also discovered that default intensity was independent of 10-year Treasury yields, the real GDP growth rate, the AAA-BAA bond yield spread and industry-average default rates. In contrast, Couderc and Renault (2005) reported that default intensity across their sample of companies was associated with a lot of variables; it was positively related to market volatility, the term spread, and yield differences between BBB bonds and AAA bonds, but it was negatively associated with market return, the Treasury yield, the real GDP growth rate, the growth rate in industrial production, inflation, personal consumption, and the spread of BBB bonds over Treasury bonds.[109]

[107] Duffie *et al.* (2007) defined default intensity as the conditional mean arrival rate of default (e.g., credit event per year); in particular, variation in a firm's default intensity is caused by the covariates from a Markov state vector of firm-specific and macroeconomic variables.

[108] Lando and Nielsen (2010) employ the S&P 500 returns, three-month Treasury yields, industrial production, and the term spread in their default intensity prediction model. They find that default intensity is negatively related to industrial production and the three-month Treasury yield. They also find a positive relationship between default intensity and both the S&P 500 returns and term spread.

[109] Their final sample covered 93 countries, 6897 firms and around approximately 66% of them are U.S. firms. They also expanded on the set of variables included in Duffie *et al.*' (2007) investigation. Specifically, they examined the impact on default intensity of a number of different market and macroeconomic variables over the period 1981 to 2003; they added personal income, the net issue of Treasury securities as well as money lending (M2-M1) and bank credit growth to the pool of variables considered.

In addition to studies about the effects of variables on credit risk correlations, a number of different 'channels' have been proposed in the literature to explain how risk is transmitted between entities; specifically, a liquidity channel, a risk premium channel and an information channel have been advanced by academics to show how risk might spread within financial systems. The liquidity transmission channel (Schnabl, 2012) suggests that risk spreads through a 'flight-to-quality' effect in bond markets; (Heider *et al.*, 2009) argue that this 'flight-to-quality' in response to a shock for a few companies may reduce liquidity for all firms and give rise to contagion. According to this perspective, a shock event in one sector or financial market may adversely affect the liquidity of other sectors or financial markets with knock-on consequences for asset prices and investor behaviour. Trading activity in other (segments of various) financial markets may be affected by the initial shock and credit may not be available as participants stop trading (Giesecke *et al.*, 2011).

Proponents of the risk-premium channel argue an initial shock event in one market or segment may affect investors' willingness to take on risk in other markets or segments; as a result, equilibrium risk premiums will rise which will have an impact on asset prices in all markets. As Acharya *et al.* (2017) stated: 'it has a significant explanatory power for which firms contribute to a potential crisis' (p.4).

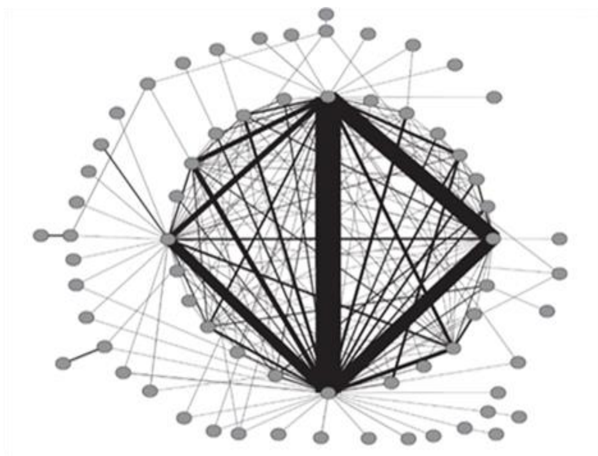
The third strand of this literature suggests that contagion arises via the correlated-information channel. Supporters of this view suggest that new information in one financial market conveys economic news about asset prices in other markets as well; as a result, the arrival of news about default for one firm may have consequences for the credit risk of other entities which causes correlations to increase. Simmons and Tantisantiwong (2014) have developed a theoretical framework involving the information channel which shows how asset return correlations may depend on whether investors are general traders or specialise in one specific asset. If they are generalists and trade in a number of assets, these investors may react to certain risk-related information in one asset market by rebalancing their portfolios, leading to a change of prices in all markets where they have funds invested. In this situation, contagion may arise - the disclosure of information about the risk of an entity or market may cause prices to change for other entities or markets – possibly without any lag. Thus, one feature of studies about credit risk correlation which draw on the information channel is the assumption that the contagion takes place via the price discovery mechanism (Borio and Zhu, 2012).

7.2.2 Application of financial network theories

Gai and Kapadia (2010) and Morris (2000) have drawn on network theory to explain credit risk correlations. The economic notion of a network is based on the assumption that all social and economic phenomena result from choices made by rational individuals. Thus, this theory assumes that market participants establish a relationship with one another depending on how beneficial the networking will be. Applying this idea to organisations, firms are thought to develop interdependences with one another after evaluating the costs and benefits of being linked together. These linkages may be direct or indirect. For example, banks may have a direct link with one another through their participation in the interbank lending market. In addition, they are also indirectly connected to one another in terms of balance-sheet linkages (Allen and Babus, 2008). As Hyung and De Vries (2005) have suggested, the potential interdependency between financial institutions may arise due to the effects of forced sales of a bank's assets on the prices of these assets held by other institutions. Extending this notion to credit networks among firms, Edirisinghe *et al.* (2015) argued that 'Network risk stems from one firm being impacted by an unanticipated adverse event, the impact of which then passes on to other firms linked to the first firm either by the firm's explicit inability to meet its obligations or by perceived weakness in other firms' (p.212). Allen and Babus (2009) have argued that the use of network theory can help to explain default risk within a system and capture any externalities associated with a risk for a single institution which can be transmitted to the entire financial system.

Therefore, one assumption behind the characterisation of a financial system as a network is that linkages are clear and have observable features which can be assessed depending upon connections between the selected participants and their positions within the network.[110] In Figure 7.1, May *et al.* (2008) present the Fedwire interbank payment network for 2012. The core of the network has 66 banks accounting for 75% of the daily value of transfers, with 25 of the banks being 'completely connected'.[111] Therefore, the behaviour of the system can be analysed in great detail over different timescales.

Figure 7.1: The Fedwire interbank payment network



Source: May *et al.* (2008)

[110] Examples of where such features are present include the labour market, buyer-and-seller networks, risk sharing networks, and product adoption. For example, in a typical labour market, studies on how networks involve the matching process between workers and their employers. Information about job vacancies and details about the ability of the workers can also be structured as networks. According to this analysis, a network can play a role in transmitting information between workers and employers across individuals.
[111] More specifically, the largest banks in order are JPMorganChase, Bank of America, Citigroup, Wells Fargo, Goldman, Metlife and MorganSt for the year of 2012.

According to Iori *et al.* (2008) and Peltonen *et al.* (2014), a number of important network features can help to assess the likelihood of default and the extent of contagion within a network. For example, the number of links within a network, the mean and the maximum level of interconnectedness within a network and the ratio of core to peripheral participants in a network were all proposed as key variables by Iori *et al.* (2008). Other features such as the longest distance amongst all the shortest paths between any two nodes (or diameter) are also highlighted within network theory as key variables; according to the literature, the diameter measures the potential speed of contagion within a network. Therefore, a low diameter value implies that no institution is remote from any potentially distressed institution within the network and the possibility of contagion is therefore stronger. However, the literature on financial networks is still at an early stage; research on this topic in the finance area has not adopted a dynamic approach but concentrated on the financial stability and contagion of any networks that may be present.[112]

The term 'financial contagion' was initially coined by Allen and Gale (2000). Pritsker (2001) subsequently argued that 'contagion occurs when a shock to one or a group of markets, countries, or institutions, spreads to other markets, or countries, or institutions'.[113] However, difficulties exist when matching up the available information about network 'actors' in the public domain in order to study the linkages that may be present. Nevertheless, a small number of studies have conducted some initial investigations in this area by documenting the determinants of the CDS spreads for a

[112] Jackson and Wolinsky (2003) argued that a network is stable when two conditions are satisfied. First, if a link between two individuals is absent from the network, then it cannot be that both individuals would benefit from forming the link. Second, if a link between two individuals is present in a network, then it cannot be that either individual would strictly benefit from removing that link.

[113] According to the definition of Pritsker (2001), two types of shocks are identified. The first type is an intermediary-specific shock, and the second one is a real shock. For example, a shock affecting a bank or non-banking institution, which is specific in its origin to that bank or financial market participants, is called as the intermediary-specific shock. By contrast, a real shock is a shock to the real sector of the economy, including but not limited to 'innovations' in technology, or a flow of information on the performance of real or financial assets.

given particular corporate bond and of the net credit protection bought or sold by market participants (Oehmke and Zawadowski, 2015). Others have tried to describe the composition of the market where trading in CDS contracts occurs (Blanco *et al.*, 2005; Chen *et al.*, 2011).

To date, prior studies (Acharya *et al.*, 2017; Augustin and Tédongap, 2016; Brownlees and Engle, 2012) have examined the effects of various US domestic economic fundamentals and market variables on credit risk correlation. No consistent evidence has emerged from these studies on how observable firm characteristics and regional-specific factors are associated with credit risk correlations throughout different sectors within a nation and between two nations. It is also not clear from the literature how the effects of various variables on credit risk correlations vary across different sectors analysed. The above questions are important because correlated credit risk has been, and still is, one of the biggest risks that banks face. However, this is not an issue that is unique to banks; with securitization and globalisation, credit risk has spread out beyond the banking sector to various market segments in different countries. This lack of clarity about how credit risk is correlated within a network between firms, within a sector and between firms across different sectors poses a major challenge for investors, portfolio managers, banks, and government regulators.

7.3 Data and methods

7.3.1 Data and preliminary analysis

The main objective of this chapter is to explain credit risk correlations between Asian named CDS reference entities and to investigate the effects of observable variables and underlying contagion channels on correlated default. To facilitate this objective, estimates of credit risk correlations and potential explanatory variables are discussed in this section. The primary data set utilised in this chapter is similar to that used in Chapter

5 and Chapter 6, but daily CDS data spanning the years 2009 to 2015. Selection of the sample firms was initially based on the dataset employed in previous chapters; the 126 reference entities were initially screened based upon the availability of all of the potential explanatory variables. The final sample includes 97 underlying reference entities encompassing 16 financial institutions and 81 non-financial firms drawn from China, Japan, Malaysia, Singapore and South Korea.[114]

Table 7.1: Distribution of CDSs reference entities by sector and country

Sector/Country		CN	JP	MY	SG	SK	Obs.
Financial Sector (F)	Bank	2	0	2	2	4	10
	Other Financial Institution	0	5	1	0	0	6
Non-financial Sector (NF)	Consumer Goods	0	3	0	0	1	4
	Electric Power	0	3	1	1	3	8
	Energy Company	0	1	1	0	1	3
	Manufacturing	3	28	1	1	4	37
	Service Company	0	5	0	0	2	7
	Telephone	1	4	1	1	1	8
	Transportation	1	9	1	0	0	11
	Other non-financial Firm	1	1	0	0	1	3
Obs.		8	59	8	5	17	97

Note: This table shows the distribution of Asian CDS contract reference entities according to both sector and country.

[114] Compared with Table 4.2 in Chapter 4, the number of financial institutions whose CDSs are studied falls from 30 to 16 while the number of non-financial firms decreases from 91 to 81. For example, in the non-financial sample, two of the firms dropped were from China (CNCOOC limited (ENC) and the PCCW-HKJ Telephone Limited (TEL)), one was from Singapore (the PSA International PTE Limited (ONF)) and five were from South Korea (GS Caltes Corporation (ENC), Korea Expressway Corporation (TRN), Korea East-West Power (ELP), Korea Midland Power (ELP) and Korea Water Resources Corporation (SEC)).

Spread changes for CDS contracts are used to compute credit risk correlations. These spread changes were selected for analysis because they capture movement in a firm's default risk and provide information about market participants' attitude to risk. Pair-wise correlations of Asian single-named CDS spread changes are calculated for every firm from the same country or from two different countries. Specifically, Spearman's rank correlations, $\rho_{ij,t}^{S_{i,j},C_{i,j}}$, are calculated using the following formula:[115]

$$\rho_{ij,t}^{S_{i,j},C_{i,j}} = \mathrm{Corr}(\Delta \mathrm{CDS}_{i,t}^{S_i,C_i}, \Delta \mathrm{CDS}_{j,t}^{S_j,C_j}) \qquad (7.1)$$

where, $\Delta CDS_{i,t}^{S_i,C_i}$ ($\Delta CDS_{j,t}^{S_j,C_j}$) are CDS spread changes of *firm i (j)* associated with the sector S_i (S_j) of country C_i (C_j) at time *t.* Because this chapter is interested in the co-movement between credit spread changes at both the domestic and the regional level, the pair-wise credit risk correlations are divided into four sub-groups: 1) domestic intra-sectoral correlations ($C_i = C_j$ and $S_i = S_j$), 2) domestic cross-sectoral correlations ($C_i = C_j$ and $S_i \neq S_j$), 3) regional intra-sectoral correlations ($C_i \neq C_j$ and $S_i = S_j$), and 4) regional cross-sectoral correlations ($C_i \neq C_j$ and $S_i \neq S_j$). For example, intra-sectoral correlations focus on credit risk correlations within the financial sector ($\rho_{ij,t}^{F,C_{i,j}}$) or within the non-financial sector ($\rho_{ij,t}^{NF,C_{i,j}}$). By contrast, cross-sectoral correlations refer to credit risk correlations between financial and non-financial firms ($\rho_{ij,t}^{F:NF,C_{i,j}}$).

The credit risk correlations for each year (from 2009 to 2015) are shown in Table 7.2; the average correlation across the whole 7-year period is also displayed. In panel A of this table, domestic credit risk correlations (for within-country pairs of entities) are

[115] A Fisher Transformation could have been applied to standardize the data, as the values of correlations are in the open interval (-1, 1) in all cases. Under a Fisher's Z-transformation of correlation coefficients, the standardized data is approximately normally distributed. In particular, Fisher's Z-transformation of the correlations is defined as: $z = \frac{1}{2}\ln(\frac{1+r}{1-r})$. Thus, the z is approximately normally distributed with mean $\frac{1}{2}\ln(\frac{1+\rho}{1-\rho})$ and standard error $\frac{1}{\sqrt{N-3}}$, where N is the sample size, and ρ is the true correlation coefficient. However, this transformation was not employed in the current thesis because of time considerations.

reported while the regional (across-country) correlations are shown in panel B; the average credit risk correlation values and the numbers of observations are provided in the final two rows of each panel. On the left-hand side of each panel, credit risk correlations for 1-year CDS spread changes are presented while on the right-hand side of each panel, correlation values for 5-year CDS spread changes are given. For the 1-year and 5-year datasets, full sample credit risk correlations ($\rho_{ij,t}^{ALL}$) and sub-sample correlations ($\rho_{ij,t}^{F}$, $\rho_{ij,t}^{NF}$ and $\rho_{ij,t}^{F:NF}$) are reported in separate columns. A visual inspection of Table 7.2 reveals a number of interesting insights.

Table 7.2: Asian credit risk correlations from 2009 to 2015

	1-year CDS contracts				*5-year CDS contracts*			
Panel A: Domestic credit risk correlations								
	$\rho_{ij,t}^{ALL,C_i}$	$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$	$\rho_{ij,t}^{ALL,C_i}$	$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$
2009	0.239	0.169	0.334	0.152	0.162	0.118	0.166	0.143
2010	0.245	0.158	0.266	0.158	0.094	0.168	0.090	0.103
2011	0.247	0.139	0.273	0.142	0.150	0.117	0.155	0.131
2012	0.210	0.198	0.227	0.139	0.121	0.181	0.123	0.113
2013	0.269	0.215	0.290	0.182	0.140	0.161	0.139	0.147
2014	0.232	0.197	0.262	0.112	0.152	0.224	0.146	0.174
2015	0.285	0.114	0.318	0.154	0.128	0.250	0.124	0.136
Average	0.247	0.170	0.281	0.149	0.135	0.174	0.135	0.135
Obs.	13,391	147	10,759	2,485	13,391	147	10,759	2,485
Panel B: Regional credit risk correlations								
	$\rho_{ij,t}^{ALL,C_{i,j}}$	$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$	$\rho_{ij,t}^{ALL,C_{i,j}}$	$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$
2009	0.105	0.194	0.089	0.125	0.136	0.249	0.135	0.127
2010	0.101	0.187	0.084	0.122	0.118	0.213	0.114	0.116
2011	0.099	0.178	0.091	0.105	0.126	0.232	0.132	0.104
2012	0.083	0.097	0.089	0.069	0.095	0.179	0.097	0.081
2013	0.160	0.174	0.162	0.156	0.132	0.231	0.137	0.112
2014	0.077	0.097	0.081	0.068	0.077	0.202	0.107	0.100
2015	0.101	0.124	0.106	0.089	0.074	0.158	0.068	0.075
Average	0.104	0.150	0.100	0.105	0.108	0.202	0.107	0.100
Obs.	19,166	693	11,921	6,552	19,166	693	11,921	6,552

Note: This table shows the credit risk correlations from 2009 to 2015 and well as the average over the whole period. Panel A presents domestic credit risk correlations while Panel B presents regional credit risk correlations. In addition, the left-hand-side panel of the table reports credit risk correlations for 1-year CDS spread changes while the right-hand-side panel reports credit risk correlations for 5-year CDS spread changes. Correlations for the whole sample, for intra-sectoral pairs (among the financial sector and among the non-financial sector) and for cross-sectoral pairs are shown for 1-year CDS and 5-year CDS instruments, respectively. The number of observations are presented in the bottom of Panel A and Panel B, respectively.

First, when the domestic credit risk correlations of 1-year CDS spread changes are compared with their 5-year counterparts in Panel A, the results indicate that the domestic credit risk correlations are generally higher in the short run. For example, the average 1-year domestic correlation of 0.247 is nearly twice the average 5-year domestic correlation (0.135). However, a different picture emerges when the sub-sample credit risk correlations, $\rho_{ij,t}^{F,C_i}$ and $\rho_{ij,t}^{F:NF,C_i}$ are studied; for the final two years studied (2014 and 2015), the short-term correlation is smaller than its longer-term counterpart (0.197 v 0.224 and 0.112 v 0.174 for 2014) (0.114 v 0.250 and 0.154 v 0.136 for 2015). These results highlight the need for sub-sample analysis of credit risk correlations since sectoral differences are present during the analysis period.

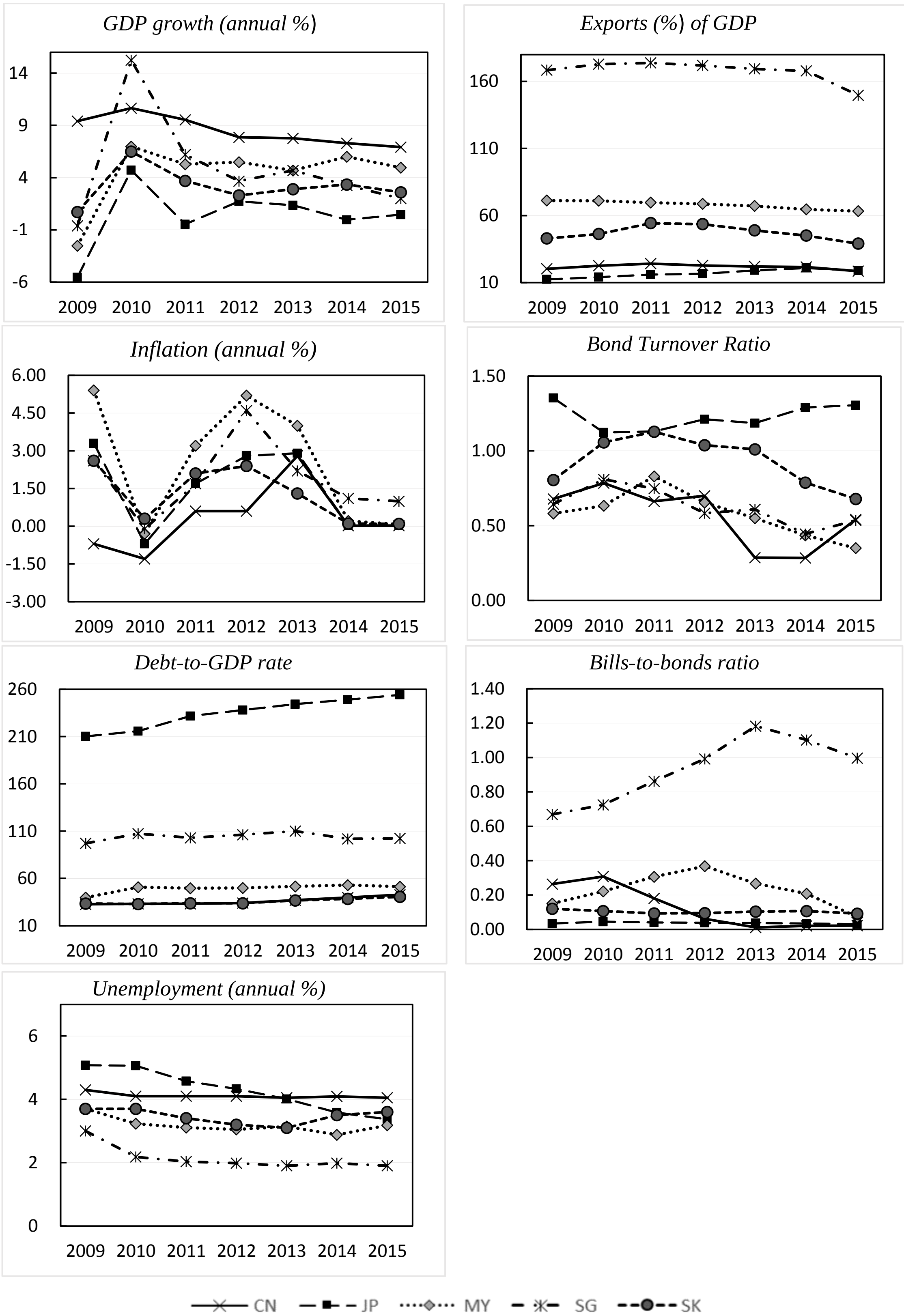
Second, an analysis of the regional credit risk correlations (for all cross-country pairs of entities) in Panel B reveals that 1-year regional credit risk correlations are smaller than their 5-year counterparts over the years 2009 to 2012 but become bigger than the 5-year correlations from 2013 to 2015; this finding holds for the non-financial (NF) sector while 1-year correlations are always lower than their 5-year counterparts for pairs of financial (F) firms. In addition, regional credit risk correlations among non-financial firms are smaller than the values documented for financial firms irrespective of the time horizon considered. For example, the average value of $\rho_{ij,t}^{F,C_{i,j}}$ is 0.150 while $\rho_{ij,t}^{NF,C_{i,j}}$ is 0.100 for 1-year CDS spread changes. However, no clear pattern emerges when differences between 1-year and 5-year regional credit risk correlations when cross-sectoral pairings are studied ($\rho_{ij,t}^{F:NF,C_{i,j}}$). Lastly, findings for both 1-year and 5-year domestic and regional correlations support the decision to analyse the results for the sub-groups separately in the thesis; the credit risk correlations are different for the F sector, the NF sector and cross-sector pairings between F and NF firms for the short and long term CDS periods.

Table 7.3: Summary statistics

Variable	Mean	Median	Min.	Max.	Std. Dev.
Panel A: Firm-level variables					
All firms					
Asset (Million)	13.04	2.800	0.004	283.698	0.366
ROE	0.067	0.078	-0.116	0.757	0.058
Current ratio	2.098	1.360	0.174	13.830	3.790
Debt-to-equity	1.471	0.922	0.050	3.227	0.061
Asset turnover	0.675	0.630	0.020	2.490	0.479
Pricing/earnings	27.761	14.70	0.000	334.000	5.198
Dividend yields	0.023	0.019	0.000	0.370	0.210
Equity volatility	0.260	0.264	0.118	0.548	0.186
Financial institutions					
Asset (Million)	47.898	17.433	0.091	283.698	0.718
ROE	0.071	0.098	-0.097	0.214	0.078
Current ratio	3.982	2.509	0.174	13.830	2.805
Debt-to-equity	2.564	2.063	0.120	2.925	0.100
Asset turnover	0.084	0.050	0.020	0.370	0.073
Pricing/earnings	15.907	11.450	0.000	226.500	4.081
Dividend yields	0.030	0.023	0.000	0.370	0.381
Equity volatility	0.267	0.259	0.121	0.510	0.103
Non-financial firms					
Asset (Million)	4.433	2.390	0.004	50.868	0.057
ROE	0.660	0.744	-0.116	0.757	0.054
Current ratio	1.529	1.310	0.300	5.980	0.863
Debt-to-equity	1.255	0.792	0.050	3.227	0.075
Asset turnover	0.792	0.730	0.030	2.490	0.438
Pricing/earnings	31.075	15.950	0.000	334.000	3.649
Dividend yields	0.021	0.019	0.000	0.064	0.122
Equity volatility	0.258	0.264	0.118	0.548	0.163
Panel B: Regional-variables					
$CDS^{F,JP}$ (bps)	1.508	1.273	0.808	2.430	0.600
$CDS^{NF,JP}$ (bps)	1.468	1.262	0.706	2.578	0.636
Panel C: Global-variables					
VIX	0.201	0.178	0.141	0.315	0.063
S&P500	0.075	0.106	-0.252	0.184	0.151
iTraxx(bps)	213.122	196.910	59.313	440.733	4.684
Slope	0.184	0.205	0.0565	0.305	0.092

Note: This table reports summary statistics for the independent variables used in the panel model analysis. Panel A shows the descriptive statistics for the firm-level variables. Panel B and Panel C provide descriptive statistics for the regional- and global-variables, respectively.

Figure 7.2: Time series of macroeconomic variables



When deciding on the various potential factors which might affect the correlations among CDS spread changes, 21 different variables were identified based on four levels of analysis undertaken: 1) firm-level variables, 2) country-level variables, 3) regional-variables, and 4) global-variables. Of the 21, eight firm-level variables were selected including one measure of firm size, four financial ratios and three stock market-related indicators. Firm size was proxied by the natural logarithm of total assets. Financial ratios measuring profitability, liquidity, leverage and efficiency were also included. Specifically, a firm's return on equity (ROE) was chosen as a measure of profitability; this ratio assesses the ability of a company to generate earnings from the assets which it owns. The current ratio (CR) measures a firm's liquidity; it assesses whether a firm can pay its short-term debt obligations from its current assets. The debt-to-equity (DE) ratio was used to measure a firm's level of gearing. Finally, the asset turnover ratio was included; this measures the ability of a firm to use its assets to generate revenues. In addition to firm-specific ratios from the financial statements, firm-level market indicators were also included as explanatory factors; each firm's pricing/earnings ratio, dividend yield and a measure of equity volatility were obtained.

Country-level variables were selected to try and capture the importance of a nation's business cycle and bond market performance when explaining correlations among CDS spread changes. These variables were chosen based on prior evidence from the empirical literature (Carling *et al.*, 2007; Ericsson *et al.*, 2009; Pu and Zhao, 2012; Wu and Zhang, 2008) as well as theoretical considerations (Almeida and Philippon, 2007; Hilscher and Nosbusch, 2010; Pesaran *et al.*, 2006). Specifically, six country-level variables including macroeconomic variables such as the real GDP growth rate, the inflation rate, the debt-to-GDP ratio, the unemployment rate, the level of exports (as a percentage of GDP) and two bond market factors (the turnover ratio for government bonds and the bills-to-bonds ratio) were identified as potential determinants of credit risk correlations. The level of exports was added as a potential explanatory factor for credit risk correlation among Asian firms. Although not highlighted in the relevant literature, it was included in this investigation because all of the Asian countries being studied depended heavily on foreign sales of goods and services over the years being examined.[116] In addition, the sample period covers an era when free trade opportunities increased throughout Asia following the launch of ASEAN which all of the sample countries had joined (Chirathivat, 2002; Sharma and Chua, 2000).

Lastly, two regional and four global variables were included in the analysis. The CDS index of the Japanese financial sector and the CDS index of Japanese non-financial sector were added as regional variables because prior studies such as Ghosh *et al.* (1999) and Yang *et al.* (2003) have traditionally viewed Japan as the most influential country in the region. In addition, results from previous chapters of this thesis have identified that the contagion effect of shocks to the Japanese financial sector was more pronounced than that of shocks in other sectors within different countries. Findings from previous chapters of this thesis have also highlighted how the non-financial sector in Japan had stronger links with other Asian financial sectors than the non-financial sectors in other Asian countries. Since no single CDS index exists for the Japanese financial sector, one was created; the CDS index of the Japanese financial sector was formed by weighting the Japanese banking CDS index and the Japanese other financial CDS index equally. The average values of five Japanese industrial CDS series were combined in a similar fashion

[116] For example, according to the records of the National Bureau of Statistics of China, China's exports have grown steadily from US$1201.61 billion to US$2274.95 billion during 2009 to 2015; from these records, it is apparent that China is the origin for 24% of Japanese imports in 2015. Other Southeast Asian countries such as Singapore, have had China as their biggest exports and imports partner till 2014; the total value of trade between China and Singapore is US$52.277 billion.

to generate a composite index for the Japanese non-financial sector.[117] The global variables selected for inclusion in this analysis were drawn from the work of Collin-Dufresne *et al.* (2001) . They included the S&P500 index which measures US equity performance, changes in the VIX index (the implied volatility of the S&P500) and the slope of US treasury yield curve (the difference in yields for US Treasury bonds of 10-year and 2-year maturities which proxies the term structure). The 5-year *iTraxx* European index was added to the set of global variables examined in the current chapter in order to capture any flow of credit risk information from countries in Europe to Asia.[118] The dataset was extracted from a number of sources: Thomson Reuters Datastream (balance sheet data and economic indicators), Markit (*iTraxx* indices family), the World Bank (national data and other economic indicators), the Federal Reserve (economic indicators from www.federalreserve.gov) and the Asian Development Bank (Asian bonds market transaction data from www.adb.org).

Table 7.3 reports summary statistics for firm-, regional- and global-level variables. An inspection of this table highlights a number of important findings about the explanatory variables. Firstly, company ratios in Panel A are different for the financial and non-financial sectors. Although the average value of total assets is USD$13.04 million for all firms, the typical company in the financial sector is over 10 times the size of its NF counterpart. For example, the mean value of total assets is USD$47.898 million for financial firms but only USD$4.433 million for non-financial firms. Secondly, financial institutions are more liquid; their average current ratio is nearly twice that of the typical non-financial firm (e.g., 3.982 is compared with 1.529). According to Table 7.3,

[117] The average values of the two sub-sectors' indices are utilised since this chapter aims to examine the general impact of sectoral variables on credit risk correlations.

[118] iTraxx index family contains various CDS indices ranging over different credit ratings and geographically locations. This specific index is selected because it covers the full sample period and is on-the-run till now.

firms in the financial sector have a higher gearing ratio, but a lower level of profitability and a lower level of operating efficiency than their counterparts in the non-financial sector. As expected, financial institutions have higher debt-to-equity ratios and larger current ratios because of the lending activities that they engage in and the regulatory requirements that they must comply with (Said and Tumin, 2011).

Thirdly, the relatively low average value of financial firms' PE ratios suggests that investors view these companies' shares as relatively low risk with stable earnings; by contrast, the relatively high average PE ratio for firms in the non-financial sector implies relatively good growth prospects for the future.[119] These views are confirmed by the other market-based ratios; according to the data in Table 7.3, financial firms in Asia have higher dividend yields over the period of analysis with slightly higher levels of equity volatility than non-financial entities (e.g., 0.030 is compared with 0.021, and 0.267 is compared with 0.258). The stable growth of the Asian non-financial sector also is evidenced by the lower credit risk correlations of the non-financial sector than those of the financial sector in Table 7.2. Overall, the summary statistics shown in Table 7.3 suggest that changes of information from firm-level indicators may have impacts on credit risk correlations and a pattern of sectoral effects may emerge.

Fourthly, the performances of financial firms are less homogeneous for the sample; the firm-level variables have higher standard deviation values for the financial sector indicating that the differences in size and financial ratios vary more across financial firms. Finally, the CDS composite indices for the Japanese financial sector and non-financial sector varied across similar ranges during the years 2009 to 2015; their minima

[119] The maximum value of the P/E ratio is reported by Keikyu Corporation from Japanese non-financial sector for the year of 2013. The willingness of investors to pay such a high price relative to reported earnings may be due to the explosive growth of its leisure service revenues, which increased by 502.4% compared with 2012. In addition, its earnings per share increased more than two times from 2012 to 2013 (i.e., JPY7.47 is compared JPY15.40) (Keikyu Corporation, 2013).

and maxima were not too different. The VIX index peaked at 0.315 in 2009 when the S&P500 return was relatively low at -0.252. Due to the euro debt crisis, the spread for the *iTraxx* index was high in 2012 peaking at as 440.733bps.

Figure 7.2 plots the time-series variations of the seven macroeconomic variables from the 2009 to 2015. What stands out in the figure is that the performance of the Asian economies was quite volatile in the beginning of the sample period; for example, the real GDP growth rates of Japan and Malaysia were negative in 2009. In addition, the Japanese debt-to-GDP rate was the highest among the five Asian economies followed by Singapore. Further, the exports-to-GDP ratio and the bills-to-bonds ratio were highest in Singapore; this is not surprising because Singapore is in one of the most important shipping lanes in the world (Qu *et al.*, 2012) and trading in short-term debt securities dominated the Singaporean debt market.[120]

7.3.2 Methods

Under the assumptions of classical CDS models, default risk depends on the stochastic process underpinning firm value and the capital structure of the firm. Extending this idea to a simple pair-wise correlation between two firms, correlated default risk depends on the joint stochastic process followed by the assets of the two firms. Therefore, credit risk correlations could be explained though various factors that affect this joint stochastic process. However, it is difficult to measure the joint stochastic process between the two different firms' assets because each individual firm has its own set of firm-level data. Inspired by financial network theories, 'distance' for a given firm-level variable between two entities is employed in the current chapter. Distance denoted by $|D_X|$ is defined as the absolute difference in value of a given variable X for a pair of firms; this

[120] Statistics for the Asian debt markets from Mohanty (2002) have emphasised the importance of 3-month government bonds in this country.

setting not only simplifies the regression inputs but also provides a standardised measure of the relationship between a pair of firms based on the same underlying indicator. A random effects panel regression model is employed in this chapter.[121] In particular, the chapter first examines pair-wise domestic correlations (two firms from the same country) for the whole sample using equation (7.2) as follows:

$$\rho_{ij,t}^{ALL,C_i} = \alpha_1 + \alpha_2 Sector_{NF} + \alpha_3 Sector_{(F:NF)} + \beta_1 \left|D_{SIZE}{}_{(i,j),t}^{ALL,C_i}\right| + \beta_2 \left|D_{ROE}{}_{(i,j),t}^{ALL,C_i}\right| + \beta_3 \left|D_{DE}{}_{(i,j),t}^{ALL,C_i}\right| + \beta_4 \left|D_{CR}{}_{(i,j),t}^{ALL,C_i}\right| + \beta_5 \left|D_{ATR}{}_{(i,j),t}^{ALL,C_i}\right| + \beta_6 \left|D_{PE}{}_{(i,j),t}^{ALL,C_i}\right| + \beta_7 \left|D_{DY}{}_{(i,j),t}^{ALL,C_i}\right| + \beta_8 \left|D_{VOL}{}_{(i,j),t}^{ALL,C_i}\right| + \gamma_1 \Delta GDPg_t^{C_i} + \gamma_2 \Delta IR_t^{C_i} + \gamma_3 \Delta DTG_t^{C_i} + \gamma_4 \Delta UER_t^{C_i} + \gamma_5 \Delta EXP_t^{C_i} + \gamma_6 \Delta BDT_t^{C_i} + \gamma_7 \Delta BTB_t^{C_i} + \delta_1 \Delta CDS_t{}^{F,JP} + \delta_2 \Delta CDS_t{}^{NF,JP} + \vartheta_1 S\&P500_t + \vartheta_2 \Delta VIX_t + \vartheta_3 \Delta iTraxx_t + \vartheta_4 \Delta \mathrm{Slope}_t + \omega_{z,t}^1 \qquad (7.2)$$

where $\omega_{z,t}^1$ is the error term for equation (7.2) which is allowed to vary over time and cross-sectionally. Equation (7.2) models the average effects of various variables on domestic credit risk correlations while the two dummy variables $Sector_{NF}$ and $Sector_{F:NF}$ are introduced to capture (i) the difference in credit risk correlations in the two sectors and (ii) the difference between intra-sectoral and cross-sectoral credit risk correlations, respectively. $Sector_{NF}$ takes the value of 1 for any correlations within the non-financial sector and zero otherwise. Similarly, $Sector_{(F:NF)}$ takes the value of 1 for any correlations of the cross-sector sub-group. If the coefficients of the dummy variables are statistically significant, it suggests that sectoral-effects are present in the correlation data. In addition to the dummy variables, the absolute difference of firm-level variables are employed as firm-level explanatory factors; for example, $\left|D_{SIZE}{}_{(i,j),t}^{ALL,C_i}\right|$ is the absolute difference of size between firm *i* and firm *j*. By contrast, the change in each individual domestic macroeconomic, regional and global variable is utilised to examine the

[121] Fixed-effects models were rejected in favour of random effects models based on the results from the Hausman test.

relationship between the country, regional and global risks and credit risk correlation; the only exception to this generalisation relates to the measurement of global stock market performances since the return of the S&P500 is already in first-difference format.

To facilitate an examination of the difference in the ability of the independent variables to explain the three sets of correlations, equation (7.3) is estimated separately for three dependent variables: $\rho_{ij,t}^{F,C_{i,j}}$, $\rho_{ij,t}^{NF,C_{i,j}}$ and $\rho_{ij,t}^{F:NF,C_{i,j}}$,

$$\rho_{ij,t}^{S_{i,j},C_i} = \alpha + \beta_1 \left|D_{SIZE}{}_{(i,j),t}^{S_{i,j},C_i}\right| + \beta_2 \left|D_{ROE}{}_{(i,j),t}^{S_{i,j},C_i}\right| + \beta_3 \left|D_{DE}{}_{(i,j),t}^{S_{i,j},C_i}\right| + \beta_4 \left|D_{CR}{}_{(i,j),t}^{S_{i,j},C_i}\right| + \beta_5 \left|D_{ATR}{}_{(i,j),t}^{S_{i,j},C_i}\right| + \beta_6 \left|D_{PE}{}_{(i,j),t}^{S_{i,j},C_i}\right| + \beta_7 \left|D_{DY}{}_{(i,j)}^{S_{i,j},C_i}\right| + \beta_8 \left|D_{VOL}{}_{(i,j),t}^{S_{i,j},C_i}\right| + \gamma_1 \Delta GDPg_t^{C_i} + \gamma_2 \Delta IR_t^{C_i} + \gamma_3 \Delta DTG_t^{C_i} + \gamma_4 \Delta UER_t^{C_i} + \gamma_5 \Delta EXP_t^{C_i} + \gamma_6 \Delta BDT_t^{C_i} + \gamma_7 \Delta BTB_t^{C_i} + \delta_1 \Delta CDS_t^{F,JP} + \delta_2 \Delta CDS_t^{NF,JP} + \vartheta_1 S\&P500_t + \vartheta_2 \Delta VIX_t + \vartheta_3 \Delta iTraxx_t + \vartheta_4 \Delta \text{Slope}_t + \omega_{z,t}^2 \quad (7.3)$$

where, $\omega_{z,t}^2$ is error term for equation (7.3).

Cross-country correlations (two firms from different countries) are then examined using equation (7.4) and equation (7.5) is employed for each of the different sub-groups. Equation (7.4) and equation (7.5) can be expressed as follows:

$$\rho_{ij,t}^{ALL,C_{i,j}} = \alpha_1 + \alpha_2 Sector_{NF} + \alpha_3 Sector_{(F:NF)} + \beta_1 \left|D_{SIZE}{}_{(i,j),t}^{ALL,C_{i,j}}\right| + \beta_2 \left|D_{ROE}{}_{(i,j),t}^{ALL,C_{i,j}}\right| + \beta_3 \left|D_{DE}{}_{(i,j),t}^{ALL,C_{i,j}}\right| + \beta_4 \left|D_{CR}{}_{(i,j),t}^{ALL,C_{i,j}}\right| + \beta_5 \left|D_{ATR}{}_{(i,j),t}^{ALL,C_{i,j}}\right| + \beta_6 \left|D_{PE}{}_{(i,j),t}^{ALL,C_{i,j}}\right| + \beta_7 \left|D_{DY}{}_{(i,j),t}^{ALL,C_{i,j}}\right| + \beta_8 \left|D_{VOL}{}_{(i,j),t}^{ALL,C_{i,j}}\right| + \gamma_1 \left|D_{GDP}{}_{g,t}^{C_{i,j}}\right| + \gamma_2 \left|D_{IR_t}{}^{C_{i,j}}\right| + \gamma_3 \left|D_{DTG_t}{}^{C_{i,j}}\right| + \gamma_4 \left|D_{UER_t}{}^{C_{i,j}}\right| + \gamma_5 \left|D_{EXP_t}{}^{C_{i,j}}\right| + \gamma_6 \left|D_{BDT_t}{}^{C_{i,j}}\right| + \gamma_7 \left|D_{BTB_t}{}^{C_{i,j}}\right| + \delta_1 \Delta CDS_t{}^{F,JP} + \delta_2 \Delta CDS_t{}^{NF,JP} + \vartheta_1 S\&P500_t + \vartheta_2 \Delta VIX_t + \vartheta_3 \Delta iTraxx_t + \vartheta_4 \Delta \text{Slope}_t + \omega_{z,t}^3 \quad (7.4)$$

$$\rho_{ij,t}^{S_{i,j},C_{i,j}} = \alpha + \beta_1 \left|D_{SIZE}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right| + \beta_2 \left|D_{ROE}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right| + \beta_3 \left|D_{DE}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right| + \beta_4 \left|D_{CR}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right| + \beta_5 \left|D_{ATR}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right| + \beta_6 \left|D_{PE}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right| + \beta_7 \left|D_{DY}{}_{(i,j)}^{S_{i,j},C_{i,j}}\right| + \beta_8 \left|D_{VOL}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right| + \gamma_1 \left|D_{GDP}{}_{g,t}^{C_{i,j}}\right| + \gamma_2 \left|D_{IR_t}{}^{C_{i,j}}\right| + \gamma_3 \left|D_{DTG_t}{}^{C_{i,j}}\right| + \gamma_4 \left|D_{UER_t}{}^{C_{i,j}}\right| + \gamma_5 \left|D_{EXP_t}{}^{C_{i,j}}\right| + \gamma_6 \left|D_{BDT_t}{}^{C_{i,j}}\right| + \gamma_7 \left|D_{BTB_t}{}^{C_{i,j}}\right| + \delta_1 \Delta CDS_t^{F,JP} + \delta_2 \Delta CDS_t^{NF,JP} + \vartheta_1 S\&P500_t + \vartheta_2 \Delta VIX_t + \vartheta_3 \Delta iTraxx_t + \vartheta_4 \Delta \text{Slope}_t + \omega_{z,t}^4 \quad (7.5)$$

where, $\omega_{z,t}^3$ and $\omega_{z,t}^4$ are error terms for equation (7.4) and equation (7.5), respectively. In particular, equation (7.4) and equation (7.5) use the absolute difference of a given macroeconomic variable between country *i* and county *j* to measure the effects of country distances on cross-country credit risk correlations.

Descriptive statistics for the right-hand-side explanatory variables are presented in Table 7.4. Eight firm-level variables are outlined in panel A of this table; the first is the 'distance' in size for a pair of firms - $|D_{Size}|$. This is given by the absolute difference in the value of the natural logarithm of total assets between two firms. The thinking behind this measure is as follows: large firms have a sizeable amount of total assets and are less likely to default on their debts; if the firm gets into difficulty, the assets can be sold to cover the debt repayments. By contrast, smaller firms have fewer assets and a greater chance of default in the event of some adverse outcome. Consequently, credit risk correlation between the two entities with a large size differential (where one is relatively big and the other is not) may be low.

However, there may be a positive association between the credit risk correlation and the size differential. Default risk for a large firm may be positively correlated with that of a small firm if they trade with each other; an initial credit shock in one firm may be transmitted to a different sized firm if it is a supplier or customer of the first company. As a result, the information channel may link two different sized firms giving a positive association between $|D_{Size}|$ and their credit risk correlation. The sign of the size differential may therefore be positive or negative in equations 7.2 to 7.5. Similar arguments can be deployed to predict the sign on the other firm-level variables being considered. The return on equity (ROE) that a firm earns and equity volatility (VOL) depend on the stochastic process generating firm value. Firms with a high ROE and low levels of profit volatility tend to have a low probability of defaulting; since debt holders rank above equity holders when it comes to the repayment of funds in the event of financial distress and since debt holders must be paid any interest owed before dividends

Table 7.4: Description of explanatory variables

Variable	Description	Predicted Sign
Panel A: Firm differences		
$\left\lvert D_{SIZE\,(i,j),t}^{\;S_{i,j},C_{i,j}}\right\rvert$	Absolute difference in value of the firm size (SIZE) for a pair of firms	+/-
$\left\lvert D_{ROE\,(i,j),t}^{\;S_{i,j},C_{i,j}}\right\rvert$	Absolute difference in value of the return of equity (ROE)	+/-
$\left\lvert D_{CR\,(i,j),t}^{\;S_{i,j},C_{i,j}}\right\rvert$	Absolute difference in value of the current ratios (CR)	+/-
$\left\lvert D_{DE\,(i,j),t}^{\;S_{i,j},C_{i,j}}\right\rvert$	Absolute difference in value of the debt-to-equity (DE) ratios	+/-
$\left\lvert D_{ATR\,(i,j),t}^{\;S_{i,j},C_{i,j}}\right\rvert$	Absolute difference in value of the total asset turnover (ATR) ratios	-
$\left\lvert D_{PE\,(i,j),t}^{\;S_{i,j},C_{i,j}}\right\rvert$	Absolute difference in value of the price-earnings (PE) ratio	-
$\left\lvert D_{DY\,(i,j),t}^{\;S_{i,j},C_{i,j}}\right\rvert$	Absolute difference in value of the dividend yields (DY)	-
$\left\lvert D_{VOL\,(i,j),t}^{\;S_{i,j},C_{i,j}}\right\rvert$	Absolute difference in value of the stock volatility (VOL)	+/-
Panel B1: Country economic risk		
$\Delta GDPg_t^{C_i}$	Change in real GDP growth rates for country *i* at time *t*	-
$\Delta IR_t^{C_i}$	Change in inflation (IR) rates	-
$\Delta DTG_t^{C_i}$	Change in debt-to-GDP (DTG) ratios	+
$\Delta UER_t^{C_i}$	Change in unemployment (UER) rates	+
$\Delta EXP_t^{C_i}$	Change in ratios of exports (EXP) to GDP	-
$\Delta BDT_t^{C_i}$	Change in government bonds turnover (BDT) ratios	-
$\Delta BTB_t^{C_i}$	Change in bills-to-bonds (BTB) ratios	-
Panel B2: Country differences		
$\left\lvert D_{GDP\,g,t}^{\;C_{i,j}}\right\rvert$	Absolute difference in real GDP growth rates for a pair of countries	+/-
$\left\lvert D_{IR\,t}^{\;C_{i,j}}\right\rvert$	Absolute difference in inflation (IR) rates	+/-
$\left\lvert D_{DTG\,t}^{\;C_{i,j}}\right\rvert$	Absolute difference in debt-to-GDP (DTG) ratios	-
$\left\lvert D_{UER\,t}^{\;C_{i,j}}\right\rvert$	Absolute difference in unemployment (UER) rates	+/-
$\left\lvert D_{EXP\,t}^{\;C_{i,j}}\right\rvert$	Absolute difference in ratios of exports (EXP) to GDP	+/-
$\left\lvert D_{BDT\,t}^{\;C_{i,j}}\right\rvert$	Absolute difference in government bonds turnover (BDT) ratios	+/-
$\left\lvert D_{BTB\,t}^{\;C_{i,j}}\right\rvert$	Absolute difference in bills-to-bonds (BTB) ratios	+/-
Panel C: Regional credit risk		
$\Delta CDS_t^{F,JP}$	Spread changes of 5-year CDS index for Japan financial sector	+/-
$\Delta CDS_t^{NF,JP}$	Spread changes of 5-year CDS index for Japan non-financial sector.	+/-
Panel D: Global market risk		
$S\&P500_t$	Return of S&P500	-
ΔVIX_t	Change in implied volatility of S&P500	+/-
$\Delta iTraxx_t$	Change in iTraxx 5-year European sovereign index	+/-
ΔSlope_t	Change in difference in US Treasury yields between 10-year and 2-year maturities	+/ -

Note: This table presents the definitions for the independent variables used in this study. Predicted signs of the associated coefficients are presented in the last column of the table. An '+' indicates a positive relationship is expected between the credit risk correlations and the independent variable while an '-'indicates that a negative relationship is expected.

are paid out to the owners, default risk will be low when ROE (VOL) is high (low). Accordingly, the association between the difference in two firms' ROE and credit risk correlation should be negative. However, the correlation between the default risk of two firms with different ROEs and different volatilities may be high if credit risk spillovers are present, the coefficient for differences in ROE and VOL may also be positive.[122] Thus, the coefficients for $|D_{ROE}|$ and $|D_{VOL}|$ may be positive or negative.

A firm's debt-to-equity ratio measures a company's indebtedness; companies with significantly less debt than equity are not highly geared and have a lower default risk since their interest payments are smaller and their repayment schedules less onerous. Again, as the distance between two firms' debt-to-equity ratios increases (where one is relatively highly geared and the other not), the correlation between their credit risks should be lower because they have different likelihoods of default; according to this line of argument, a negative relationship should exist between the two variables. However, default risk of financial firms is often linked to the survival of non-financial companies since banks rely on the non-financial firms repaying their loans in order to ensure their own survival. Therefore, debt tends to link the two sectors since default by a non-financial firm on its loans may impact on the performance (and survival) of the bank lending the funds. As a result, a large distance in the leverage ratios between a financial institution and a non-financial firm may associate with high credit risk correlation. Thus, the sign for the leverage measure may be positive or negative depending on the firm pairing being considered.

The difference in the current ratio ($|D_{CR}|$) between two firms is also included as an explanatory variable in the analysis. This factor is particularly important for correlations

[122] Campbell and Taksler (2003) and Campbell *et al.* (2001) have evidenced an upward tendency of all firm-level volatilities when risk is similar.

among 1-year CDS spread changes since it indicates whether or not a company repay its short-term obligations from current assets. The sign on the coefficient for $|D_{CR}|$ could be negative since the greater the distance, the smaller the likelihood that both firms will suffer from liquidity problems at the same time and default on their short-term loans. However, a liquidity shock for one illiquid firm may impact on the liquidity of another company even though it has a higher CR ratio as investors re-appraise all of the investments in their portfolios. Therefore, the relationship between $|D_{CR}|$ and credit risk correlation may either be positive or negative. Finally, the distance in asset turnover ratio ($|D_{ATR}|$) measures whether efficiency levels in two firms are similar or different. Again, a negative sign is predicted since if this distance measure is large, the two firms will be operating at different levels of efficiency and hence will have different default probabilities. This variable will probably be more important for intra-sectoral credit risk correlations involving NF entities.

With regard to firm's market performance indicators, the distance in PE ratios for a pair of firms may indicate that the two are expected to grow at different rates in the future or to experience different levels of risk. A negative relationship is therefore expected between the distance in PE ratios and credit risk correlations since the two firms have different risk levels (Rajan, 2006). Similarly, a negative relationship is expected between the distance in dividend yields for a pair of firms and their credit risk correlations.

The second panel of Table 7.4 presents country-level variables investigated in an attempt to explain the effects of economic risk and local debt market development on correlation in CDS spread changes. In particular, Panel B1 presents the country-level input variables used to explain domestic credit risk correlations in equation (7.2) and equation (7.3) (e.g., a change in a given macroeconomic variable, denoted by $\Delta X_t^{C_i}$). Panel B2 notes the country-level input variables which measure economic differences between the two countries where considered firms are located. These differences may impact on cross-country credit risk correlations according to the estimates of equation (7.4) and equation (7.5) (e.g., the absolute difference between two countries' macroeconomic indicators is denoted by $\left|D_{X_t}^{C_{i,j}}\right|$).

Beginning with the underlying factors, the main macroeconomic variables of interested are the debt-to-GDP ratio (DTG) and the exports-to-GDP (EXP) ratio. The debt-to-GDP ratio has been shown to be particularly important in past studies for US and European countries since a number of investigations (Bernoth *et al.*, 2004; De Bruyckere *et al.*, 2013) have emphasised the importance of this ratio in determining a country's sovereign rating; a high debt-to-GDP ratio indicates a high risk of default by a particular nation because the higher level of debt has a negative impact on economic activity. Therefore, a positive sign is predicted for the $\Delta DTG_t^{C_i}$ variable in Panel B1 since an increase of DTG ratio is associated with an increase of credit risk of domestic sovereign debtor and this may potentially lead to the increase of overall default risk of all firms in the country. By contrast, exports (as a % of GDP) are generally found to be insignificant in most studies of credit risk correlations for developed countries; but this variable may have an impact on credit risk correlations in Asian countries because of their export-driven economies.[123] Therefore, a negative sign is predicted for $\Delta EXP_t^{C_i}$; an increase in exports is associate with a potential increase of economic growth for Asian countries. In line with prior studies (Couderc and Renault, 2008; Duffie *et al.*, 2007), factors such as the real GDP growth rate, the inflation rate and the unemployment rate are also used to capture variations in macroeconomic conditions (and hence in default likelihoods). Since

[123] For example, China and Japan have accounted for 15% of the world exports in 2008 (Eaton *et al.* 2010). Specifically, as the literature review in section 7.2 highlighted, trade finance may create a potential transmission channel for credit risk among exporting firms. Furthermore, since financial institutions provide funding to exporters, a credit risk link may exist between banks and exporters (Moser *et al.* 2008).

evidence (Gilchrist *et al*., 2009; Gilchrist and Zakrajšek, 2012; Tang and Yan, 2010) indicates that credit spreads increase during economic downturns and decrease during upturns in the economic cycle, these variables are included in equations 7.2 to 7.5. A negative relationship is predicted for the effects of $\Delta GDP_{g,t}^{C_i}$ and $\Delta IR_t^{C_i}$ on domestic credit risk correlations while a change in unemployment rate is expected to be positively associated with domestic credit risk correlations (Bai, 2015; EI Kalak and Hudson, 2016).[124]

The characteristics of a country's underlying bond market are also included in the current analysis because the development of credit derivatives allows market investors to hedge and insure themselves against the risk of default in their bond and loan portfolios (De Teran, 2005). Therefore, the government bond turnover ratio and bills-to-bonds ratio are utilized in the analysis of this chapter. For example, the bond turnover ratio measures the liquidity of underlying bond market; thus, the higher the turnover ratio, the more active the secondary market is, suggesting a low demand for credit risk protection and a lower credit risk correlation. The total bills-to-bonds ratio is the ratio of total government bills outstanding to total government bonds outstanding; a high ratio suggests a high sensitivity to interest rate changes (since a lot of Government debt is short term) which is associated with interest rate risk. Therefore a high credit risk is expected within a given nation when this ratio is high.

Panel B2 of the table lists the country-level variables included in the analysis of regional credit risk correlations (Equation (7.4) and Equation (7.5)). Firms which hold

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[124] Bai (2015) combined credit risk with unemployment rates in his analysis by assuming that 'the only assets firms own are their relationship with workers'. According to his analysis, in an economic recession the value of an employment relationship is low and employers allocate less resources to recruit new employees; thus, the labour market is depressed leading to an increase in unemployment rates. Similarly, when the employment relationship is valued less by many firms, 'the only assets firms own' are undervalue. This leads to a decrease of firms' assets back and an increase of their credit risk together. Thus, high overall unemployment rate may be associated with a high credit risk correlation between firms.

debts in a low debt-to-GDP ratio country may not react to a credit risk shock for another firm in high debt-to-GDP country as any spillover is likely to be small; a big difference in two countries' debt-to-GDP ratios, therefore, is thought to be associated with low credit risk correlations. A similar argument can be deployed for all of these variables in Panel B2 of Table 7.4; the bigger the difference between two countries' economies, the less likely it is that the credit risk of a firm in one country will be correlated with the credit risk of a firm in another country because credit risk is related more to the economic circumstances of the country where a firm is located. However, the liquidity channel argument and the information channel approach would suggest that a rise in the default risk for a firm in one country may have implications for the default risk of another firm from a different country within the region; in this case, credit risk correlation between two countries could be high since a shock of credit risk from one country can decrease investors' willingness to bearing risk. In addition, the absolute difference in the two variables, which measures the difference in bond market activity of two countries, may have a positive or negative association with regional credit risk correlations.

Panel C and panel D in Table 7.4 show regional and global variables included in this investigation, respectively. The effects of changes in the Japanese financial sector index and the effects of changes in the Japanese non-financial sector index are expected to be positively associated with credit risk correlations for pairs of entities within Asia. Prior studies such as Tölö *et al.* (2017) and Galariotis *et al.* (2016) have identified that the iTraxx index is one of the most important factors for explaining the credit risk (and presumably, the credit risk correlations) of firms. In addition, Miyakawa and Watanabe (2014) have highlighted the significant role of the Japanese CDS index as an indicator of implied correlated default because the index provides a measure of the overall price of credit protection in Asia. By contrast, a negative relationship is expected between the correlation among CDS spread changes and the return of the S&P500 index; lower equity returns may indicate an economic downturn which raise the possibility of default among all stock market participants (Byström, 2005; Fung *et al.*, 2008). Also, higher correlations among credit spreads are expected in a period of higher volatility throughout the world's markets particularly in the US (this phenomenon occurred during a period of financial market instability in late 2008). In addition, the iTraxx CDS index is comprised of the most liquid corporate CDSs in Europe. Therefore, an increase in the iTraxx CDS index which reflects higher credit risk in Europe is predicted to be associated with higher credit risk correlation between a pair of the entities included in the current sample. The last variable used in the analysis is the change in the slope of the yield curve; this slope is the difference between 10-year and 2-year US Treasury bond yields from 2009 to 2015. This measure is expected to be negatively associated with credit risk correlations in line with the evidence from Collin-Dufresne *et al.* (2001) .

7.4 Empirical findings

Discussion of the results in the current chapter is split into two sub-sections: 1) the associations between the explanatory variables and the correlations in 1-year CDS spread changes and 2) robustness checks with correlations data for 5-year CDS spread changes. The results for equations (7.2) to (7.5) which examine the association between correlations among spread changes and the set of independent variables drawn from firm-level, country-level, regional-level and global-level data are discussed in both sub-sections. For each equation, four models are estimated. Model 1 examines the effects of firm-level variables while model 2 investigates the effects of country-level variables. Model 3 adds regional-variables to model 2 while model 4 contains all of the independent variables including the firm-, regional- and global-level variables. To maintain a level of consistency throughout the whole thesis, discussion of the estimation results begins with an analysis of findings about domestic credit risk correlations (involving a pair of firms from the same country). Results for cross-country credit risk correlations (involving a pair of firms from two different countries) then follows. An LR test is used to compare a restricted (e.g., model 1, model 2 and model 3) with an unrestricted model (e.g., model 4). If the associated chi-square test statistic is larger than the critical value at the 5% significance level for the unrestricted model, then the restricted model is rejected in favour of the unrestricted alternative.

7.4.1 Effects of variables on 1-year CDS spread changes correlations

7.4.1.1 Domestic correlations

Results from equation (7.2) for four models (labelled (1), (2), (3) and (4)) are reported in four columns of Table 7.5. For each of these columns, the dependent variable is the credit risk correlations among all pairs of entities. The first column in Table 7.5 lists the explanatory variables included in the different models. A dummy variable ($Sector_{NF}$) is included in all four models for equation (7.2) and equation (7.3) to take account of any differences in correlation between the financial and non-financial sectors. A second dummy variable ($Sector_{F:NF}$) in each of the models is included to examine whether the correlations for pairs of firms drawn from across the F and NF sectors are different from their within-sector counterparts. The second column lists the predicted signs of the independent variables based on the discussion in the previous section of the current chapter. Summary information for each model (the number of observations, the adjusted R^2, the log likelihood value and the Chi-square statistics for the LR test) are provided in the final four rows of the table.

The results of Table 7.5 suggest that a limited number of variables included in the investigation are associated with domestic credit risk correlations. An inspection of statistics from the LR tests reveals that model 4 performs better than model 1, model 2

Table 7.5: The aggregate effects of variables on short-term domestic correlations

	Sign	(1) $\rho_{ij,t}^{ALL,C_i}$	(2) $\rho_{ij,t}^{ALL,C_i}$	(3) $\rho_{ij,t}^{ALL,C_i}$	(4) $\rho_{ij,t}^{ALL,C_i}$
Intercept	+	0.186**	0.155**	0.162**	0.192**
		(0.05)	(0.049)	(0.049)	(0.049)
$Sector_{NF}$	-	0.114**	0.121**	0.121**	0.121**
		(0.049)	(0.049)	(0.049)	(0.049)
$Sector_{F:NF}$	-	0.021	-0.004	-0.004	0.023
		(0.053)	(0.050)	(0.050)	(0.053)
Panel A: Firm differences					
$\left\|D_{SIZE}{}_{(i,j),t}^{ALL,C_i}\right\|$	+/-	-0.001			-0.001
		(0.001)			(0.001)
$\left\|D_{ROE}{}_{(i,j),t}^{ALL,C_i}\right\|$	+/-	-0.032**			-0.034**
		(0.013)			(0.013)
$\left\|D_{CR}{}_{(i,j),t}^{ALL,C_i}\right\|$	+/-	-0.007**			-0.007**
		(0.001)			(0.001)
$\left\|D_{DE}{}_{(i,j),t}^{ALL,C_i}\right\|$	+/-	0.000			0.001
		(0.001)			(0.001)
$\left\|D_{ATR}{}_{(i,j),t}^{ALL,C_i}\right\|$	-	-0.019**			-0.019**
		(0.006)			(0.006)
$\left\|D_{PE}{}_{(i,j),t}^{ALL,C_i}\right\|$	-	-0.107**			-0.106**
		(0.031)			(0.031)
$\left\|D_{DY}{}_{(i,j),t}^{ALL,C_i}\right\|$	-	0.004			0.004
		(0.002)			(0.002)
$\left\|D_{VOL}{}_{(i,j),t}^{ALL,C_i}\right\|$	+/-	-0.003			-0.006
		(0.006)			(0.006)
Panel B: Country economic risk					
$\Delta GDPg_t^{C_i}$	-		-0.061	-0.022	-0.070
			(0.109)	(0.132)	(0.133)
$\Delta IR_t^{C_i}$	-		-0.296	-0.251	-0.408
			(0.311)	(0.259)	(0.404)
$\Delta DTG_t^{C_i}$	+		-0.238**	-0.241**	-0.228**
			(0.071)	(0.074)	(0.074)
$\Delta UER_t^{C_i}$	+		-0.362	-0.642	-0.272
			(0.421)	(0.813)	(0.433)
$\Delta EXP_t^{C_i}$	-		-0.183**	-0.199**	-0.143
			(0.092)	(0.095)	(0.094)
$\Delta BDT_t^{C_i}$	-		-0.114	-0.115**	-0.107**
			(0.017)	(0.018)	(0.018)
$\Delta BTB_t^{C_i}$	-		-0.012	-0.023	0.005
			(0.063)	(0.064)	(0.064)
Panel C: Regional credit risk					
$\Delta CDS_t^{F,JP}$	+/-			0.072**	0.064**
				(0.028)	(0.028)
$\Delta CDS_t^{F,JP}$	+/-			-0.068**	-0.067**
				(0.02)	(0.02)
Panel D: Global market risk					
$S\&P500_t$	-			-0.119	-0.130**
				(0.061)	(0.061)
ΔVIX_t	+/-			-0.021	-0.014
				(0.023)	(0.023)
$\Delta iTraxx_t$	+/-			0.0001	0.0001
				(0.0001)	(0.0001)
$\Delta Slope_t$	+/-			-0.0003	-0.0004
				(0.001)	(0.001)
Observations		13,391	13,391	13,391	13,391
Adjusted R^2		0.82	0.82	0.82	0.82
Log likelihood		7085.33	7031.51	7012.04	7121.23
LR tests		71.794	179.44	218.37	

Note: Robust standard errors are reported in parentheses. ** denotes significance at 5%

Table 7.6: The effects of variables on short-term domestic correlations, by sectors

	Sign	(1)			(2)			(3)			(4)		
		$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$	$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$	$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$	$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$
Intercept	+	0.103**	0.153**	0.292**	0.137**	0.145**	0.3**	0.127**	0.228**	0.333**	0.07**	0.103**	0.153**
		(0.045)	(0.014)	(0.029)	(0.031)	(0.018)	(0.012)	(0.033)	(0.012)	(0.011)	(0.048)	(0.013)	(0.029)
Panel A: Firm differences													
$\left\lvert D_{SIZE}{}_{(i,j),t}^{S_{i,j},C_i}\right\rvert$	+/-	-0.023	-0.006	0.004**							-0.020	-0.023	0.005**
		(0.012)	(0.021)	(0.002)							(0.012)	(0.022)	(0.002)
$\left\lvert D_{ROE}{}_{(i,j),t}^{S_{i,j},C_i}\right\rvert$	+/-	-0.02**	-0.002	-0.045**							-0.100	0.057**	-0.054**
		(0.065)	(0.024)	(0.016)							(0.064)	(0.024)	(0.016)
$\left\lvert D_{CR}{}_{(i,j),t}^{S_{i,j},C_i}\right\rvert$	+/-	-0.084	0.046	-0.004**							0.001	0.008**	-0.004**
		(0.003)	(0.004)	(0.002)							(0.004)	(0.004)	(0.002)
$\left\lvert D_{DE}{}_{(i,j),t}^{S_{i,j},C_i}\right\rvert$	+/-	0.001	0.009**	0.000							-0.021**	0.015	0.001
		(0.008)	(0.021)	(0.002)							(0.007)	(0.022)	(0.002)
$\left\lvert D_{ATR}{}_{(i,j),t}^{S_{i,j},C_i}\right\rvert$	-	-0.465	-0.020**	-0.027**							-0.457**	-0.02**	-0.026**
		(0.239)	(0.007)	(0.013)							(0.229)	(0.007)	(0.012)
$\left\lvert D_{PE}{}_{(i,j),t}^{S_{i,j},C_i}\right\rvert$	-	0.045**	0.0001	0.081							0.042	0.0001	0.095
		(0.021)	(0.003)	(0.057)							(0.022)	(0.003)	(0.057)
$\left\lvert D_{DY}{}_{(i,j),t}^{S_{i,j},C_i}\right\rvert$	-	0.076	-0.003	0.012**							0.061	-0.006	0.009
		(0.054)	(0.006)	(0.005)							(0.054)	(0.006)	(0.005)
$\left\lvert D_{VOL}{}_{(i,j),t}^{S_{i,j},C_i}\right\rvert$	+/-	0.045	-0.175**	0.001							0.030	-0.161**	0.002
		(0.195)	(0.036)	(0.012)							(0.204)	(0.036)	(0.012)
Panel B: Country economic risk													
$\Delta GDPg_t^{C_i}$	-				-0.170	0.170	0.015	-0.739	0.355	-0.212	-0.570	0.303	-0.344
					(0.395)	(0.171)	(0.148)	(0.592)	(0.192)	(0.194)	(0.582)	(0.190)	(0.200)
$\Delta IR_t^{C_i}$	-				-0.606	-0.721	-0.734	-0.619	-0.761	-0.739	-0.476	-0.748	-0.746
					(0.819)	(0.589)	(0.512)	(0.503)	(0.536)	(0.605)	(0.959)	(0.536)	(0.624)
$\Delta DTG_t^{C_i}$	+				-0.015	-0.515**	0.043	-0.097	-0.507**	0.035	-0.023	-0.532**	-0.017
					(0.254)	(0.116)	(0.09)	(0.269)	(0.119)	(0.094)	(0.271)	(0.120)	(0.098)
$\Delta UER_t^{C_i}$	+				-1.947	-1.036**	-3.850**	-4.371	-1.010**	-1.115	-1.221	1.448**	-3.122
					(4.172)	(1.696)	(1.502)	(5.118)	(1.853)	(1.783)	(4.986)	(1.826)	(1.784)
$\Delta EXP_t^{C_i}$	-				-0.177	-0.259	-0.274**	-0.309	-0.274	-0.293**	-0.393	-0.260	-0.322**
					(0.300)	(0.148)	(0.121)	(0.320)	(0.151)	(0.125)	(0.296)	(0.152)	(0.127)
$\Delta BDT_t^{C_i}$	-				-0.016	-0.178**	-0.063**	-0.035	-0.187**	-0.051	0.031	-0.179**	-0.052
					(0.076)	(0.025)	(0.025)	(0.083)	(0.026)	(0.027)	(0.078)	(0.026)	(0.027)
$\Delta BTB_t^{C_i}$	-				0.013	-0.081	-0.125	-0.038	-0.112	-0.113	-0.008	-0.089	-0.108
					(0.216)	(0.101)	(0.085)	(0.225)	(0.103)	(0.086)	(0.223)	(0.101)	(0.087)
Panel C: Regional credit risk													
$\Delta CDS_t^{F,JP}$	+/-							0.179	0.148**	0.105**	0.185	0.149**	0.113**
								(0.156)	(0.039)	(0.045)	(0.146)	(0.039)	(0.045)
$\Delta CDS_t^{F,JP}$	+/-							-0.187	-0.092**	-0.107**	-0.201	-0.099**	-0.121**
								(0.111)	(0.030)	(0.032)	(0.104)	(0.030)	(0.033)
Panel D: Global market risk													
$S\&P500_t$	-							-0.431	-0.134	-0.079	-0.372	-0.142	-0.092
								(0.265)	(0.085)	(0.091)	(0.252)	(0.084)	(0.091)
ΔVIX_t	+/-							-0.371**	-0.031	-0.135**	-0.323**	-0.034	-0.148**
								(0.127)	(0.034)	(0.036)	(0.118)	(0.034)	(0.037)
$\Delta iTraxx_t$	+/-							0.001	0.0002**	0.001	0.001	0.0002**	0.001
								(0.001)	(0.0001)	(0.001)	(0.001)	(0.0001)	(0.001)
$\Delta Slope_t$	+/-							0.003	-0.001	0.001	0.002	-0.001	0.001
								(0.004)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)
Observations		147	10,759	2,485	147	10,759	2,485	147	10,759	2,485	147	10,759	2,485
Adjusted R^2		0.52	0.83	0.57	0.48	0.83	0.58	0.48	0.83	0.58	0.50	0.84	0.58
Log likelihood		86.31	5583.7	1542.2	96.95	5511	1574	83.98	5496	1556	117.56	5697.12	1615.6
LR tests		62.51	226.81	146.86	41.22	372.05	83.10	67.16	402.03	118.44			

Note: Robust standard errors are reported in parentheses. ** denotes significance at 5%

and model 3.[125] Specifically, focusing on model 4, firm-level variables such as the$|D_{ROE}|$, $|D_{CR}|$, $|D_{ATR}|$, $|D_{PE}|$ have significant coefficients and negative signs. Their estimation signs are in line with predictions and evidence that transmission channels between companies with similar firm-level measures (and hence smaller 'distances') tend to be associated with larger correlations. In addition to the firm-level findings, changes of a country's DTG ratio and bond turnover ratio are found to be negatively correlated with domestic credit risk correlations. So lower correlation is seen in countries with high leverage and a more liquid debt market. The significance of the dummy variables confirms the importance of sub-group analysis when explaining credit risk correlations. In particular, the positive and significant coefficient of the dummy variable, $Sector_{F:NF}$, implies that differences in domestic credit risk correlations between the financial and non-financial sectors are important and the equation should be estimated separately for both groups. Therefore, the results presented in Table 7.5 highlight the need for further sub-group analysis of credit risk correlations; the findings for this sub-group analysis (equation (7.3)) are presented in Table 7.6.

Table 7.6 reports estimated coefficients for the variables when the three sets of credit risk correlations are analysed separately: $\rho_{ij,t}^{F,C_i}$ for correlations between two financial institutions in the same country; $\rho_{ij,t}^{NF,C_i}$ for the correlations between two non-financial firms in the same country; and $\rho_{ij,t}^{F:NF,C_i}$ for the correlations between a

[125] It is noticed that the common issues of omitted variable bias and redundant variables may be present in the current analysis and lead to difficulties when comparing the results. For example, when a variable is related in the data generating process to the dependent variable (i.e., here is the credit risk correlation), but is removed from the regression, an omitted variable bias would result. In contrast, if irrelevant variables are included in the model, the OLS estimators will still give unbiased and consistent coefficient estimates, but they are no longer BLUE-that is, the variance among the class of unbiased estimators is enlarged unnecessarily, and the accuracy of the estimates decline. However, as stated before, the selection of the independent variables depended on theoretical frameworks of debt pricing such as Merton's (1974) model as well as the empirical studies (Pu and Zhao, 2012) on credit risk correlations.

financial institution and a non-financial firm in the same country. The LR test statistics again confirm that from a structural perspective, model 4 is a better specification of the equation for explaining credit risk correlations. The intercept values for model 4 are positive and significant ranging from 0.070 for the F sector to 0.153 for the financial and non-financial sector. This finding is consistent with the results of Table 7.5 and suggests that financial firms are connected more with their non-financial counterparts (in terms of credit default risk) than with each other. The size effects are significant but only when the credit risk correlation relates to pairs of firms drawn from different sectors. The positive coefficient of 0.005 for the $\left|D_{SIZE}{}_{(i,j),t}^{S_{i,j},C_i}\right|$ variable is significant at the 5% level indicating that an increase in the size difference for a pair of domestic firms (where one is in the F sector and the other is located in the NF sector) is associated with higher credit risk correlation in short-term.

According to Table 7.6, differences in profitability levels are not significant in explaining credit risk correlation for pairs of firms in the F sector but are significant in explaining credit risk transmission in the non-financial and the financial with non-financial sectors. Furthermore, the estimated positive coefficient of the ROE differential for the non-financial sector implies that the credit risk correlation among non-financial firms is higher when larger differences in profitability are present. The negative significant coefficient for the volatility differential variable among the non-financial sector pairings also confirms that volatility is an important factor for explaining credit risk correlation among NF firms. Therefore, in short-term, the credit risk correlation of domestic non-financial firms is linked more with equity returns and volatilities ($|D_{ROE}|$ and $|D_{VOL}|$) while the credit risk correlation of domestic financial institutions is more associated with the leverage factor ($|D_{DE}|$). Another key finding from Table 7.6 is that credit risk correlation among pairs of domestic financial sector firms is associated with the volatility of S&P500 (i.e., VIX) but tends to be unaffected by macroeconomic condition and regional-level credit risk; this highlights the global nature of credit risk in the financial sector where firms operate in many countries and are sensitive to events that impact entities throughout the world.

7.4.1.2 Regional correlations

The results in Table 7.7 suggest that many of the variables included in the current investigation are associated with credit risk correlation for pairs of firms from different countries. An inspection of the statistics for the LR tests and the values of log likelihood ratios reveals that model 2 is the best. So the country differences are important in determining credit risk correlation. This finding is in line with the prior studies that have evidenced the importance of macroeconomic conditions in affecting the correlated default risk across countries (Bluhm *et al.*, 2016; Schwaab *et al.*, 2017).

The significance of the dummy variables in model 2 further confirms the importance of sub-group analysis when explaining credit risk correlations. In particular, the negative and significant coefficients of these dummy variables imply that regional credit risk correlations within the financial sector are higher than those within the non-financial sector and those between the financial and non-financial sectors. Therefore, the results presented in Table 7.7 confirm the need for sub-group analysis of credit risk correlations; the findings for this sub-group analysis (equation (7.5)) are presented in Table 7.8.[126]

Table 7.8 shows the estimated coefficients of the variables for the three sets of credit risk correlations ($\rho_{ij,t}^{F,C_{i,j}}$ for correlations between two financial institutions in different countries, $\rho_{ij,t}^{NF,C_{i,j}}$ for correlations between two non-financial firms in different

[126] The effects of variables are also examined on aggregate intra-sectoral credit risk correlations including correlations within the financial sector and within the non-financial sector together. The results were not very different.

countries and $\rho_{ij,t}^{F:NF,C_{i,j}}$ for correlations between a domestic financial institution and a foreign non-financial firm). The LR test statistics in Table 7.8, unlike those in Table 7.7, confirm that from a structural perspective, model 4 is the appropriate equation for examining credit risk correlations; these correlations are affected by regional and global variables as well as by firm-level and country-level measures. Positive and significant intercept values for model 4 vary from a low of 0.133 for the non-financial sector to a high of 0.304 for the financial sector. This finding is consistent with the results in Table 7.7 and suggests that financial institutions have greater linkages with each other (in terms of credit risk) possibly due to the inter-bank lending that they engage in as well as overlaps in their asset portfolios (Furfine, 2003; Mistrulli, 2011; Rochet and Tirole, 1996).

The influence of firm-level variables varies among the different sub-groups in model 4. For instance, the difference in the size of entities (|D_SIZE |) is only significant for credit risk correlations within the non-financial sector; the coefficient for this variable is insignificant for the other two sub-groups. This could be due to the fact that differences in size are more pronounced among the NF firms while most financial institutions tend to be large in terms of assets. According to Table 7.8, differences in profitability levels are significant in explaining credit risk transmission in the non-financial sector but insignificant for the financial sector. Furthermore, the estimated coefficient of 0.062 for |D_ROE | implies that a greater difference in profitability is associated with higher credit risk correlations. By contrast, the effect of liquidity differences is more important when credit risk correlations for firms within the financial sector and between the financial and non-financial sub-groupings are examined. In both cases, the positive findings suggest that as differences in liquidity

Table 7.7: The aggregate effects of variables on short-term regional correlations

	Sign	(1)	(2)	(3)	(4)
		$\rho_{ij,t}^{ALL,C_{i,j}}$	$\rho_{ij,t}^{ALL,C_{i,j}}$	$\rho_{ij,t}^{ALL,C_{i,j}}$	$\rho_{ij,t}^{ALL,C_{i,j}}$
Intercept	+	0.119**	0.209**	0.193**	0.167**
		(0.014)	(0.014)	(0.01)	(0.011)
$Sector_{NF}$	-	-0.010	-0.032**	-0.032**	-0.002
		(0.012)	(0.009)	(0.009)	(0.011)
$Sector_{F:NF}$	-	-0.028**	-0.031**	-0.031**	-0.013
		(0.010)	(0.009)	(0.009)	(0.009)
Panel A: Firm differences					
$\left\|D_{SIZE}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	-0.001**			-0.001
		(0.0001)			(0.001)
$\left\|D_{ROE}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	-0.001**			-0.001**
		(0.0001)			(0.0001)
$\left\|D_{CR}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	0.004**			0.003**
		(0.0002)			(0.0002)
$\left\|D_{DE}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	0.0001			0.001
		(0.002)			(0.001)
$\left\|D_{ATR}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	-	0.002**			0.001**
		(0.002)			(0.0002)
$\left\|D_{PE}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	-	-0.004**			-0.004**
		(0.002)			(0.0002)
$\left\|D_{DY}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	-	0.006			0.007**
		(0.003)			(0.0003)
$\left\|D_{VOL}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	0.033**			0.021
		(0.013)			(0.013)
Panel B: Country differences					
$\left\|D_{GDP}{}_{g,t}^{C_{i,j}}\right\|$	+/-		-0.003	-0.004	-0.008
			(0.037)	(0.038)	(0.038)
$\left\|D_{IR}{}_{t}^{C_{i,j}}\right\|$	+/-		-0.005**	-0.005**	-0.005**
			(0.0002)	(0.0004)	(0.0003)
$\left\|D_{DTG}{}_{t}^{C_{i,j}}\right\|$	-		-0.030**	-0.030**	-0.029**
			(0.003)	(0.003)	(0.003)
$\left\|D_{UER}{}_{t}^{C_{i,j}}\right\|$	+/-		-1.305**	-1.313**	-1.212**
			(0.227)	(0.227)	(0.228)
$\left\|D_{EXP}{}_{t}^{C_{i,j}}\right\|$	+/-		0.005	0.005	0.006
			(0.005)	(0.005)	(0.005)
$\left\|D_{BDT}{}_{t}^{C_{i,j}}\right\|$	+/-		-0.016**	-0.016**	-0.019**
			(0.005)	(0.005)	(0.005)
$\left\|D_{BTB}{}_{t}^{C_{i,j}}\right\|$	+/-		0.020**	0.020**	0.015**
			(0.006)	(0.006)	(0.006)
Panel C: Regional credit risk					
$\Delta CDS_t^{F,JP}$	+/-			0.277**	0.266**
				(0.013)	(0.013)
$\Delta CDS_t^{F,JP}$	+/-			-0.223**	-0.214**
				(0.011)	(0.011)
Panel D: Global market risk					
$S\&P500_t$	-			-0.216**	-0.210**
				(0.015)	(0.015)
ΔVIX_t	+/-			-0.217**	-0.204**
				(0.012)	(0.013)
$\Delta iTraxx_t$	+/-			-0.001**	-0.001**
				(0.0001)	(0.0001)
$\Delta Slope_t$	+/-			0.004**	0.004**
				(0.0001)	(0.0001)
Observations		19,166	19,166	19,166	19,166
Adjusted R^2		0.45	0.45	0.45	0.45
Log likelihood		16,166	16,334	16,316	16,298
LR tests		263.87	-70.99	-36.25	

Note: Robust standard errors are reported in parentheses. ** denotes significance at 5%

Table 7.8: The effects of variables on short-term regional correlations, by sectors

	Sign	(1)			(2)			(3)			(4)		
		$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$	$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$	$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$	$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$
Intercept	+	0.165**	0.088**	0.101**	0.273**	0.161**	0.184**	0.295**	0.140**	0.175**	0.304**	0.133**	0.175**
		(0.027)	(0.011)	(0.014)	(0.037)	(0.013)	(0.015)	(0.031)	(0.008)	(0.01)	(0.035)	(0.008)	(0.012)
Panel A: Firm differences													
$\left\lvert D_{SIZE\,(i,j),t}^{S_{i,j},C_{i,j}}\right\rvert$	+/-	-0.001	-0.002**	0.004							0.0001	-0.001**	0.003
		(0.005)	(0.0001)	(0.005)							(0.004)	(0.0001)	(0.005)
$\left\lvert D_{ROE\,(i,j),t}^{S_{i,j},C_{i,j}}\right\rvert$	+/-	-0.003	0.056**	-0.001**							0.0001	0.062**	-0.001**
		(0.029)	(0.019)	(0.0001)							(0.028)	(0.019)	(0.0002)
$\left\lvert D_{CR\,(i,j),t}^{S_{i,j},C_{i,j}}\right\rvert$	+/-	0.003**	0.002	0.041**							0.002**	0.0001	0.043**
		(0.0001)	(0.001)	(0.011)							(0.001)	(0.001)	(0.011)
$\left\lvert D_{DE\,(i,j),t}^{S_{i,j},C_{i,j}}\right\rvert$	+/-	-0.001	0.001	0.0001							-0.001	0.001	0.0001
		(0.004)	(0.001)	(0.001)							(0.004)	(0.001)	(0.001)
$\left\lvert D_{ATR\,(i,j),t}^{S_{i,j},C_{i,j}}\right\rvert$	-	-0.136	0.012**	0.002**							-0.118	0.005	0.001**
		(0.120)	(0.004)	(0.0001)							(0.111)	(0.004)	(0.0002)
$\left\lvert D_{PE\,(i,j),t}^{S_{i,j},C_{i,j}}\right\rvert$	-	-0.013	-0.002	-0.008**							-0.013	0.000	-0.009**
		(0.013)	(0.002)	(0.004)							(0.012)	(0.002)	(0.004)
$\left\lvert D_{DY\,(i,j),t}^{S_{i,j},C_{i,j}}\right\rvert$	-	-0.036	0.001	0.010							-0.013	0.003	0.006
		(0.019)	(0.004)	(0.005)							(0.019)	(0.004)	(0.005)
$\left\lvert D_{VOL\,(i,j),t}^{S_{i,j},C_{i,j}}\right\rvert$	+/-	-0.030	0.013	0.063**							-0.067	0.0001	0.057**
		(0.072)	(0.018)	(0.022)							(0.071)	(0.018)	(0.022)
Panel B: Country differences													
$\left\lvert D_{GDP_{g,t}}^{C_{i,j}}\right\rvert$	+/-				0.161	0.201**	-0.268**	0.114	0.202**	-0.274**	0.113	0.206**	-0.309**
					(0.192)	(0.047)	(0.063)	(0.194)	(0.048)	(0.064)	(0.192)	(0.048)	(0.065)
$\left\lvert D_{IR_t}^{C_{i,j}}\right\rvert$	+/-				-0.010**	-0.006**	-0.002**	-0.011**	-0.006**	-0.002**	-0.011**	-0.006**	-0.002**
					(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
$\left\lvert D_{DTG_t}^{C_{i,j}}\right\rvert$	-				-0.073**	-0.019**	-0.044**	-0.072**	-0.019**	-0.044**	-0.064**	-0.020**	-0.042**
					(0.014)	(0.003)	(0.004)	(0.014)	(0.003)	(0.004)	(0.014)	(0.003)	(0.004)
$\left\lvert D_{UER_t}^{C_{i,j}}\right\rvert$	+/-				-1.277	-2.503**	1.500**	-1.413	-2.509**	1.476**	-1.189	-2.548**	1.646**
					(1.209)	(0.280)	(0.394)	(1.211)	(0.281)	(0.395)	(1.261)	(0.282)	(0.398)
$\left\lvert D_{EXP_t}^{C_{i,j}}\right\rvert$	+/-				-0.076**	0.031**	-0.045**	-0.079**	0.031**	-0.045**	-0.077**	0.032**	-0.037**
					(0.026)	(0.006)	(0.008)	(0.026)	(0.006)	(0.008)	(0.026)	(0.006)	(0.008)
$\left\lvert D_{BDT_t}^{C_{i,j}}\right\rvert$	+/-				0.031	-0.029**	0.012	0.033	-0.029**	0.012	0.029	-0.029**	0.008
					(0.025)	(0.006)	(0.008)	(0.025)	(0.006)	(0.008)	(0.025)	(0.006)	(0.008)
$\left\lvert D_{BTB_t}^{C_{i,j}}\right\rvert$	+/-				0.115**	0.012	0.042**	0.121**	0.012	0.042**	0.114**	0.010	0.028**
					(0.032)	(0.008)	(0.010)	(0.032)	(0.008)	(0.010)	(0.033)	(0.008)	(0.011)
Panel C: Regional credit risk													
$\Delta CDS_t^{F,JP}$	+/-							0.557**	0.255**	0.300**	0.536**	0.249**	0.281**
								(0.062)	(0.017)	(0.021)	(0.063)	(0.017)	(0.022)
$\Delta CDS_t^{F,JP}$	+/-							-0.507**	-0.201**	-0.248**	-0.492**	-0.196**	-0.235**
								(0.052)	(0.014)	(0.018)	(0.053)	(0.014)	(0.018)
Panel D: Global market risk													
$S\&P500_t$	-							-0.692**	-0.160**	-0.287**	-0.710**	-0.151**	-0.283**
								(0.080)	(0.018)	(0.026)	(0.083)	(0.018)	(0.026)
ΔVIX_t	+/-							-0.506**	-0.188**	-0.256**	-0.495**	-0.178**	-0.233**
								(0.057)	(0.016)	(0.020)	(0.059)	(0.017)	(0.021)
$\Delta iTraxx_t$	+/-							0.0001	-0.001**	-0.001**	0.0001	-0.001**	0.0001**
								(0.001)	(0.0001)	(0.0001)	(0.001)	(0.0001)	(0.0001)
$\Delta Slope_t$	+/-							-0.002	0.006**	0.003**	-0.002	0.006**	0.002**
								(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Observations		693	11,921	6,552	693	11,921	6,552	693	11,921	6,552	693	11,921	6,552
Adjusted R^2		0.63	0.45	0.44	0.65	0.47	0.45	0.65	0.47	0.45	0.65	0.47	0.45
Log likelihood		462	10,705	5,184	495	10,885	5,261	483	10,868	5,244	535	10,946	5,329
LR tests		146.25	482.45	290.06	79.58	121.54	136.13	103.91	156.56	169.12			

Note: Robust standard errors are reported in parentheses. ** denotes significance at 5%

increase between a pair of entities, the credit risk correlation may rise. This result may be due to the distinctive linkages among financial institutions where inter-bank lending is common; when one financial institution with low levels of liquidity borrows off another with sizeable liquidity reserves, the default risk of the two firms may become more linked. The positive coefficient for the financial and non-financial cross sector correlation may also be due to the borrowing by relatively illiquid non-financial firms from relatively liquid financial institutions which increases links between the two entities; therefore, increases in liquidity differences will be associated with higher credit risk correlations. The final column of Table 7.8 also indicates that a number of firm-level variables are only significant in explaining the cross-sector correlations. Specifically, $|D_{ATR}|$, and $|D_{VOL}|$ ($|D_{PE}|$) are positively (negatively) associated with cross-sector correlations. A relatively efficient and less risky non-financial firm may borrow from a financial institution increasing the transmission between the credit risk of both entities. However, low credit risk correlation is present in the two entities with greater differences in the growth potential, consistent with (Du and Schreger, 2016; Edwards, 1983). The present results highlight the differential impact of the firm-level variables on credit risk correlation across industries. They also confirms that the sub-grouping strategy adopted in the current study was the appropriate approach to follow and provides valuable insights into the sectoral influences of firm differences on credit risk correlations.

Panel B of Table 7.8 highlights the effects of country-level variables on credit risk correlations within and between sectors. The results in this table confirm the findings reported in Table 7.7. Unlike the results in Table 7.7, all country-level factors are significant in Table 7.8 but vary according to the pairs considered. This finding not only emphasises the important roles of country-level variables in affecting regional credit risk but also evidences the need of sub-group investigations. Differences in inflation rates, debt-to-GDP ratios and exports are statistically significant at 5% level for all sub-groups. This finding is consistent with evidence from prior studies (Obstfeld *et al.*, 2009; Reinhart and Rogoff, 2010) that have highlighted the importance of a country's ability to repay debts on the willingness of creditors to lend and the interest rate charged when lending. According to these studies, therefore, differences in these macroeconomic variables impact on the credit risk correlations for firms from different countries through the lending-borrowing channel (Attinasi *et al.*, 2009). Interestingly, the estimated signs for debt-to-GDP ratios and exports vary among these three sub-groups. A negative relationship exists between the effects of debt-to-GDP and credit risk correlations for these three sub-groupings while the opposite sign is reported between the effects of exports and credit risk correlation for the NF sector. Large national differences in indebtedness is associated with lower credit risk correlation in the financial sector and lower credit risk correlation between firms in the financial and non-financial sectors from different countries. Furthermore, differences in bond turnover ratios are only significant for the credit risk correlations of non-financial firms from different countries; by contrast, differences in bills-to-bond ratios of countries are significant for the financial and the cross-sectoral sub-groups, respectively.

Results for regional variables are presented in Panel C while findings for the global variables are given in Panel D of Table 7.8. An unusual feature of the coefficients for the two regional-level variables in Panel C is that the signs are different. The effects of changes in the Japanese financial sector CDS index on credit risk correlations are positive while the effects of changes in the Japanese non-financial sector CDS index are negative. This result indicates that when default risk increases in the Japanese financial sector, credit risk correlation is higher throughout the region for the F and NF sectors and between these two sectors. The result suggests a possible domino effect in the Asian financial sector of a credit default shock in a Japanese financial institution; it also highlights the leading position of the Japanese financial sector in Asia. By contrast, when credit risk is high in Japan's non-financial sector, credit risk correlation tends to be lower across the region. This result may be due to the fact that the Asian countries considered in this thesis are all export-oriented and competitors in the global market place. Considering credit risk in a broader context, the results show that when the credit risk of European CDS index ($\Delta iTraxx$) is higher, credit risk correlation within the financial sector and between the financial and non-financial sectors in Asia increases. However, credit risk correlation within the non-financial sector decreases. Thus, some Asian non-financial firms, which are (relatively speaking) less connected to financial firms, may be safe from any spillover effect caused by a credit crisis in other regions. Moreover, the results shows that cross-country credit risk correlation in the Asian financial and non-financial sectors is higher when returns in the US equity market are low and the US market less liquid (e.g., during the 2008-09 financial crisis). As expected, credit risk correlations in the non-financial sector and between the financial and non-financial sectors are positively associated with the term structure in the global bond market; these correlations increase when the term structure's slope becomes steeper possibly due to a higher risk premium being charged.

Overall, the results from Table 7.5 to Table 7.8 provide important insights into four aspects of credit risk correlations between entities in different Asian countries. First, sectoral-effects have a statistically significant impact on both domestic and regional credit risk correlations. Domestic credit risk correlations in the non-financial sector are higher than in the financial sector, and intra-sectoral correlations are higher than the inter-sectoral correlation between the financial and non-financial firms. Second, regional credit risk correlations among financial institutions are higher than among non-financial firms and between the financial and non-financial sectors. Third, country-level variables such as the debt-to-GDP and exports as a % of GDP are important factors in determining regional credit risk for both intra-sectoral and cross-sectoral credit risk correlations in Asia. Last but not the least, information on credit risk from the Japanese financial and non-financial sectors is a key factor in credit risk linkages throughout the Asian region.

7.4.2 Robustness tests using 5-year CDSs

As a robustness check, the analysis of the current chapter also examined the effects of the same independent variables on correlations among 5-year CDS spread changes. The results of this analysis are reported in Table 7.1A to Table 7.4A for models 1 to 4.

7.4.2.1 Domestic credit risk correlations: 5-year CDSs

The results of LR test at the bottom of Table 7.1A are somewhere surprising given that model 4 is not the appropriate specification for explaining credit risk correlation; the null hypothesis cannot be rejected due to the negative critical value of LR tests. Over the longer term, credit risk correlation between pairs of domestic firms seem to be associated with country-level variables because the highest log-likelihood value is documented for model 2. Furthermore, the impact of sectoral effects largely disappears due to the insignificant coefficients of the two dummy variables included in the analysis. Therefore, combining the results from the LR tests and the insignificant dummy coefficients, the findings suggest that macroeconomic factors and global market risk are more associated with domestic credit risk correlations than the firm-level factors. This finding is in line with prior studies such as Duffie *et al.* (2009), Giesecke (2004) and Koopman *et al.* (2011). However, the negative LR tests for model 4 may due to the incorrect pooling method employed; because the intercept terms can only account for constant credit risk correlations across the three groups, the variation of the relationships between factors and credit risk correlations in each sub-grouping is not captured. The results from a sub-group analysis for the 5-year domestic credit risk correlations are presented in the Table 7.10 and that the constant is different for the different pairings.

Results from Table 7.2A reveal that the credit risk correlations among domestic non-financial firms are more affected by firm and country risk.[127] For instance, the effects of the distance between two entities' CR ratio (0.010) are only significant for the NF sub-groupings but insignificant for the *F* and the *F:NF* sub-pairings. In addition, domestic intra-sectoral credit risk correlations of the F sub-pairings are independent of the effects of the country-level variables. By contrast, the significant effects of regional- and global-level variables imply that the credit risk correlations of domestic financial institutions and the correlations between the financial and the non-financial firms are more affected by the regional and global risk factors.

7.4.2.2 Regional credit risk correlations: 5-year CDSs

The effects of sector dummy variables are significant across models 1 to 4 in Table 7.3A, which supports the sub-grouping strategy employed when analysing regional credit risk correlations. The negative sign of the coefficients for the two dummy variables provides evidence that regional credit risk correlation within the

[127] The results of LR tests show that Model 4 explains better than the rest three models, regardless the different groupings of credit risk correlations.

financial sector is high in both the short-term (1-year horizon) and the longer-term (5-year horizon). Furthermore, a comparison of the LR tests and the log likelihood values in Table 7.7 and Table 7.4A indicate that model 2 performs best when explaining the short-term regional credit risk correlations while model 4 is the best model for explaining long-term correlation.[128] As with the results from analysing 1-year CDS data, the results of the LR tests confirm that regional credit risk correlation is better explained by a model which includes variables from the firm, country, regional and global levels.

This finding reinforces the view that the effect of country-level variables is particularly important when explaining long-term correlation. The co-efficient results in Panel A from Table 7.8 and Table 7.4A are largely consistent; they suggest that there is a moderate negative association between the effects of the ROE differential and credit risk correlations for the non-financial sector as well as the cross-sectoral sub-grouping. Apparently, when the difference between two firms' profitability is large, the link with their credit risk correlation is not pronounced in either the long-term or the short-term.

In terms of the effects of country-level variables on long-term regional credit risk correlations, we are particularly interested in the coefficients for differences in DTG ($\left|D_{DTG_t}\right|$) and differences in EXP ($\left|D_{EXP_t}\right|$) among the two countries where the firms are located. It is clear that the effects of a change in the DTG ratio are consistently negative and significant at the 5% level in model 4 for both intra- and cross-sectoral correlations. In addition, as Panel B of Table 7.4A shows, the effects of export differentials are significant and negative on regional credit risk correlations for

[128] However, a much more systematic approach would more convincing if the effects of the contracts' maturities are included in.

the non-financial sector but insignificant for the financial and the cross-sectoral sub-groupings. Taken together with the results from the same panel of Table 7.8, the evidence supports the idea that the effects of exports are particularly important for Asian regional credit risk correlations within the non-financial sector. The insignificant of an export differentials' effect on credit risk correlations in the financial sector is consistent with the finding of prior studies, which have employed 5-year CDS data in examining credit risk correlation between financial institutions.

With regard to the effect of changes in the Japanese CDS indexes, the return of S&P 500 equity, changes in VIX and spread changes for the *iTraxx* CDS index, the results are similar to the findings from 1-year CDS data. However, Table 7.8 reports a smaller effect of the S&P500 and a larger effect of VIX in 5-year CDS data than in 1-year CDS spread change correlations.

7.5 Conclusion

Since globalisation has increased market integration and the global movement of capital, the chapter examines how correlations among credit risks are affected by fundamentals of entities or countries or by regional or global risks and whether these effects are unique to the financial sector or more widely present both among non-financial firms as well as between financial and non-financial companies. In addition, this chapter also examines the effects of various variables on credit risk correlations for both 1-year and 5-year CDS contracts. Although previous studies assume that the 5-year CDS contract is the most liquid, the market liquidity of short-term CDS contracts has improved significantly in recent years. This setting allows to build up a comparison of the factors which affect credit risk correlations across different maturities. In addition, inspired by financial network theory, the absolute difference in value of any given firm-level variable (e.g., 'distance') is employed to explain the entire credit risk correlations while the difference in value of country-level variables is employed for the regional correlations.

The results of the current chapter provide important insights into three aspects of the issue being studied. First, credit risk correlations are indeed different cross sectors and contract maturities. For example, short-term credit risk correlations between the financial and non-financial sectors are higher than the other sub-grouping sectors (the financial sector and the non-financial sector, respectively). By contrast, in long-term, credit risk correlations within the financial sector are higher than those within in the non-financial sector or between the financial and non-financial sectors. In addition, the variables, which are related to the credit risk correlations between a pair of firms, vary from the financial to the non-financial sector. Second, differences exist in the ability of the explanatory variables from various ‘levels’ to explain credit risk correlations; country-level variables, particularly the Debt-to-GDP ratio and the export (% GDP), are important factors in explaining credit risk linkages for both intra-sectoral and cross-sectoral credit risk correlations and a fewer number of firms-level variables have significant coefficients. Last but not the least, information on credit risk in Japan appears to be a key factor in explaining credit risk correlations among pairs of firms throughout the Asian region.

Overall, the growth of the CDS market is due to an increasing number of bond issuers in the debt market and high demand for credit risk protection. Thus, credit has gradually changed from an illiquid risk that was not considered suitable for trading to a risk that can be traded via credit derivatives. Knowing the linkages between the credit risks of firms in the financial and the non-financial sectors is especially important for bankers, investors, policy-maker and regulations. With globalisation, the interaction and interdependence between firms and economies have increased. The development of policies or bank regulations should recognise the increasing linkages between firms. Further research might usefully build on the analysis in this chapter and focus on the speed of changes in credit risk correlation, thresholds in credit risk correlations, and financial resilience more globally.

Chapter 8: Conclusion

8.1 Introduction

This chapter provides a summary of the main conclusions reached in the current thesis and evaluates a number of key empirical findings that help address the research questions posed in the beginning of the dissertation. It begins with a brief description of the process that led me to the research topic examined in the thesis as well as a discussion of the journey that I have taken while completing this PhD. Such a discussion should help the reader to understand the context in which the research was conducted and the motivation behind some of the choices made.

The topic of the current thesis was inspired by my MSc degree at the University of Dundee, in 2013. During my study for this masters qualification, I had a number of lectures on credit derivative markets and researched developments in this area for one of my MSc modules; as a result, I became interested in how Asian CDSs were performing since this derivatives market was relatively new for the region. I was also keen to find out how CDSs had survived the 2008 financial crisis; while a sizeable literature has highlighted how the world reacted to the panic associated with the 2008 global financial crisis, there were very few articles that investigated how emerging markets, such as those in Asia, responded to the turmoil. This initial interest in Asian derivative markets during my MSc degree was deepened after a more specific study of the existing literature for the current thesis.

Discussions with my MSc supervisor suggested that, unlike the developed nations, OTC derivatives such as CDSs were still in their infancy in most Asian countries. However, trading of CDS contracts was vital to the development of risk management within the region as CDS spreads are an informative tool for investigating credit risk as well as studying credit risk linkages. Yet the derivative markets in Asia seemed to be largely ignored in previous studies; this paucity of prior research was surprising as the potential for financial contagion among Asian named CDSs as well as the potential 'domino effects' that might spread throughout the world from defaults by Asian entities suggested that this topic was worthy of detailed scrutiny.

My journey towards a greater understanding of Asian CDSs began with enrolment on the PhD programme at the University of Dundee in the end of 2013; this has been a relatively long voyage of discovery which has tested my stamina as well my perseverance during difficult periods of data analysis and chapter write-ups; what kept me motivated during the journey is my innate interest in the area that I was researching. I initially sought to conduct a comprehensive analysis of the global CDS market, including investigations of developed as well as developing nations. Therefore, I had hoped to examine the dynamics of the CDS markets in developed nations over a long period in order to provide a frame of reference and a context for the growth of Asian CDSs. However, this idea had to be abandoned because it was too ambitious and historic data for Asian CDS spreads over a long time span were not available. In addition, the dominant type of CDSs traded in the advanced nations were different from those bought and sold in most (Asian) developing countries. Therefore, a decision was taken to focus on the spillover effects between Asian CDSs after the 2008 financial turmoil.

Furthermore, the amount of quantitative analysis involved was time consuming; I had underestimated the difficulties associated with data manipulation and data analysis at the start of the empirical work. For example, as one aim of the thesis was to investigate variations in credit risk spillover effects among different sectors and countries, data for a total of 20,760 pairs of firms had to be analysed using Bivariate GARCH models. Furthermore, recording and re-running regressions that did not converge took a great deal of time and a lot of care as well as patience. The large number of regression output files also consumed many hours in distilling the results so that the most interesting findings could be highlighted in summary tables. For example, a detailed discussion of the estimation results for 5-year CDSs was moved into an appendix of the thesis because one of the aims of the thesis was to provide evidence from the perspective of short-term credit risk spillovers since several prior studies had analysed data for 5-year CDS. Furthermore, one of my supervisors moved institution in the middle of the first year of my PhD programme; managing the situation where one of my supervisors was at another institution initially required adaptation on my part. Therefore, discussions and feedback between my supervisors and myself sometimes took more time than when my PhD journey started. As a result, this thesis has been a learning process that required a lot of softer skills in addition to the more conventional requirements that I had expected to develop as my research progressed.

Despite all of the difficulties that I encountered, the PhD journey progressed and the current thesis has emerged from the process. The current chapter attempts to summarise the overall findings from the research that are contained in the thesis. While a conclusion was supplied at the end of each chapter, the current summary adopts a more holistic approach by tying different findings together and relating the results to the research questions that were posed at the beginning. Thus, this conclusion links the results from the different chapters and identifies broad findings before highlighting where further work is needed.

The remainder of this chapter is structured as follows. Section 8.2 provides a summary of the main empirical findings which emerge from the current research. Section 8.3 lists out the areas where the thesis makes a contribution to our knowledge about CDSs while section 8.4 points out the potential limitations associated with the current thesis. Section 8.5 concludes the chapter and provides suggestions for further research.

8.2 Empirical findings

This research was conducted following a review of the related literature and is based on a quantitative analysis of credit risk spillover effects of Asian CDSs during the period 2009-2015. Credit risk spillovers were examined using multivariate GARCH-full-BEKK models; this setting not only allowed for the investigation of own-spillover effects but also provided information on cross-spillover linkages. Initially, Trivariate GARCH models were used to investigate domestic credit risk spillover effects among three groupings within a country; the sovereign debtor, a nation's financial institutions and a nation's non-financial firms. To expand on this initial domestic-only investigation, both sectoral and regional-level credit risk spillover effects were examined across the five countries studied. Bivariate GARCH models were utilised to document spillover effects in four different groups of pairs: 1) Domestic intra-sectoral credit risk spillovers, 2) Domestic cross-sectoral credit risk spillovers, 3) Regional intra-sectoral credit risk spillovers and 4) Regional cross-sectoral credit risk spillovers. A panel model analysis was also conducted to examine the effects of various corporate and market factors on credit risk correlations for the four different groups, respectively. All of these methods were used separately for 1-year and 5-year CDS spread changes in order to provide a comprehensive analysis of credit risk transmission between Asian CDSs and to identify the related factors that have important influences on credit risk linkages.

The current thesis has identified a number of key findings that are associated with the credit risk spillover effects in the Asian CDS market. One of the most important results to emerge from this thesis relates to the existence of own-effects among credit risk spillovers for Asian CDSs. The findings in Chapter 5 of the thesis evidence that an entity's own past credit risk information has a significant influence on its current CDS spread changes. While the influence of their own past spread changes are slightly different between 1-year and 5-year CDSs, in general, it appears that the Asian CDS market is not weak form efficient. In a weak-form efficient market, security prices reflect all historic information and attempts to predict current returns from past price changes is futile; the existence of own-effects spillovers in the CDS market suggest that some element of predictability is present. For example, the strong GARCH(1,1) process indicates that entities' own past shocks and volatilities affect the conditional variances of CDS spread changes for Asian entities. That is, information form a firm's own past shocks and volatilities are transmitted to its own current shocks and volatilities; for example, the findings in Chapter 5 of the thesis indicate that 93.65% of the 1-year CDSs for Japanese non-financial firms are affected by their own past volatilities and the average value of the coefficient for own-effects of volatility spillover is 0.8584.

A second finding from this investigation is that domestic credit risk spillover effects vary among countries. As one of the main goals of the thesis was to examine differences between the effects of within-sector and across-sector credit risk spillovers for a given Asian nation, the findings help to explain the how credit risk information appears to be transmitted within a country. There was some support for the view that significant intra-sectoral and cross-sectoral credit risk spillovers were present in the mean and the volatility of spread changes; for instance, the findings in Chapter 6 showed that bidirectional credit risk spillover effects between pairs of financial institutions varied in each Asian country (e.g., ranging from 4.67% for China to 47.62% for Japan) and most of the significant linkages that were uncovered were positive. Furthermore, shocks to the conditional variance and covariance tended to be highly persistent within a country and one unit change of the CDS spread typically led to relatively high future forecasts of the variance for a protracted period of time. The magnitudes of shock and volatility spillover effects varied for 1-year and 5-year CDSs; in particular, the transmission of shocks and volatility was more pronounced in longer-term spillover effects than that in their shorter-term counterparts.

Third, from the bivariate GARCH framework, the results in Chapter 6 also suggest that domestic intra-sectoral credit risk spillovers vary for financial and non-financial firms; the percentages of significant domestic spillovers between pairs of financial institutions were larger than that between pairs of domestic non-financial firms in China, Japan, Malaysia and Singapore. The opposite picture emerged in South Korea (which had 20 pairs for the non-financial sector and 17 pairs for the financial sector) where spillovers were more prominent among non-financial firms; a possible explanation may be that large family-owned conglomerates within the non-financial sector of South Korea fund one firm with cash from another entity within the 'group'; as a result, internal finance may create a potential channel of credit risk transmission since a default by one entity may lead to liquidity problems in another South Korean firm that relies on the first company for inter-company funding or trade credit (Claessens *et al.* 2000). The analysis of domestic cross-sectoral credit risk spillover effects also revealed a number of linkages within the different countries. The findings suggest the credit relationships between the sovereign debtor and non-financial firms tend to be country specific. For instance, the financial sector in Japan appeared to play an intermediary role in transmitting credit risk among the other two sectors while in China the credit standing of the Chinese sovereign debtor lead the credit status of domestic firms. Taken together, the findings indicate that credit risk in the three sectors was linked for each of the five Asian countries – although the links were different in each country; representing a country-specific pattern of credit risk transmission.

The fourth empirical finding of the current thesis is that regional credit risk spillovers vary for sectors and nations. Using the bivariate GARCH framework for a pair of firms from two different countries, the findings in Chapter 6 suggest clear evidence of regional links between their credit risk over both short-term and long-term horizons. In particular, from the perspective of regional credit risk spillover effects within a sector, significant values were documented for the financial sector in the short-term depending on the geographical location of the country and the type of financial system adopted. For example, where markets were geographically close or shared a similar financial system, the impact of spread changes for financial institutions in one country on the spread changes of financial institutions of another country was greatest. This feature was especially pronounced for Malaysia and Singapore where Islamic financial markets are important and where the distance between the countries is small. In addition, the dominant role of the Japanese non-financial sector in the transmission of credit risk among different sectors in Asia was apparent from the results; for instance, CDS spread changes in the non-financial sector of Japan were linked with spread changes in the financial and non-financial sectors of other Asian countries (e.g., 54.5% of credit risk spillovers from the Japanese non-financial sector to Chinese financial sector were significant). By contrast, the Singaporean financial sector acted as a shock and volatility transmission path to the sovereign sector of China and Malaysia. For instance, 66.67% of the shock and volatility credit risk spillovers from the Singapore financial sector to the Chinses and Malaysian sovereign debtors were significant over the long-term (i.e., 5-year CDSs).

The fifth major finding relates to credit risk correlations. The findings in Chapter 7 indicate that the credit risk correlations differ across sectors and CDS contract maturities. For example, short-term credit risk correlations between the financial and non-financial sectors were higher than between the financial sector and the non-financial sector. By contrast, in the long-term (i.e., 5-year CDSs), the credit risk correlations within the financial sector were higher than those within the non-financial sector or between the financial and non-financial sectors. As one aim of the current thesis was to explore the potential effect of different factors on sectoral- and country-level credit risk correlations in Asian CDS market, the analysis in Chapter 7 addresses this issue. The findings indicated that the selected firm-level variables (i.e., the firm size differential), country-level variables (i.e., change in the Debt-to-GDP ratios and change in the ratio of exports to GDP) and regional as well as global variables (i.e., changes in Japanese CDS index and changes in the implied volatility of S&P 500) were associated with correlations between credit spread changes. The results also suggested that different variables were significantly associated with credit risk correlations for different types of pairs: within a sector in a country; between sectors in a country; within a sector across countries; and between sectors in different countries. The relevance of country-level variables such as the Debt-to-GDP ratio and exports (%GDP) were clearly important factors in explaining credit risk linkages for both intra-sectoral and cross-sectoral credit risk correlations within a country. By contrast, the firm-level variables (i.e., the difference between two firms' return of equity and that between two firms' debt-to-equity ratios) and the regional credit risk variables such as the spread changes of 5-year CDS index for Japan financial sector and for Japan non-financial sector were significantly associated with credit risk correlations for pairs of firms in different sectors across different countries. The findings also confirmed the result in Chapter 6 that information on credit risk in Japan appeared to be a key factor influencing Asian CDSs.

Taken together, these findings suggest a role for the credit risk spillovers (especially among volatilities) in producing financial contagion throughout Asia. The findings from the GARCH models suggested that spillovers among volatilities were stronger than spillovers among mean spread changes. In addition, the findings of significant credit risk spillover effects between pairs of firms in different sectors and countries provide strong evidence of credit risk transmission in the region. The findings support the financial theory of contagion which argues that an initial shock event in one market may affect an investor's willingness to bear risk in other markets and hence default risks may become linked.

Furthermore, the important effects of firm-level variables such as the difference in the return on equity and the difference in the leverage ratio on the credit risk correlations highlighted the potential usefulness of financial network theory when thinking about credit risk correlations. In particular, the significant effects from the difference of the exports (%GDP) for pairs of nations on regional credit risk correlations seemed to provide insights into the effects of inter-regional trade on credit risk correlations. Although this thesis focused on the Asian CDS market, the findings may well have a bearing on the advanced nations' CDS market.

8.3 Contribution to knowledge

This thesis contributes to our understanding of credit risk spillover effects in a number of ways. First, this study is one of the first attempts to thoroughly examine credit risk spillover effects between Asian CDSs over both a short-term and a long-term perspective. As the literature review in Chapter 3 highlighted, a large number of studies have focussed on 5-year CDSs when looking at credit risk. The findings of this thesis suggests that the market appetite for credit risk in the short term (i.e., 1-year CDSs) is different and worthy of separate study; credit spreads and their spillovers change as the maturity of CDS contracts varies. The fear of long-term uncertainty in relation to a firm's financial standing seems to be priced into the CDS spreads causing more pronounced credit risk spillover effects in 5-year CDSs than in their 1-year counterparts. Thus, the findings of different credit risk spillover effects for 1-year and 5-year CDSs contributes to our knowledge about the transmission of credit risk in Asia.

Second, this thesis has investigated credit risk spillover effects within and between Asian countries; for the most part, this is an area that has been neglected by researchers. In particular, spillover effects for credit risk are investigated for different types of firm pairings in the current thesis; within a sector and within a country; across sectors within a country; within a sector across countries and across sectors in different countries. As far as I am aware, such a detailed classification has not been employed by other researchers when investigating this topic. Yet, the spread of credit risk may be different in the various categories of pairings as different transmission channels may be active and different explanations may be advanced to explain any variation in findings arrived at. Thus, one of the key contributions of this thesis has been the focus on credit risk spillovers in sectors and countries. Therefore, the typology of spillovers investigated of this thesis could serve a basis for future studies in emerging markets and supplement investigations of the global CDS market.

The findings from the effects of firms' own credit risk spillovers provide evidence that the Asian CDS market may not be weak-form efficient. This finding can have important implications for regulatory authorities and theorists concerned with the spread of default risk. As a result, the thesis may contribute to policy discussions about how authorities in these countries protect themselves from default contagion which may endanger their financial systems. In addition, the findings also shed light on contagion theory and the role of networks in Finance suggesting an avenue that regulators might want to consider when thinking about contagion. Furthermore, the findings from the cross-country spillover effects may also be used to investigate the importance of different transmission channels within/between countries/sectors. In particular, the analysis of the credit risk spillover effects among non-financial institutions undertaken in this thesis, has extended our knowledge about the transmission credit risk for this important segment of the market which has largely been ignored in the literature. For example, the findings of significant direct spillover effects between the sovereign debtor and non-financial firms provides important insights into the role of non-financial firms in transmitting credit risk across sectors and countries

Last but not the least, the effects of various variables on credit risk correlations is an important contribution of the current thesis. The associations identified in the thesis, as well as the approach used to measure important variables, should assist in our understanding of the role of firm-level, macroeconomic and market-wide variables in influencing credit risk correlations. Findings on the association between various factors and credit risk correlation are relatively novel in the literature and provide additional evidence about the relationship between firm-level variables, in particular, and credit risk correlation. The effect of differentials in variables for a pair of firms on credit risk linkages offers a framework for the exploration of correlated default among firms by others - both practitioners and policy-makers.

Taken together, the results of this thesis have a number of implications for policy-makers, regulators and investors. From the perspective of policy-makers, the empirical evidence on significant volatility spillovers can provide useful information in formulating policies for market stability. For instance, policy-makers can refer to the magnitudes and the directions of credit risk spillovers when setting up an early warning indicator for the transmission of shocks. In particular, as this dissertation employs a pairwise analysis of the full sample of firms both at cross-sector and cross-country levels, the 'sunspot' or the transmission centre of credit shocks can be identified in various groups of CDS reference entities. This should help policy-makers to customize a set of threshold values for different purposes. Furthermore, the findings also point to the significant effects of trade on credit risk interdependence regardless of the variety of sectors and Asian countries examined. Thus, trade linkage is documented as a significant transmission channel of credit risk for Asian countries, and this should be taken into account together with the information relating to volatility spillovers when designing policies to promote economic stability.

From the stand point of investors who hold government or corporate bonds, they can benefit from purchasing CDS contracts since this type of financial instrument is designed to transfer and sell the credit risk of the given underlying debts. More importantly, the conditional volatility (i.e., the conditional variance and the conditional covariance) derived from the bivariate GARCH-full-BEKK model can supply investors with key input information about the optimal weight in designing investment portfolios. In other words, when the magnitudes of volatility spillovers are large, the likelihood of joint default for these spillover firms is high; thus investors may want to reduce their holding of these affected firms at the same time and diversify risk in less affected sectors and countries. In particular, initial observations also suggest that there is a link between variations in global financial indicators and the credit risk correlations among Asian entities; thus investors may use information from these significant indictors (i.e., S&P500 and iTraxx index) to anticipate credit risk spillovers and diversify their portfolio risk accordingly.

8.4 Limitations of the current thesis

The aim of the current thesis was to explore various credit risk spillover effects in Asian CDSs and to identify the related factors that may have impacts on credit risk correlations. To achieve the goals of the current thesis, a comprehensive study of the subject was conducted. However, it is inevitable that the generalisability of these results is subject to certain limitations. Further, the conduct of any research involves choices by the researcher where others would have made a different selection and the current thesis is no different. This section of the Conclusion chapter outlines these limitations in order to arrive at a reflective judgement on the contribution of the work.

The first limitation of the thesis was that the empirical analysis did not include any analysis of credit risk spillover effects in Asia before the recent financial crisis. I had hoped to conduct an analysis of credit risk spillover effects in Asia before and after the 2008 global financial crisis in order to see if there was a difference; further, a study of market expectations about default risk based on CDS spreads would have been very opportune before, during and after a financial crisis. The investigation of pre-crisis credit risk spillover effects in the Asian CDS market was initially planned, however, the non-availability of data for Asian CDSs before 2009 meant that this plan had to be abandoned; the global CDS market became relatively active from 2006 and Asian named CDSs started to trade around 2009. As a result, plans for the examination of credit risk spillover effects before 2008 fell through.

Another limitation of the thesis is the uneven distribution of the sample data. This occurred for two reasons. First, this study was designed to investigate the credit risk spillovers between sectors and countries; thus Asian countries that did not meet the selection criteria (e.g., full available CDS records covering of the sovereign debtor, the financial institutions and the non-financial firms) were excluded. This left a final sample of 121 firms and 5 sovereign debtors covering 5 Asian countries. Unfortunately, entities had to be removed from the sample because of the sample selection criteria. Second, this thesis also sought to examine the effects of a wide range of relevant variables on the credit risk correlations. However, due to the missing firm-level data records for a small number of firms (e.g., 29 out of 121 selected firms), a decision was taken to only focus on the 92 firms with full financial reporting data in Chapter 7. Thus, the sample is not identical in each chapter and is heavily dominated by non-financial firms from Japan (e.g., 54

Japanese non-financial firms out of 121 selected firms for Chapter 5 and Chapter 6; 54 out of 92 firms for Chapter 7).

Another limitation is also related to the availability of data. The exclusion of CDS market liquidity indicators could have affected the measurement of various factors on credit risk correlations. Although the thesis has successfully demonstrated that the effects of various variables were important on credit risk correlations, it has certain limitations in terms of the role of liquidity in this relationship. However, there are reasons for this limitation. I had hoped to include a liquidity factor such as bid-ask spreads and trading volumes of individual CDS contracts. But there were limited details for such measures; although the bid-ask spreads of the underlying bonds may help to provide a measure of liquidity, the thesis set out to analyse the effects of CDS market liquidity on correlations between CDS spread changes. Thus, the lack of a liquidity measure in the sample adds a further note of caution regarding the generalisability of the findings.

Lastly, the thesis was unable to analyse the effects of firm-level variables on the credit risk correlations between the sovereign debtors and firms. Although this thesis has successfully demonstrated the important effects of return on equity differentials, firm size differentials and volatility differentials on credit risk correlations for a pair of firms, it has certain limitations in terms of the application of these measures for explaining the credit risk correlations between a firm and a sovereign debtor. The most obvious reason for this is that the sovereign sector does not have an ‘equity’ measure; thus differences in the return on equity between a firm and a sovereign debtor are not measureable. Thus, it is impossible to investigate the differences between firm-level indicators on the credit risk correlation between firms and sovereign debtors. Although an estimation of the effects of various macroeconomic and market factors can be done by excluding the firm-level variables, as one goal of the thesis is to contribute our knowledge about the effects of firm-level variables on credit risk correlations firm-level variables were retained and the credit risk correlation between a sovereign debtor and a firm was ignored.

8.5 Conclusion and future research

This chapter has presented the main concluding remarks of the current thesis. It highlights the most important findings from the research undertaken. In addition, it illustrates various contributions of the thesis to our understanding of the area as well as highlighting several inevitable limitations associated with the work.

This current research has thrown up many questions in need of further investigation and it is worth highlighting these in the conclusion to the thesis. First, it would be interesting to continue the work done here by investigating whether any results still hold in a more recent time period. Further, the use of different research methods such as Impose Response Functions and the neural network approaches might add to the conclusions reached in this thesis. This analysis could focus on the responses of one firm or one sector to a shock in another individual entity or in the whole financial system. Such an analysis might contribute to the literature on financial fragility and resilience. Also, direct credit risk linkages between different CDS underlying reference entities located in advanced nations and developing nations would be particularly insightful for any analysis of spillover effects and their transmission channels. Furthermore, an analysis of the recovery rate from a default or the likelihood of repayment of the principal from the CDS underlying reference entity would enhance our understanding of the pricing efficiency of CDS contracts.

Future studies on credit risk in developing countries could apply a quality analysis method. They could concentrate on the intention of policy-makers in developing countries to simulate the growth of credit derivative instruments as well as the trade-off between market regulation and openness. This would not only benefit the growth of credit derivatives but also would be important for the development of bond markets in these developing countries. Overall, research on credit risk spillover effects still has a long way to go; as Allen and Gale (2000) noted:

> ‘An interesting question is what kinds of arrangements banks will choose to set up, given the trade-off between the individual benefits of access to liquidity and the social costs of contagion. This is an important topic for further study’ (p.27).

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Appendices

Appendices 3.1

Table 3.1A: A summary of articles using CDSs: sovereigns

Article	Sample span	Sample country	Maturity	Method	Findings
Panel A: Europe and North America					
Basurto *et al.* (2010)	2005-2010	12 EMU countries, excluding Finland and Luxembourg	10-year CDSs	GARCH(1,1)	Low credit rated sovereigns such Greece or Italy tend to exhibit larger sensitivities to credit shocks and remote probabilities of distress among high credit rated sovereigns.
De Santis (2012)	1st September 2008-4th August 2011	Greece, Ireland, Portugal, Belgium, Italy, Spain, Austria, Finland, France and the Netherlands	5-year CDSs	OLS and co-integration tests	Country-specific credit ratings have played a key role in the developments of the spreads for Greece, Ireland, Portugal and Spain.
Dieckmann and Plank (2012)	January 2007-April 2010	18 European countries	10-year CDSs	Principal component analysis and panel model	Credit risk transmission pattern differs across countries operating under different monetary authorities.
Kalbaska and Gątkowski (2012)	August 2005-September 2010	PIIGS, France, Germany, the UK and the US	5-year CDSs	EWMA correlation analysis, Granger-Causality test	Greece and other PIIGS have lower capacity to trigger contagion than core EU countries. In addition, Portugal is the most vulnerable and the UK is the most immune to shocks.
Aizenman *et al.* (2013a)	January 2005-August 2012	European countries	3-, 5- and 10-year CDSs	Dynamic panel regressions	A credit rating upgrade decreases CDS spreads by about 45 basis points on average for EU countries.
Calice *et al.* (2013)	2009-2010	Euro zone	5- and 10-year CDSs	Time-varying VAR	There are substantial variation in the patterns of the transmission effect between maturities and across countries
Groba *et al.* (2013)	January 2008-July 2012	Austria, Belgium, Germany, Finland, France, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Denmark, Sweden and the UK.	1-, 3- and 5-year CDSs	Univariate Exponential GARCH, bivariate-GARCH-BEKK and OLS	A significant risk transmission from the peripheral to the non-peripheral countries is empirically observed during the period analyzed. Both the risk premium and the default components of CDS spreads are particularly explained by global and local macroeconomic factors.

Chiarella *et al.* (2015)	January 2004-April 2013	13 European countries	5-year CDSs	Panel model regression with time-fixed effect and structure model	Expectation on economic fundamentals play roles in affecting most European sovereign CDS markets.
Fontana and Scheicher (2016)	January 2007 to December 2012	Ten euro zone countries	10-year CDSs	Panel regression with time-fixed effects	CDS spreads exhibits a strong correlation with country-specific drivers of credit risk.
Isiugo *et al.* (2016)	October 2000-October 2013	19 emerging market countries, including China	5-year CDSs	VAR-DCC-GARCH and OLS	Trade and commodity prices have a statistically and economically significant effect on the sovereign credit risk of emerging economies
Panel B: Emerging markets					
Pan and Singleton (2008)	March 2001-August 2006	Mexico, Turkey and South Korea	1-,2-,3-,5-, and 10-year CDSs	Affine model with maximum likelihood estimates	A substantial portion of the co-movement among the term structure of sovereign CDS spreads across countries was induced by changes in investors' appetites for credit exposure at a global level, rather than by reassessments of the fundamental strengths of these specific sovereign economics.
Remolona *et al.* (2008)	January 2002-June 2006	10 Latin American, 7 European, 6 Asian and 4 Middle Eastern and African (MEA) countries	5-year CDSs	Panel regressions	Their findings supported to the debt intolerance and original sin hypotheses for country risk.
Ismailescu and Kazemi (2010)	2nd January 2001-22nd April 2009	22 emerging market countries, including China, Malaysia and South Korea	5-year CDSs	Logit models and event study	The transmission mechanisms are the common creditor and competition in trade markets.
Ammer and Cai (2011)	26th February 2001-31st March 2005	Brazil, China, Colombia, Mexico, Philippines, Russia, Turkey, Uruguay and Venezuela	5-year CDSs	CR clause, Vector error correction (VECM) model	Sovereign CDS spreads move ahead of bond spreads in short-term but they are linked by a stable linear long-run equilibrium relation. Liquidity is the main factor in the process of price discovery between CDS and bond markets. In particular, their findings evidence a significant of 'cheapest-to-deliver' option of CDS settlement.
Fender *et al.* (2012)	August 2007-	12 emerging market	5-year CDSs	Principal Components	Their findings suggested possibility of significant international spillovers

	December 2011	borrowers from Central and Eastern Europe, Latin America, Asia and South Africa		Analysis (PCA)	from developments in international and, particularly, US financial markets to emerging market sovereign borrowers.
Adam (2013)	Latin American and Asian countries: January 2008 - January 2012 Eurozone and EMEA countries: September 2008- January 2012	China, Indonesia, South Korea, Malaysia, Philippines, Thailand, Eurozone and Middle Eastern and African (EMEA) countries	5-year CDSs	VAR model	The sovereign spreads are not determined by domestic factors, but intra-regional credit risk spillovers are important.
Panel C: Worldwide					
Wang and Moore (2012)	January 2007- December 2009	The US and other 37 advanced and emerging countries	5- and 7-year CDSs	Bivariate GARCH model and panel model regression	For both developed and emerging markets, declining US interest rates are found to be the main driving factor behind the higher level of correlation during crisis period.
Beirne and Fratzscher (2013)	1999-2011	31 advanced and emerging countries	5-year CDSs	OLS regressions	Financial markets have become more sensitive to changes in economic fundamentals. Regional spillovers can explain 100-200 bps of the risk in sovereign yield spreads among PIIGS, this implies that market has started to discriminate more in the basis of countries fundamentals during the Euro debt crisis.
Kim *et al.* (2015)	November 2007- March 2012	19 countries including China, Japan, South Korea	5-year CDSs	EGARCH	Good news from China lowers sovereign CDS spreads in other countries while bad news raises spreads.

Table 3.2A: A summary of articles using CDSs: financial institutions

Article	Sample span	Sample country	Maturity	Method	Findings
Panel A: Europe and North America					
Miquel *et al.* (2012)	January 2004-March 2012	Austria, Belgium, Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK and the US	5-year CDSs	Principal Components Analysis	The results of the empirical analysis are indicative of a change in the correlation structure of CDS returns due to the financial crisis.
Tamakoshi and Hamori (2013a)	January 2004-November 2011	The EU, the US and the UK	5-year CDS index	AR-EGARCH	CDS indices fluctuate widely in banks of EU, US and UK.
Yang and Zhou (2013)	January 2007 – September 2008	the US, the UK, Germany, Switzerland, France, Italy, Netherlands, Spain, and Portugal	5-year CDSs	principal component analysis (PCA), Bayesian Network (DAG) analysis and VAR models	Leverage ratios and particularly the short-term debt ratio appear to be significant determinants of the roles of financial institutions in credit risk transfer, while corporate governance indexes, size, liquidity and asset write-downs are not significant.
Black *et al.* (2016)	January 2001 – January 2013	France, Germany, the UK, Switzerland, Austria, Belgium, Luxembourg, the Netherlands, Denmark, Norway, Sweden, Italy, Spain, Greece, Ireland and Portugal	Euro-dominated 5-year CDSs	Designed a systemic risk measure based on Merton(1974)Model	Banks sizes and the interconnections have the explanation power of systemic importance of individual banks.
Panel B: Worldwide					
Baba and Inada (2009)	2nd April 2004-30th December 2005	Japan	5-year CDSs	Bivariate GARCH and panel model	There are significantly co-integration between the Japanese banks.

Calice *et al.* (2012)	20th October 2003-29th April 2009	The US, the US, France, German and Swiss	the North American CDX and the European iTraxx	VAR-MV-GARCH	Banks' equity volatility associated with significant stress in the CD market matters for systemic distress.

Table 3.3A: A summary of articles using CDSs: non-financial firms

Article	Sample span	Sample country	Maturity	Method	Findings
Panel A: Europe and North America					
Friewald *et al.* (2014)	2nd January 2001-26th April 2010	US,491 firms	1-,3-,5-,7-,10-year CDSs	Spreads estimation model	The term structure of CDS spreads contains risk premium information that is relevant for pricing stocks.
Jang *et al.* (2016)	January 2001-December 2011	US,198 firms	N/A	Structure model incorporate both macroeconomic risks and firm-specific jump risks	Macroeconomic factors are important in modelling credit risk and CDS spreads could be dependent on the current economic state.
Panel B: Emerging markets					
Kim *et al.* (2010)	January 2005-January 2009	Asia-ex-Japan including China, Malaysia, Singapore and South Korea	N/A	Panel model and PCA	There was a risk shift as well as a reassessment of risk drive valuations of CDS in 202-2007.

Table 3.4A: A summary of articles using CDSs: sovereigns and non-sovereigns

Article	Sample span	Sample country	Maturity	Method	Findings
Panel A: Europe and North America					
Alter and Schüler (2012)	June 2007-May 2012	Euro zone	5-year CDSs	VER and VAR model	A financial sector event has stronger effects on sovereign debt market.
Greatrex and Rengifo (2012)	17th July 2006-31st December 2009	348 US firms	5-year CDSs	Panel model	CDS spreads responded favorably to government intervention as abnormal spread changes were negative and statistically significant for both financial and non-financial firms.
Tamakoshi and Hamori (2013b)	January 2008-December 2011	Eurozone	5-year CDSs	AR-EGARCH	By investigating the two CDS indices (i.e., the Eurozone banking sector CDS index and the 5-year Greek sovereign CDS spreads), they found significant transfer of credit from banks to sovereigns, while the transmission direction changes to the opposite way after the 2010 Euro debt crisis.
Zoli (2013)	2007-2012	Italy	5-year sovereign CDS	Ordinary Least Squares (OLS) regressions	News on the Euro area debt crisis and country specific events are important drivers of sovereign spreads.
Acharya *et al.* (2014)	January 2007-Aprial 2011	Eurozone, Denmark, Norway, Sweden, Switzerland and the UK	5-year CDSs	Panel model regression	Banks are exposed to home-country sovereign risk through their holdings of sovereign bonds.
Alter and Beyer (2014)	February 2010-June 2012	Euro zone	5-year CDSs	VARX model	The captured Time-varying interdependence between banks and sovereigns emphasizes the evolution of their strong inter-structure.
Haerri *et al.* (2014)	January 2009-Janary 2011	Europe	5-year CDSs	Panel regression analysis	Based on the findings from 107 European CDS reference entities (including banks and non-financial firms), the impact of sovereign credit risk presents both for banks and corporates.
Bedendo and Colla (2015)	January 2008-December 2011	Belgium, Finland, France, Germany, Italy, the Netherlands, Portugal and Spain	Euro-dominated 5-year CDSs	OLS regression	An increase in sovereign spreads leads to a significant increase in credit spreads of non-financial firms. The sovereign-to-corporate spillover is stronger for firms that are more likely to benefit from government aid, and those sales are concentrated in the domestic

					market, and relying on banking financing.
Augustin *et al.* (2016)	February 2010-May 2010	Europe (226 corporates in 15 countries)	5-year CDSs	Panel model regression	There was a significant credit risk relation between the sovereigns and corporates during the crisis time, this is pronounced in Eurozone countries that were more financially distressed.
Pagano and Sedunov (2016)	2007-2011	Europe	5-year sovereign CDSs	Adapted Exposure Co-VaR model	The aggregate systemic risk exposure of financial institutions is positively related to the probability of a default on sovereign debt in European countries.
Panel B: Worldwide					
Lahmann (2012)	October 2005-April 2011	Asia-pacific, Europe, Middle East, Russia and the US	5-year CDSs	VAR and VEC model	There is significant increase of the CDS spreads correlations among inter and intra-regions.
Gross and Kok (2013)	2008-2013	Europe, the US and Japan	5-year CDSs	VAR model	The most pronounced credit risk spillover effects from banks to sovereigns are observed during the second half of 2008, around the time of Lehman Brothers' default. In contrast, the sovereign-to-bank credit risk spillovers were strong in 2011 during the Euro debt crisis.

Table 3.5A: A summary of articles using CDSs: non-sovereigns

Article	Sample span	Sample country	Maturity	Method	Findings
Panel A: Europe and North America					
Zhang *et al.* (2009)	January 2001-December 2003	the US (307 CDS entities including banks and non-financial firms)	5-year CDSs	Morton-type pricing model and panel model regression	Equity volatility and jumps are one of the most significant factors explaining the determination of CDS spreads both in financial and non-financial firms.
Tang and Yan (2010)	June 1997-March 2006	the US	5-year CDSs	Panel model regression	The volatility of a firm is an important credit spread determinant.
Galil *et al.* (2014)	2002-2013	718 US firms	5-year CDSs	Panel model regression	After controlling for firm-specific variables, market factors can add to explaining CDS spread changes.
Subrahmanyam *et al.* (2014)	January 2002-March 2006	901 North American firms	5-year CDSs	Event study and panel model regression	The likelihood of bankruptcy for the average firm more than doubles after the starting of CDS trading.
Panel B: Emerging markets					
Kim *et al.* (2010)	January 2005-January 2009	38 corporates from Asia-ex-Japan region (including China, Malaysia, Singapore and South Korea)	5-year CDSs	OLS and PCA	The increasing credit risk of Asian firms during the 2008 global financial crisis is due to the co-movement of global- and regional-specific pricing factors, as well as from revision to the expected loses from defaults.
Panel C: Worldwide					
Micu *et al.* (2006)	January 2001-March 2005	European, the US and Japan	5-year CDSs	Event study	The CDS prices were affected by all types of rating announcements-outlook, reviews and rating changes (including positive and negative).
Aretz and Pope (2013)	January 1990-December 2008	24 countries including the UK, the US and Japan	5-year CDSs	Random coefficient modelling approach	Changes in default risk always depend mostly strongly on global and industry effects.

Appendices 4.1

Table 4.1A: The sample of Chinese CDS reference entities

Code	CDS reference entities	Sector	Credit rating[129]
Panel A: Sovereigns			
CN	People's Republic of China	SOV	Aa3.Apr.2013
Panel B: Financial institutions			
ABC	Agricultural Bank of China	BK	A1. Jul. 2007
BOC	Bank of China Limited	BK	A1. Jul. 2007
CIB	Citic Ka Wah Bank limited	OFI	------
CKH	Cheng Kong Holdings Limited	OFI	------
EIB	The Export-Import Bank of China	BK	A3. Apr .2013
HW	Hutchison Whampoa	OFI	A3. Apr .2013
ICB	Industry and Company Bank of China	BK	------
Panel C: Non-financial institutions			
CNO	China Overseas Land and Investment Limited	TRN	Baa1.Apr.2013
CNM	China Mobile Limited	TEL	Aa3.Apr .2013
CNC	CNCOOC Limited	MAG	------
HLD	Henderson Land Development Company Limited	ONC	------
JM	Jardine Matheson	TRN	------
MC	Motor Corporation Limited	MAG	------
PT	PCCW-HKJ Telephone Limited	MAG	------
SP	Swire Pacific Limited	TRN	A3.Mar.2006
WL	The Wharf (Holdings) Limited	TEL	------

Note: The Citic Ka Wah Bank limited, the Export-Import Bank of China, the Industry and Company Bank of China and the CNCOOC limited are not included in the analysis of Chapter 7.

[129] Issuer Ratings are opinions of the ability of entities to honour senior unsecured financial obligations and contracts. Moody's expresses Issuer Ratings on its general long-term and short-term scales. Moody's ratings on long-term structured finance obligations primarily address the expected credit loss an investor might incur on or before the legal final maturity of such obligations vis-à-vis a defined promise. As such, these ratings incorporate Moody's assessment of the default probability and loss severity of the obligations. They are calibrated to Moody's Global Scale. Such obligations generally have an original maturity of one year or more, unless explicitly noted.

Table 4.2A: The sample of Japanese CDS reference entities

Code	Description	Sector	Credit rating
Panel A: Sovereigns			
JP	Japan	SOV	Aa3.Aug.2011
Panel B: Financial institutions			
AC	Acom Company	OFI	-----
DI	Daiwa Securities Group Incorporated	OFI	-----
MBK	Mizuho Corporation Bank Limited	BK	A1.Jul.2013
MS	Mitsui Sumitomo Incorporated	OFI	-----
OC	Orix Corporation	OFI	Baa2.Feb.2013
TB	The Btmbi UFJ Limited	BK	-----
TC	Tokio M and Fins Company Limited	OFI	-----
Panel C: Non-financial institutions			
AE	Aeon Company	SEC	-----
AG	Asahi Glass Company	MAG	A2.Aug.2013
AJ	Ajinomoto Company	COG	-----
BC	Bridgestone Corporation	MAG	A2.Sep.2013
CA	Canon Income	MAG	-----
CH	Citizen Holdings Company Limited	MAG	-----
CO	Cosmo Oil Company, Limited	ENC	Ba1.Dec.2012
FE	Fuji Electric Company Limited	ELP	-----
FT	Fukuyama Transporting Company	TRN	-----
FU	Fujitsu Limited	MAG	A3.Jun.2009
HI	Hitachi	MAG	A3.May.2009
HO	Hokuriku Electrical Power Company	ELP	-----
IC	Itochu Corporation	MAG	Baa1.Aug.2006
IM	Isuzu Motors Limited	MAG	-----
JT	Japan Tobacco Income	COG	Aa3.Mar.2007
KD	KDDI Corporation	TEL	-----
KE	Kansai Electrical Power Company Incorporated	ELP	-----
KR	Keihin Electric Express Rail Company	TRN	-----
KRC	Keisei Electrical Rail Company	TRN	-----
MAC	Marubeni Corporation	MAG	Baa2.Jul.2007
MG	Marui Group Company Limited	SEC	-----
MIC	Mitsui and Company	MAG	-----
MK	Mitsui O S K Lines	TRN	Baa3.Aug.2013
MM	Mazda Motor Corporation	MAG	-----
MMC	Mitsubishi Materials Corporation	MAG	-----
NCC	Nishimatsu Construction Company	MAG	-----
NEC	NEC Corporation	MAG	Baa2.Jul.2013
NER	Nankai Electric Rail Company	TRN	-----
NI	Nippon Express Company	TRN	-----
NMC	Nissan Motor Company Limited	MAG	-----
NP	Nippon Paper Industries Company	MAG	-----
NT	Nippon Telegraph and Telephone Corporation	TEL	Aa2.Sep.2011
NTT	NTT Docomo	TEL	Aa2.Jun.2012
NY	Nippon Yusen KBKH	TRN	Baa2.Aug.2013
OR	Odakyu Electrical Rail Company	TRN	-----
PC	Panasonic Corporation	MAG	Baa3.Dec.2013
RC	Ricoh Company	MAG	-----
SA	Sapporo Holdings Limited	COG	-----
SBM	Softbank Mobile Corporation	TEL	-----
SCC	Sekisui Chemical Company	MAG	-----
SH	Sekisui House	MAG	-----
SHC	Sharp Corporation	MAG	-----
SHI	Shimizu Corporation	SEC	-----
SO	Sojitz Corporation	MAG	Ba1.Jan.2014
SR	Sumitomo Real and Development Company	SEC	-----
SU	Sumitomo Corporation	MAG	Aa3.Aug.2011
SY	Sony Corporation	MAG	Ba1.Jan.2014
TC	Taisei Corporation	MAG	-----
TE	Tokyo Electron Limited	ONF	-----
TMC	Toyota Motor Corporation	MAG	Aa3.Jun.2013
TO	Toshiba Corporation	MAG	Baa2.Apr.2009
TRC	Tobu Railway Company Limited	TRN	-----
TYC	Takashimaya Company	SEC	-----
YE	Yokogawa Electrical Corporation	MAG	-----

Table 4.3A: The sample of Malaysian CDS reference entities

Code	Description	Sector	Credit rating
Panel A: Sovereigns			
MY	Malaysia	SOV	A3.Nov.2013
Panel B: financial institutions			
CB	CIMB Bank Berhad	BK	A3.Nov.2013
GBK	Genting Berhad	OFI	Baa1.Apr.2014
MBK	Malayan Banking Berhad	BK	A3.Nov.2013
Panel C: non-financial firms			
IOI	IOI Corporation Berhad	MAG	Baa.2May.2013
MBR	Miscellaneous Berhad	TRN	-----
PNB	Petroliam Nasional Berhad	ENC	A1.May.2013
TMB	Telekom Malaysia Berhad	TEL	A3.Nov.2013
TNB	Tenaga Nasional Berhad	ELP	Baa1.Jul.2005

Table 4.4A: The sample of Singaporean CDS reference entities

Code	Description	Sector	Credit rating
Panel A: sovereigns			
SG	Singapore	SOV	Aaa.Jun.2002
Panel B: financial institutions			
DBS	DBS Bank Limited	BK	Aa1.Aug.2013
OBK	Overseas Chinese Banking Corporation Limited	BK	Aa1.May.2007
TH	Temasek Holdings	OFI	Aaa.Apr.2013
Panel C: non-financial institutions			
CAL	Capitaland Limited	MAG	-----
PSA	PSA International PTE Limited	ONF	A1.Oct.2013
SPL	Singapore Power Limited	ELP	Aa3.Apr.2008
SPP	SP Powerassets Limited	ELP	Aa3.Apr.2008
STE	Singapore Telecomms	TEL	-----

Table 4.5A: The sample of South Korean CDS reference entities

Code	Description	Sector	Credit rating
Panel A: sovereigns			
SK	South Korea	SOV	Aa3.Aug.2012
Panel B: financial institutions			
EIBK	The Expt-Impt Bank of Korea	BK	Aa3.Aug.2012
HBK	Hana Bank	BK	A1.Jan.2013
HCS	Hyundai Capital Service	OFI	Baa1.Oct.2012
IBK	Industrial Bank of Korea	BK	Aa3.Aug.2012
KBK	Kookmin Bank	BK	A1.Jan.2013
KDB	Korea Deposit Insurance Corporation	OFI	-----
KEB	Korea Exchange Bank	BK	A1.Apr.2013
SBK	Shinhan Bank	BK	A1.Jan.2013
TKB	The Korea Development Bank	BK	Aa3.Apr.2014
WOB	Woori bank	BK	A1.Jul.2013
Panel C: non-financial firms			
GSC	GS Caltex Corporation	ENC	Baa3.Feb.2014
HMH	Hyundai Motor Company	MAG	Baa1.Oct.2012
KCC	KCC Corporation	MAG	Baa2.Jul.2007
KEC	Korea Expressway Corporation	TRN	A1.Apr.2010
KEP	Korea Electrical Power Corporation	ELP	-----
KEW	Korea East-West Power	ELP	A1.Apr.2010
KGC	Korea Gas Corporation	ENC	A1.Apr.2010
KIA	KIA motors Corporation	MAG	Baa1.Oct.2012
KLC	Korea land Corporation	SEC	-----
KMP	Korea Midland Power Limited	ELP	A1.Apr.2010
KTG	KT and G Company	COG	-----
KWR	Korea Water Resources Corporation	SEC	A1.Apr.2010
LG	LG Electronics Incorporated	MAG	Baa3.Feb.2014
POS	Posco	MAG	Baa2.Nov.2013
SCL	Shinsegae Company Limited	SEC	-----
SCO	Samsung Electronics Company Limited	MAG	A1.Dec.2013
SKC	SK Innovation Company Limited	ENC	Baa2.Feb.2014
SKT	SK Telecom Company	TEL	A3.Aug.2013

Note: The Expt-Impt Bank of Korea, the Hyundai Capital Service, the Korea Deposite Insurance Corporation, the Korea Development Bank, the GS Caltex Corporation, the Korea Expressway Corporation, the Korea East-West Power and the Korea Water Resources Corporation are not include in the analysis of Chapter 7 of this thesis.

Appendices 5. 1

Table 5.1A: The percentages of significant coefficients for 5-year CDSs: East Asia

Variables	China						Japan						South Korea					
	$\Delta CDS_{i,t}^{SOV}$		$\Delta CDS_{j,t}^{F}$		$\Delta CDS_{k,t}^{NF}$		$\Delta CDS_{i,t}^{SOV}$		$\Delta CDS_{j,t}^{F}$		$\Delta CDS_{k,t}^{NF}$		$\Delta CDS_{i,t}^{SOV}$		$\Delta CDS_{j,t}^{F}$		$\Delta CDS_{k,t}^{NF}$	
Panel A: Spread changes spillovers																		
$\Delta CDS_{i,t-1}^{SOV}$	0.00		0.00		0.00		100.00		100.00		37.04		0.00		0.00		27.78	
$\Delta CDS_{j,t-1}^{F}$	0.00		0.00		11.11		37.04		37.04		35.98		0.00		0.00		0.00	
$\Delta CDS_{k,t-1}^{NF}$	11.11		11.11		0.00		35.98		35.98		100.00		5.56		5.56		5.56	
Panel B: Shock and volatility Spillovers																		
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B_1: Shock spillovers																		
$\varepsilon_{i,t-1}^2$	55.56	39.68	34.92	44.44	38.10	31.75	14.81	7.41	8.20	7.14	7.14	7.14	12.22	3.33	4.44	3.33	3.89	3.33
$\varepsilon_{j,t-1}^2$	36.51	36.51	26.98	23.81	28.57	25.40	24.34	24.34	21.69	24.07	23.02	21.96	42.22	42.22	8.89	28.89	13.89	15.56
$\varepsilon_{k,t-1}^2$	26.98	26.98	26.98	20.63	22.22	20.63	14.02	21.69	14.02	11.11	11.11	9.79	30.00	8.89	30.00	13.33	26.67	12.22
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	36.51	30.16	25.40	36.51	25.40	20.63	15.87	12.96	13.23	13.49	14.02	11.11	12.22	7.78	4.44	12.22	4.44	5.00
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	38.10	25.40	31.75	23.81	34.92	26.98	7.14	12.70	8.20	8.20	17.72	11.90	3.89	3.89	7.22	4.44	12.78	7.22
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	30.16	20.63	20.63	20.63	23.81	19.05	15.34	14.81	15.61	14.02	16.67	15.08	8.33	13.89	13.33	21.67	16.67	21.67
B_2: Volatility spillovers																		
$h_{ii,t-1}$	93.65	39.68	39.68	85.71	80.95	36.51	46.03	19.31	21.69	40.21	41.27	20.63	98.33	17.78	15.56	71.67	73.33	14.44
$h_{jj,t-1}$	44.44	93.65	41.27	77.78	41.27	84.13	25.13	46.56	21.96	43.39	24.34	41.53	46.67	97.78	22.78	85.00	26.11	77.78
$h_{kk,t-1}$	42.86	39.68	93.65	34.92	77.78	84.13	26.19	22.75	46.30	23.54	43.92	41.80	45.56	32.78	98.33	31.67	86.11	77.78
$h_{ij,t-1}$	80.95	88.89	34.92	93.65	82.54	80.95	43.92	39.15	21.69	46.56	40.74	39.42	83.89	72.22	14.44	98.33	69.44	65.56
$h_{ik,t-1}$	80.95	38.10	79.37	80.95	93.65	73.02	43.92	21.69	42.06	39.68	46.56	38.10	86.67	19.44	76.11	69.44	97.78	63.89
$h_{jk,t-1}$	41.27	82.54	79.37	73.02	71.43	93.65	27.25	40.21	43.12	39.68	42.59	47.09	41.11	77.78	77.78	78.89	78.89	98.33
No. of models	63						378						180					

Note: This table shows the percentages of significant coefficients for the estimates of 5-year CDS reference entities in East Asia.

Table 5.2A: The percentages of significant coefficients for 5-year CDSs: Southeast Asia

Variables	Malaysia			Singapore		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread changes spillovers						
$\Delta CDS_{i,t-1}^{SOV}$	93.33	53.33	53.33	33.33	0.00	0.00
$\Delta CDS_{j,t-1}^{F}$	53.33	93.33	80.00	0.00	33.33	0.00
$\Delta CDS_{k,t-1}^{NF}$	80.00	80.00	93.33	0.00	0.00	33.33

Panel B: Shock and volatility Spillovers	Malaysia						Singapore					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B_1: Shock spillovers												
$\varepsilon_{i,t-1}^2$	26.67	13.33	20.00	13.33	6.67	13.33	40.00	13.33	20.00	6.67	13.33	6.67
$\varepsilon_{j,t-1}^2$	26.67	26.67	13.33	6.67	0.00	13.33	40.00	40.00	20.00	13.33	6.67	13.33
$\varepsilon_{k,t-1}^2$	20.00	13.33	20.00	6.67	13.33	6.67	33.33	20.00	33.33	6.67	13.33	13.33
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	0.00	0.00	20.00	20.00	6.67	13.33	13.33	13.33	20.00	26.67	13.33	6.67
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	6.67	6.67	6.67	0.00	33.33	13.33	13.33	13.33	13.33	6.67	20.00	13.33
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	13.33	6.67	6.67	6.67	13.33	20.00	6.67	13.33	13.33	6.67	6.67	20.00
B_2: Volatility spillovers												
$h_{ii,t-1}$	100.00	53.33	33.33	86.67	93.33	33.33	100.00	40.00	33.33	66.67	80.00	33.33
$h_{jj,t-1}$	46.67	93.33	66.67	93.33	53.33	86.67	20.00	93.33	40.00	60.00	33.33	66.67
$h_{kk,t-1}$	40.00	46.67	93.33	46.67	93.33	86.67	40.00	20.00	80.00	33.33	60.00	53.33
$h_{ij,t-1}$	93.33	86.67	46.67	93.33	93.33	86.67	53.33	66.67	33.33	86.67	66.67	66.67
$h_{ik,t-1}$	93.33	46.67	93.33	93.33	93.33	80.00	53.33	26.67	73.33	46.67	86.67	60.00
$h_{jk,t-1}$	33.33	93.33	93.33	93.33	93.33	86.67	40.00	60.00	66.67	60.00	53.33	80.00
No. of models	15						15					

Note: This table shows the percentages of significant coefficients for the estimates of 5-year CDS reference entities in Southeast Asia.

Table 5.3A: The percentages of significant negative coefficients for 5-year CDSs: East Asia

Variables	China			Japan			South Korea		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread changes spillovers									
$\Delta CDS_{i,t-1}^{SOV}$	N/A	N/A	N/A	100.00	18.25	22.87	N/A	N/A	100.00
$\Delta CDS_{j,t-1}^{F}$	N/A	N/A	71.47	0.00	0.00	1.47	N/A	N/A	N/A
$\Delta CDS_{k,t-1}^{NF}$	0.00	42.84	N/A	5.14	4.42	56.35	100.00	100.00	0.00

Panel B: Shock and volatility Spillovers	China						Japan						South Korea					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B₁: Shock spillovers																		
$\varepsilon_{i,t-1}^{2}$	0.00	0.00	0.00	50.00	50.00	35.00	0.00	0.00	0.00	29.63	44.44	40.74	0.00	0.00	0.00	66.67	28.57	33.33
$\varepsilon_{j,t-1}^{2}$	0.00	0.00	0.00	33.33	44.44	31.25	0.00	0.00	0.00	47.25	36.78	49.40	0.00	0.00	0.00	61.54	28.00	64.29
$\varepsilon_{k,t-1}^{2}$	0.00	0.00	0.00	46.15	35.71	69.23	0.00	0.00	0.00	40.48	47.62	45.95	0.00	0.00	0.00	45.83	58.33	50.00
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	52.17	42.11	62.50	52.17	62.50	38.46	43.33	44.90	46.00	35.29	47.17	40.48	50.00	42.86	50.00	4.55	50.00	44.44
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	50.00	37.50	60.00	26.67	59.09	64.71	55.56	41.67	51.61	48.39	38.81	42.22	42.86	42.86	53.85	37.50	13.04	38.46
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	57.89	69.23	46.15	46.15	33.33	58.33	46.55	42.86	52.54	43.40	49.21	50.88	33.33	44.00	66.67	64.10	56.67	12.82
B₂: Volatility spillovers																		
$h_{ii,t-1}$	0.00	0.00	0.00	35.19	47.06	26.09	0.00	0.00	0.00	45.39	45.51	30.77	0.00	0.00	0.00	58.14	58.33	30.77
$h_{jj,t-1}$	0.00	0.00	0.00	59.18	23.08	52.83	0.00	0.00	0.00	42.68	27.17	37.58	0.00	0.00	0.00	39.22	23.40	41.43
$h_{kk,t-1}$	0.00	0.00	0.00	22.73	59.18	52.83	0.00	0.00	0.00	30.34	39.76	49.37	0.00	0.00	0.00	26.32	35.48	51.43
$h_{ij,t-1}$	58.82	33.93	68.18	0.00	51.92	49.02	41.57	44.59	40.24	0.00	37.01	46.31	39.07	55.38	30.77	0.00	40.80	59.32
$h_{ik,t-1}$	56.86	37.50	46.00	52.94	0.00	30.43	40.36	40.24	46.54	48.67	0.00	43.75	36.54	45.71	58.39	56.00	0.00	60.00
$h_{jk,t-1}$	19.23	57.69	54.00	58.70	60.00	0.00	33.01	51.97	37.42	39.33	42.24	0.00	33.78	52.86	40.71	35.92	36.62	0.00

Note: This table shows the percentages of significant negative coefficients for the estimates of 5-year CDS reference entities in East Asia.

Table 5.4A: The percentages of significant negative coefficients for 5-year CDSs: Southeast Asia

Variables	Malaysia			Singapore		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread Changes Spillovers						
$\Delta CDS_{i,t-1}^{SOV}$	100.00	75.00	75.00	0.00	N/A	N/A
$\Delta CDS_{j,t-1}^{F}$	0.00	42.86	0.00	N/A	100.00	N/A
$\Delta CDS_{k,t-1}^{NF}$	0.00	0.00	14.28	N/A	N/A	60.01

Panel B: Shocks and Volatility Spillovers	Malaysia						Singapore					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B_1: Shock Spillovers												
$\varepsilon_{i,t-1}^2$	0.00	0.00	0.00	50.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon_{j,t-1}^2$	0.00	0.00	0.00	100	N/A	50.00	0.00	0.00	0.00	0.00	0.00	50.00
$\varepsilon_{k,t-1}^2$	0.00	0.00	0.00	100	0.00	100.00	0.00	0.00	0.00	0.00	100.00	50.00
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	N/A	N/A	0.00	0.00	100.00	100.00	50.00	100.00	33.33	50.00	50.00	100.00
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	0.00	0.00	100.00	N/A	20.00	50.00	0.00	50.00	50.00	100.00	66.67	100.00
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	100.00	100.00	100.00	0.00	50.00	0.00	100.00	0.00	100.00	0.00	0.00	0.00
B_2: Volatility spillovers												
$h_{ii,t-1}$	0.00	0.00	0.00	46.15	64.29	20.00	0.00	0.00	0.00	40.00	41.67	20.00
$h_{jj,t-1}$	0.00	0.00	0.00	42.86	37.50	84.62	0.00	0.00	0.00	55.56	20.00	50.00
$h_{kk,t-1}$	0.00	0.00	0.00	57.14	42.86	23.08	0.00	0.00	0.00	60.00	77.78	25.00
$h_{ij,t-1}$	42.86	46.15	42.86	0.00	85.71	61.54	62.50	40.00	40.00	0.00	40.00	40.00
$h_{ik,t-1}$	42.86	42.86	64.29	21.43	0.00	50.00	75.00	50.00	36.36	28.57	0.00	44.44
$h_{jk,t-1}$	60.00	21.43	92.86	35.71	42.86	0.00	0.00	22.22	60.00	66.67	62.50	0.00

Note: This table shows the percentages of significant negative coefficients for the estimates of 5-year CDS reference entities in Southeast Asia.

Table 5.5A: The averaged values of coefficients for 5-year CDSs: East Asia

Variables	China			Japan			South Korea		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread Changes Spillovers									
$\Delta CDS_{i,t-1}^{SOV}$	0.0000	0.0000	0.0000	-0.3791	0.0762	0.6242	0.0000	0.0000	-0.0742
$\Delta CDS_{j,t-1}^{F}$	0.0000	0.0000	-0.0043	0.000	2.4973	0.0120	0.0000	0.0000	0.0000
$\Delta CDS_{k,t-1}^{NF}$	0.0201	0.0072	0.0000	0.0292	3.8691	-0.0101	-0.0010	-0.0010	0.0021

Panel B: Shocks and Volatility Spillovers	China						Japan						South Korea					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B_1: Shock Spillovers																		
$\varepsilon_{i,t-1}^2$	0.0142	0.0063	0.0037	0.0000	-0.0018	0.0007	0.0032	0.0007	0.0008	0.0000	-0.0001	0.0000	0.0034	0.0004	0.0002	-0.0001	0.0000	0.0001
$\varepsilon_{j,t-1}^2$	0.0103	0.0103	0.0033	0.0001	-0.0002	0.0003	0.0044	0.0044	0.0030	-0.0004	0.0002	0.0002	0.0074	0.0074	0.0004	-0.0007	0.0002	-0.0003
$\varepsilon_{k,t-1}^2$	0.0031	0.0033	0.0031	0.0004	-0.0001	-0.0011	0.0028	0.0030	0.0028	0.0000	-0.0001	-0.0001	0.0061	0.0004	0.0061	0.0001	-0.0006	0.0000
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	-0.0010	-0.0010	-0.0012	0.0049	-0.0008	0.0004	0.0002	-0.0002	0.0007	0.0007	-0.0002	0.0001	-0.0007	-0.0001	-0.0001	0.0018	0.0000	-0.0001
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	-0.0036	0.0003	-0.0008	0.0023	-0.0010	-0.0013	-0.0002	0.0002	0.0001	-0.0001	0.0011	-0.0001	0.0000	0.0000	0.0001	0.0001	0.0018	-0.0001
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	0.0000	-0.0007	0.0013	0.0000	0.0008	-0.0015	-0.0001	-0.0004	-0.0004	0.0000	-0.0001	0.0000	-0.0001	0.0005	-0.0007	-0.0006	-0.0005	0.0036
B_2: Volatility Spillovers																		
$h_{ii,t-1}$	0.8475	0.0016	0.0011	0.0142	0.0034	0.0001	0.4174	0.0011	0.0010	0.0031	-0.0009	0.0002	0.8690	0.0006	0.0009	-0.0029	-0.0073	0.0002
$h_{jj,t-1}$	0.0019	0.8417	0.0010	-0.0112	0.0006	-0.0012	0.0006	0.4254	0.0012	0.0011	-0.0002	-0.0008	0.0011	0.8662	0.0006	0.0054	0.0001	0.0026
$h_{kk,t-1}$	0.0013	0.0010	0.8380	-0.0002	-0.0026	-0.0018	0.0009	0.0011	0.4249	-0.0002	0.0033	0.0004	0.0008	0.0010	0.8728	0.0001	0.0076	0.0003
$h_{ij,t-1}$	-0.0226	0.0283	-0.0009	0.8475	-0.0011	0.0024	0.0018	0.0063	0.0000	0.4235	-0.0010	-0.0010	0.0111	-0.0046	-0.0002	0.8694	0.0032	-0.0075
$h_{ik,t-1}$	-0.0058	0.0004	0.0070	-0.0019	0.8433	0.0149	0.0061	0.0000	-0.0019	0.0014	0.4243	0.0033	0.0157	0.0001	-0.0137	-0.0010	0.8655	-0.0037
$h_{jk,t-1}$	0.0011	-0.0065	-0.0033	-0.0033	-0.0120	0.8402	0.0001	0.0014	-0.0010	0.0033	0.0015	0.4306	0.0001	-0.0007	0.0063	0.0069	0.0060	0.8713

Note: This table shows the averaged values of the coefficients for the estimates of 5-year CDS reference entities in East Asia.

Table 5.6A: The averaged values of the coefficients for 5-year CDSs: Southeast Asia

Variables	Malaysia			Singapore		
	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$	$\Delta CDS_{i,t}^{SOV}$	$\Delta CDS_{j,t}^{F}$	$\Delta CDS_{k,t}^{NF}$
Panel A: Spread Changes Spillovers						
$\Delta CDS_{i,t-1}^{SOV}$	-0.4681	-0.0552	-0.0770	0.0291	0.0000	0.0000
$\Delta CDS_{j,t-1}^{F}$	0.1363	0.0064	0.1071	0.0000	-0.0410	0.0000
$\Delta CDS_{k,t-1}^{NF}$	0.5374	0.2601	0.2093	0.0000	0.0000	-0.0010

Panel B: Shocks and Volatility Spillovers	Malaysia						Singapore					
	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$	$h_{ii,t}$	$h_{jj,t}$	$h_{kk,t}$	$h_{ij,t}$	$h_{ik,t}$	$h_{jk,t}$
B_1: Shock Spillovers												
$\varepsilon_{i,t-1}^{2}$	0.0047	0.0013	0.0010	-0.0001	0.0001	-0.0002	0.0067	0.0005	0.0003	0.0001	0.0001	0.0002
$\varepsilon_{j,t-1}^{2}$	0.0056	0.0056	0.0059	-0.0003	0.0000	-0.0013	0.0081	0.0081	0.0013	0.0005	0.0002	0.0001
$\varepsilon_{k,t-1}^{2}$	0.0062	0.0059	0.0062	-0.0001	0.0021	-0.0012	0.0063	0.0013	0.0063	0.0001	-0.0002	0.0001
$\varepsilon_{i,t-1}\varepsilon_{j,t-1}$	0.0000	0.0000	0.0021	0.0045	-0.0003	-0.0003	-0.0001	-0.0006	-0.0005	0.0068	-0.0002	-0.0005
$\varepsilon_{i,t-1}\varepsilon_{k,t-1}$	0.0003	0.0001	-0.0014	0.0000	0.0038	0.0001	0.0001	0.0004	0.0000	-0.0002	0.0019	-0.0003
$\varepsilon_{j,t-1}\varepsilon_{k,t-1}$	-0.0029	-0.0003	-0.0015	0.0005	-0.0003	0.0047	-0.0002	0.0003	-0.0007	0.0001	0.0004	0.0067
B2: Volatility spillovers												
$h_{ii,t-1}$	0.9157	0.0017	0.0026	-0.0141	0.0003	-0.0004	0.8950	0.0006	0.0008	-0.0005	0.0076	0.0000
$h_{jj,t-1}$	0.0007	0.8625	0.0027	-0.0034	-0.0002	-0.0318	0.0005	0.8367	0.0007	-0.0009	0.0005	-0.0018
$h_{kk,t-1}$	0.0011	0.0019	0.8355	-0.0009	-0.0074	0.0150	0.0034	0.0013	0.7269	0.0003	-0.0132	0.0130
$h_{ij,t-1}$	-0.0067	-0.0283	-0.0027	0.8583	-0.0336	0.0003	-0.0033	-0.0017	-0.0011	0.7749	0.0029	0.0051
$h_{ik,t-1}$	-0.0154	-0.0009	-0.0032	0.0229	0.8435	-0.0157	-0.0227	-0.0012	0.0153	0.0120	0.7793	-0.0013
$h_{jk,t-1}$	0.0001	0.0454	-0.0653	-0.0077	-0.0033	0.7861	0.0025	0.0301	-0.0028	-0.0085	-0.0008	0.7243

Note: This table shows the averaged values of the coefficients for the estimates of 5-year CDS reference entities in Southeast Asia.

Appendices 6.1

Table 6.1A: A summary of the significant parameters for 5-year CDSs: domestic intra-sectoral spillover effects

Parameters		China		Japan		Malaysia		Singapore		South Korea	
		F	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*
Panel A: Mean spread changes spillover effects											
$\gamma_{ij}^{S,C}$	$**$	23.81	30.56	14.29	28.86	0.00	30.00	0.00	0.00	26.67	15.69
	$**^{(-)}$	0.00	0.00	0.00	0.48	N/A	0.00	N/A	N/A	0.00	12.50
$\gamma_{ji}^{S,C}$	$**$	23.81	25.00	47.62	34.73	66.67	70.00	66.67	20.00	40.00	21.57
	$**^{(-)}$	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	3.01
Panel B: Shock ad volatility spillover effects											
$a_{ij}^{S,C}$	$**$	47.62	22.22	42.86	31.38	0.00	20.00	33.33	30.00	24.44	19.61
	$**^{(-)}$	50.00	37.49	66.66	52.55	N/A	50.00	100.00	100.00	9.08	43.35
$a_{ji}^{S,C}$	$**$	19.05	16.67	38.10	33.26	0.00	0.00	0.00	10.00	15.56	19.61
	$**^{(-)}$	49.97	66.65	37.51	51.26	N/A	N/A	N/A	100.00	57.13	43.35
$g_{ij}^{S,C}$	$**$	42.86	30.56	52.38	44.51	33.33	20.00	0.00	20.00	22.22	33.99
	$**^{(-)}$	33.34	27.26	45.46	47.88	0.00	0.00	N/A	50.00	59.99	51.93
$g_{ji}^{S,C}$	$**$	33.33	27.78	19.05	43.05	0.00	20.00	0.00	20.00	28.89	29.41
	$**^{(-)}$	71.44	69.98	75.01	44.65	N/A	50.00	N/A	100.00	53.86	39.99
Panel C: Restriction tests											
H$_0$: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		100.00	100.00	95.24	1001.33	100.00	90.00	100.00	100.00	95.56	98.69
H$_0$: $a_{ij}^{X,C} = a_{ji}^{X,C}$		85.71	97.22	92.86	66.39	100.00	100.00	100.00	80.00	91.11	88.89
H$_0$: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.00	97.78	99.35
No. of pairs		21	36	21	1431	3	10	3	10	45	153

Note: This table shows the percentages of significant parameters and the percentages of significant negative parameters for the estimates from 5-year CDSs.

Table 6.2A: A summary of the averaged values of the parameters for 5-year CDSs: domestic intra-sectoral spillover effects

Parameters	China		Japan		Malaysia		Singapore		South Korea	
	F	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*
Panel A: Mean spread changes spillover effects										
$\gamma_{ij}^{S,C}$	0.0309	0.0528	0.0100	2.2898	0.0000	0.1006	0.0000	0.0000	0.0630	0.0278
	(0.0116)	(0.0184)	(0.0039)	(0.9519)	(0.00001)	(0.0347)	(0.00001)	(0.00001)	(0.0215)	(0.0128)
$\gamma_{ji}^{X,C}$	0.0266	0.0371	0.1508	2.1274	0.1050	0.2338	0.0933	0.0287	0.1183	0.0553
	(0.0119)	(0.0141)	(0.0511)	(0.7933)	(0.0387)	(0.0775)	(0.0463)	(0.0140)	(0.0419)	(0.0202)
Panel B: Shock and volatility spillover effects										
$a_{ij}^{S,C}$	0.0011	0.0291	-0.0117	-0.0032	0.0000	-0.0180	-0.1157	-0.0630	0.0266	0.0091
	(0.0150)	(0.0134)	(0.0201)	(0.0077)	(0.0000)	(0.0122)	(0.0403)	(0.0120)	(0.0093)	(0.0087)
$a_{ji}^{S,C}$	0.0037	-0.0021	0.0083	-0.0033	0.0000	0.0000	0.0000	-0.0011	-0.0039	-0.0018
	(0.0062)	(0.0075)	(0.0090)	(0.0087)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0047)	(0.0055)
$g_{ij}^{S,C}$	-0.0010	0.0176	0.0307	0.0002	0.0147	0.0176	0.0000	-0.0023	-0.0028	0.0022
	(0.0070)	(0.0063)	(0.0153)	(0.0046)	(0.0057)	(0.0075)	(0.0000)	(0.0068)	(0.0024)	(0.0048)
$g_{ji}^{S,C}$	-0.0002	-0.0092	-0.0120	0.0018	0.0000	0.0128	0.0000	-0.0070	-0.0097	0.0084
	(0.0064)	(0.0046)	(0.0019)	(0.0043)	(0.0000)	(0.0046)	(0.0000)	(0.0021)	(0.0038)	(0.0044)
Panel C: Annual correlations										
2009	0.36	0.17	-0.09	0.08	0.42	0.68	0.31	0.18	0.50	0.37
2010	0.32	0.19	-0.07	0.08	0.57	0.70	0.40	0.21	0.55	0.37
2011	0.32	0.19	-0.05	0.09	0.54	0.77	0.45	0.20	0.55	0.37
2012	0.29	0.18	-0.01	0.09	0.57	0.76	0.48	0.17	0.57	0.36
2013	0.30	0.19	0.02	0.10	0.56	0.78	0.59	0.18	0.60	0.38
2014	0.33	0.18	0.02	0.09	0.62	0.76	0.62	0.18	0.60	0.38

Note: This table shows the averaged values of the parameters for the estimates from 5-year CDSs.

Table 6.3A: A summary of the significant parameters for 5-year CDSs: domestic cross-sectoral spillover effects

Parameters		China			Japan			Malaysia			Singapore			South Korea		
		SOV:F	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*
Panel A: Mean spread changes spillover effects																
$\gamma_{ij}^{S,C}$	$**$	71.43	55.56	7.94	14.29	31.48	39.15	33.33	60.00	26.67	66.67	40.00	13.33	0.00	0.00	45.56
	$**^{(-)}$	0.00	0.00	0.00	0.00	0.00	0.68	0.00	66.67	0.00	0.00	0.00	0.00	N/A	N/A	0.00
$\gamma_{ji}^{S,C}$	$**$	0.00	11.11	41.27	42.86	38.89	34.92	100.00	80.00	60.00	0.00	0.00	26.67	0.00	5.56	11.67
	$**^{(-)}$	N/A	0.00	0.00	0.00	4.76	0.76	0.00	0.00	0.00	N/A	N/A	0.00	N/A	100.00	23.81
Panel B: Shock and volatility spillover effects																
$a_{ij}^{S,C}$	$**$	14.29	33.33	34.92	14.29	22.22	44.97	33.33	60.00	13.33	33.33	20.00	6.67	0.00	5.56	21.11
	$**^{(-)}$	100.00	33.33	36.36	0.00	33.33	45.29	100.00	33.33	50.00	100.00	100.00	0.00	N/A	100.00	50.00
$a_{ji}^{S,C}$	$**$	28.57	22.22	25.40	57.14	37.04	10.32	33.33	20.00	26.67	33.33	0.00	0.00	40.00	38.89	22.78
	$**^{(-)}$	0.00	0.00	68.75	50.00	70.00	56.41	100.00	0.00	25.00	0.00	N/A	N/A	50.00	85.71	58.54
$g_{ij}^{S,C}$	$**$	57.14	33.33	50.79	14.29	37.04	46.56	66.67	40.00	26.67	66.67	20.00	0.00	10.00	27.78	31.11
	$**^{(-)}$	0.00	66.67	53.13	0.00	50.00	53.98	50.00	0.00	25.00	0.00	0.00	N/A	100.00	40.00	53.57
$g_{ji}^{S,C}$	$**$	28.57	11.11	49.21	42.86	53.70	26.72	66.67	40.00	20.00	66.67	20.00	6.67	50.00	38.89	32.78
	$**^{(-)}$	100.00	100.00	38.71	66.67	51.72	45.54	50.00	100.00	33.33	100.00	100.00	0.00	20.00	57.14	40.68
Panel C: Restriction tests																
H_0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		100.00	88.89	98.41	100.00	98.15	99.47	100.00	100.00	93.33	100.00	80.00	93.33	100.00	94.44	98.89
H_0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		85.71	88.89	95.24	71.43	90.74	79.37	66.67	100.00	80.00	66.67	60.00	100.00	70.00	77.78	94.44
H_0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	85.71	100.00	99.74	100.00	100.00	100.00	100.00	100.00	100.00	90.00	100.00	99.44
No. of pairs		7	9	63	7	54	378	3	5	15	3	5	15	10	18	180

Note: This tables show the percentages of significant parameters and the percentages of significant negative parameters for the estimates from 5-year CDSs.

Table 6.4A: A summary of the averaged values of parameters for 5-year CDSs: domestic cross-sectoral spillover effects

Parameters	China			Japan			Malaysia			Singapore			South Korea		
	SOV:F	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*
Panel A: Mean spread changes spillover effects															
$\gamma_{ij}^{S,C}$	0.1181	0.0640	0.0032	3.2090	1.5313	0.0265	0.0196	-0.0973	0.0730	0.0428	0.0413	0.0069	0.0000	0.0000	0.1158
	(0.0349)	(0.0210)	(0.0014)	(1.4024)	(0.6501)	(0.0101)	(0.0086)	(0.0561)	(0.0291)	(0.015)	(0.0153)	(0.0032)	(0.00001)	(0.00001)	(0.0375)
$\gamma_{ji}^{S,C}$	0.0000	0.0179	0.0840	0.0004	0.0309	3.9119	0.2589	0.5730	0.0940	0.0000	0.0000	0.0239	0.0000	-0.0006	0.0148
	(0.00001)	(0.0086)	(0.0322)	(0.0002)	(0.012)	(1.5073)	(0.0992)	(0.1254)	(0.0350)	(0.00001)	(0.00001)	(0.0093)	(0.00001)	(0.0002)	(0.0085)
Panel B: Shock and volatility spillover effects															
$a_{ij}^{S,C}$	-0.0221	0.0006	0.0054	0.0173	0.0087	-0.0016	-0.0550	0.0150	0.0001	-0.0073	-0.0322	0.0061	0.0000	-0.0059	-0.0019
	(0.0039)	(0.0051)	(0.0140)	(0.0086)	(0.0048)	(0.0048)	(0.0100)	(0.0166)	(0.0005)	(0.0017)	(0.0106)	(0.0026)	(0.0000)	(0.0351)	(0.0071)
$a_{ji}^{S,C}$	0.0373	0.0189	-0.0272	-0.0101	-0.0115	-0.0012	-0.0650	0.0086	0.0216	0.0490	0.0000	0.0000	0.0008	-0.0019	-0.0171
	(0.0134)	(0.0082)	(0.0085)	(0.0027)	(0.0051)	(0.0042)	(0.0183)	(0.0042)	(0.0157)	(0.0123)	(0.0000)	(0.0000)	(0.0035)	(0.0023)	(0.0105)
$g_{ij}^{S,C}$	0.0149	-0.0151	-0.0103	0.0331	-0.0103	-0.0009	0.0117	0.0186	0.0060	0.0583	0.0054	0.0000	-0.0063	0.0053	-0.0020
	(0.0030)	(0.0061)	(0.0060)	(0.0060)	(0.0029)	(0.0021)	(0.0080)	(0.0022)	(0.0025)	(0.0187)	(0.0020)	(0.0000)	(0.0006)	(0.2578)	(0.0044)
$g_{ji}^{S,C}$	-0.0151	-0.0133	0.0142	-0.0144	-0.0015	0.0011	0.0123	-0.0044	0.0014	-0.1390	-0.0208	0.0011	0.0096	-0.0001	0.0106
	(0.0021)	(0.0038)	(0.0063)	(0.0017)	(0.0033)	(0.0040)	(0.0063)	(0.0016)	(0.0008)	(0.0550)	(0.0038)	(0.0005)	(0.0016)	(0.0198)	(0.0092)
Panel C : Annual correlations															
2009	0.36	0.33	0.18	-0.39	0.01	0.04	0.41	0.77	0.40	0.31	0.13	0.19	0.01	-0.04	0.46
2010	0.37	0.27	0.18	-0.34	0.05	0.06	0.50	0.78	0.41	0.28	0.06	0.20	0.04	-0.02	0.47
2011	0.36	0.33	0.18	-0.33	0.07	0.07	0.47	0.81	0.41	0.32	0.07	0.21	0.04	-0.01	0.46
2012	0.36	0.33	0.19	-0.31	0.01	0.07	0.56	0.80	0.41	0.29	0.06	0.22	0.02	0.01	0.48
2013	0.39	0.34	0.19	-0.30	0.04	0.09	0.49	0.81	0.46	0.29	0.07	0.24	0.07	0.00	0.48
2014	0.41	0.34	0.18	-0.31	0.04	0.09	0.57	0.81	0.46	0.31	0.04	0.23	0.11	0.00	0.48

Note: This tables show the averaged values of parameters for the estimates from 5-year CDSs and the respective annual credit risk correlations.

Table 6.5A: A summary of the significant parameters for 5-year CDSs: regional intra-sectoral spillover effects

Parameters		**Regional pairings of financial institutions**									
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects											
$\gamma_{ij}^{S,C}$	$**$	34.69	23.81	14.29	0.00	0.00	14.29	11.43	55.56	10.00	0.00
	$**^{(-)}$	5.88	0.00	0.00	N/A	N/A	0.00	12.50	0.00	0.00	N/A
$\gamma_{ji}^{S,C}$	$**$	10.20	52.38	0.00	58.57	38.10	23.81	44.29	11.11	43.33	50.00
	$**^{(-)}$	0.00	0.00	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Panel B: Shock and volatility spillover effects											
$a_{ij}^{S,C}$	$**$	30.61	52.38	9.52	20.00	19.05	23.81	27.14	11.11	33.33	40.00
	$**^{(-)}$	20.41	33.33	0.00	10.00	9.52	14.29	0.00	11.11	33.33	23.33
$a_{ji}^{S,C}$	$**$	18.37	9.52	9.52	20.00	19.05	9.52	18.57	0.00	23.33	13.33
	$**^{(-)}$	12.24	0.00	9.52	8.57	4.76	0.00	0.00	0.00	10.00	6.67
$g_{ij}^{S,C}$	$**$	51.02	52.38	23.81	27.14	38.10	42.86	38.57	11.11	36.67	53.33
	$**^{(-)}$	18.37	23.81	9.52	10.00	23.81	19.05	0.00	0.00	10.00	10.00
$g_{ji}^{S,C}$	$**$	38.78	38.10	33.33	27.14	23.81	33.33	31.43	33.33	26.67	50.00
	$**^{(-)}$	24.49	14.29	9.52	20.00	19.05	28.57	1.43	22.22	16.67	40.00
Panel C: Restriction tests											
H_0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		97.96	95.24	95.24	97.14	100.00	95.24	98.57	100.00	96.67	96.67
H_0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		75.51	61.90	57.14	84.29	71.43	80.95	87.14	88.89	83.33	80.00
H_0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	100.00	95.24	100.00	98.57	100.00	100.00	100.00
No. of pairs		49	21	21	70	21	21	70	9	30	30

Note: This table shows the percentages of significant parameters and the percentages of significant negative parameters for the estimates from 5-year CDSs.

Table 6.5A: continued

Parameters		Regional pairings of non-financial firms									
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects											
$\gamma_{ij}^{S,C}$	$**$	16.87	20.00	15.56	23.46	17.78	21.48	13.27	36.00	44.44	3.33
	$**^{(-)}$	2.44	0.00	0.00	0.00	0.00	0.00	3.88	0.00	0.00	66.67
$\gamma_{ji}^{S,C}$	$**$	19.34	53.33	2.22	20.37	24.81	12.96	22.94	0.00	23.33	24.44
	$**^{(-)}$	1.06	0.00	100.00	3.03	0.00	5.71	1.35	N/A	9.52	0.00
Panel B: Shock and volatility spillover effects											
$a_{ij}^{S,C}$	$**$	20.78	26.67	20.00	30.86	54.07	36.30	52.37	20.00	18.89	22.83
	$**^{(-)}$	10.29	15.56	13.33	17.28	27.41	18.33	25.93	4.00	11.11	15.56
$a_{ji}^{S,C}$	$**$	43.21	11.11	31.11	16.05	22.22	17.04	20.47	16.00	15.56	13.04
	$**^{(-)}$	19.96	2.22	20.00	8.64	10.37	10.83	10.70	12.00	6.67	3.33
$g_{ij}^{S,C}$	$**$	34.77	44.44	40.00	40.12	63.33	48.89	61.01	32.00	32.22	34.78
	$**^{(-)}$	15.02	22.22	24.44	17.28	25.19	20.83	27.98	16.00	16.67	13.33
$g_{ji}^{S,C}$	$**$	51.23	22.22	42.22	29.63	36.30	30.74	35.91	36.00	26.67	26.09
	$**^{(-)}$	24.90	6.67	15.56	16.05	18.89	16.25	17.49	20.00	13.33	16.67
Panel C: Restriction tests											
H_0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		99.79	97.78	97.78	98.77	99.63	100.00	99.79	96.00	97.78	98.89
H_0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		93.42	82.22	88.89	92.59	77.04	70.00	89.51	80.00	88.89	92.22
H_0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	99.38	100.00	100.00	99.90	100.00	100.00	100.00
No. of pairs		486	45	45	162	270	270	972	25	90	90

Table 6.6A: The averaged values of parameters for 5-year CDSs: regional intra-sectoral spillover effects

Parameters	Regional pairings of financial institutions									
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects										
$\gamma_{ij}^{S,C}$	0.0269	0.0204	0.0083	0.0000	0.0000	0.0047	0.0157	0.0312	0.0253	0.0000
	(0.0102)	(0.0084)	(0.0038)	(0.00001)	(0.00001)	(0.0019)	(0.0086)	(0.0123)	(0.0101)	(0.00001)
$\gamma_{ji}^{S,C}$	0.0114	0.0756	0.0000	0.0729	0.0405	0.0450	0.0420	0.0187	0.0368	0.0228
	(0.0053)	(0.0281)	(0.00001)	(0.025)	(0.0150)	(0.0171)	(0.0165)	(0.0083)	(0.0140)	(0.0086)
Panel B: Shock and volatility spillover effects										
$a_{ij}^{S,C}$	-0.0215	-0.0289	0.0137	0.0001	0.0130	-0.0159	0.0121	-0.0074	-0.0450	0.0006
	(0.0128)	(0.0156)	(0.0038)	(0.0074)	(0.0033)	(0.0132)	(0.0104)	(0.0024)	(0.0138)	(0.0088)
$a_{ji}^{S,C}$	-0.0128	0.0484	-0.0142	0.0097	0.0029	0.0164	0.0041	0.0000	-0.0098	0.0126
	(0.0130)	(0.0086)	(0.0039)	(0.0129)	(0.0042)	(0.0051)	(0.0076)	(0.0000)	(0.0048)	(0.0082)
$g_{ij}^{S,C}$	0.0022	0.0453	-0.0050	0.0021	-0.0002	0.0162	0.0033	0.0114	0.0093	0.0127
	(0.0040)	(0.0020)	(0.0029)	(0.0039)	(0.0083)	(0.0121)	(0.0067)	(0.0027)	(0.0039)	(0.0032)
$g_{ji}^{S,C}$	0.0092	-0.0196	0.0087	-0.0122	0.0008	-0.0196	-0.0165	-0.0079	-0.0023	-0.0591
	(0.0052)	(0.0065)	(0.0078)	(0.0052)	(0.0049)	(0.0062)	(0.0055)	(0.0073)	(0.0041)	(0.0156)
Panel C: Annual correlations										
2009	0.18	0.12	0.16	0.20	0.11	-0.03	0.11	0.11	0.23	0.12
2010	0.20	0.11	0.24	0.21	0.12	0.05	0.10	0.10	0.22	0.15
2011	0.21	0.10	0.23	0.22	0.14	0.08	0.11	0.12	0.24	0.19
2012	0.18	0.07	0.22	0.16	0.17	0.06	0.09	0.10	0.23	0.16
2013	0.18	0.07	0.25	0.18	0.17	0.09	0.10	0.12	0.23	0.22
2014	0.16	0.06	0.27	0.19	0.17	0.12	0.10	0.12	0.24	0.23

Note: This table shows the averaged values of parameters for the estimates from 5-year CDSs.

Table 6.6A: continued

Parameters	Regional pairings of non-financial firms									
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects										
$\gamma_{ij}^{S,C}$	0.0302	0.0407	0.0181	0.0577	1.2665	1.2498	1.3175	0.0299	0.1204	-0.0024
	(0.0111)	(0.0157)	(0.0078)	(0.0213)	(0.5246)	(0.5067)	(0.5836)	(0.0123)	(0.0400)	(0.0029)
$\gamma_{ji}^{S,C}$	1.0139	0.0648	-0.0008	0.0151	0.0318	0.0162	0.0190	0.0000	0.0308	0.0204
	(0.4271)	(0.0222)	(0.0002)	(0.0061)	(0.0110)	(0.0062)	(0.0077)	(0.00001)	(0.0128)	(0.0073)
Panel B: Shock and volatility spillover effects										
$a_{ij}^{S,C}$	0.0000	-0.0122	-0.0348	-0.0002	-0.0032	-0.0015	0.0007	0.0145	0.0018	-0.0073
	(0.0088)	(0.0121)	(0.0075)	(0.0091)	(0.0054)	(0.0061)	(0.0065)	(0.0092)	(0.0076)	(0.0066)
$a_{ji}^{S,C}$	-0.0018	0.0075	-0.0327	0.0016	-0.0030	-0.0011	-0.0017	-0.0066	0.0003	0.0093
	(0.0076)	(0.0029)	(0.0112)	(0.0086)	(0.0064)	(0.0042)	(0.0082)	(0.0039)	(0.0056)	(0.0051)
$g_{ij}^{S,C}$	0.0046	-0.0045	-0.0056	-0.0003	0.0002	0.0010	-0.0020	-0.0066	-0.0077	0.0092
	(0.0052)	(0.0052)	(0.0081)	(0.0040)	(0.0036)	(0.0046)	(0.0030)	(0.0056)	(0.0043)	(0.0035)
$g_{ji}^{S,C}$	-0.0062	-0.0074	0.0268	-0.0001	0.0077	0.0046	0.0014	-0.0102	-0.0052	-0.0251
	(0.0039)	(0.0042)	(0.0059)	(0.0064)	(0.0072)	(0.0045)	(0.0072)	(0.0044)	(0.0038)	(0.0105)
Panel C: Annual correlations										
2009	0.01	0.20	0.01	0.16	0.01	0.08	0.03	0.11	0.33	0.12
2010	0.01	0.19	0.05	0.14	0.01	0.09	0.02	0.16	0.34	0.13
2011	0.02	0.21	0.05	0.15	0.02	0.09	0.02	0.15	0.36	0.13
2012	0.01	0.19	0.06	0.14	0.01	0.09	0.03	0.16	0.35	0.11
2013	0.01	0.20	0.06	0.14	0.01	0.09	0.02	0.16	0.34	0.11
2014	0.01	0.21	0.06	0.14	0.02	0.10	0.02	0.18	0.34	0.12

Table 6.6A: continued

Parameters	Regional pairings of sovereign debtors									
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:MY*	*JP:SG*	*JP:SK*	*MY:SG*	*MY:SK*	*SG:SK*
Panel A: Mean spread changes spillover effects										
$\gamma_{ij}^{S,C}$	0.0000	0.4283	0.0000	0.0000	2.1242	-1.8971	0.0000	-0.0961	0.0000	0.0000
	(0.00001)	(0.0558)	(0.00001)	(0.00001)	(0.0002)	(0.00001)	(0.00001)	(0.1091)	(0.00001)	(0.00001)
$\gamma_{ji}^{S,C}$	0.0000	-0.1436	0.0000	0.0000	0.0005	0.0009	0.0000	0.5542	0.0000	0.0000
	(0.00001)	(0.0558)	(0.00001)	(0.00001)	(0.0002)	(0.0004)	(0.00001)	(0.1091)	(0.00001)	(0.00001)
Panel B: Shock and volatility spillover effects										
$a_{ij}^{S,C}$	0.0000	0.0000	0.0000	0.0000	-0.0224	-0.0033	0.0000	0.0000	0.0000	0.0000
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.0016)	(0.0007)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
$a_{ji}^{S,C}$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2051	0.0000	-0.0176
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.0000)	(0.00001)	(0.00001)	(0.0291)	(0.00001)	(0.0057)
$g_{ij}^{S,C}$	0.0000	0.0000	0.0000	0.0000	0.0118	0.0009	0.0000	0.0455	0.0000	0.0000
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.0012)	(0.0002)	(0.00001)	(0.0094)	(0.00001)	(0.00001)
$g_{ji}^{S,C}$	0.0000	0.0680	0.0000	0.0000	-0.0585	0.0000	0.0000	-0.1315	0.0202	0.0000
	(0.00001)	(0.0268)	(0.00001)	(0.00001)	(0.0182)	(0.00001)	(0.00001)	(0.0141)	(0.0021)	(0.00001)
Panel C: Annual correlations										
2009	0.31	0.37	0.41	0.35	0.35	0.35	0.36	0.40	0.39	0.31
2010	0.33	0.38	0.40	0.37	0.37	0.36	0.35	0.41	0.38	0.32
2011	0.32	0.36	0.36	0.34	0.34	0.33	0.33	0.39	0.36	0.29
2012	0.38	0.42	0.42	0.39	0.40	0.39	0.40	0.43	0.40	0.34
2013	0.37	0.40	0.38	0.38	0.38	0.37	0.39	0.41	0.39	0.32

Table 6.7A: A summary of the significant parameters for 5-year CDSs: home-country sovereigns and foreign financial institutions

Parameters		**East Asian sovereigns and financial institutions in other countries**											
		Chinese pairings				Japanese pairings				South Korean pairings			
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects													
$\gamma_{ij}^{S,C}$	$**$	57.14	66.67	66.67	50.00	14.29	33.33	0.00	0.00	0.00	0.00	0.00	0.00
	$**^{(-)}$	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A
$\gamma_{ji}^{S,C}$	$**$	0.00	0.00	0.00	10.00	14.29	33.33	0.00	40.00	0.00	0.00	0.00	0.00
	$**^{(-)}$	N/A	N/A	N/A	0.00	0.00	0.00	N/A	0.00	N/A	N/A	N/A	N/A
Panel B: Shock and volatility spillover effects													
$a_{ij}^{S,C}$	$**$	28.57	33.33	0.00	30.00	0.00	66.67	66.67	70.00	14.29	0.00	0.00	0.00
	$**^{(-)}$	50.00	0.00	N/A	66.67	N/A	50.00	50.00	42.86	0.00	N/A	N/A	N/A
$a_{ji}^{S,C}$	$**$	42.86	0.00	66.67	20.00	42.86	33.33	0.00	10.00	28.57	42.86	33.33	0.00
	$**^{(-)}$	33.33	N/A	100.00	50.00	66.67	100.00	N/A	0.00	100.00	66.67	100.00	N/A
$g_{ij}^{S,C}$	$**$	28.57	33.33	0.00	40.00	14.29	66.67	100.00	60.00	14.29	28.57	33.33	0.00
	$**^{(-)}$	50.00	100.00	N/A	50.00	0.00	0.00	66.67	33.33	100.00	50.00	100.00	N/A
$g_{ji}^{S,C}$	$**$	14.29	0.00	66.67	40.00	42.86	33.33	0.00	40.00	28.57	14.29	33.33	0.00
	$**^{(-)}$	100.00	N/A	0.00	75.00	66.67	100.00	N/A	75.00	50.00	100.00	0.00	N/A
Panel C: Restriction tests													
H_0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		100.00	100.00	100.00	90.00	85.71	66.67	100.00	90.00	100.00	100.00	100.00	100.00
H_0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		85.71	66.67	66.67	80.00	85.71	66.67	66.67	50.00	57.14	71.43	66.67	66.67
H_0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.00	100.00	100.00	100.00	100.00
No. of pairs		7	3	3	10	7	3	3	10	7	7	3	3

Note: This table shows the percentages of significant and the percentages of significant negative parameters for the estimates of 5-year CDSs.

Table 6.7A: continued

Parameters		Southeast Asian sovereigns and financial institutions in other countries							
		Malaysian pairings				Singaporean pairings			
		MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects									
$\gamma_{ij}^{S,C}$	$**$	14.29	42.86	0.00	10.00	85.71	42.86	66.67	40.00
	$**^{(-)}$	0.00	0.00	N/A	100.00	0.00	0.00	0.00	0.00
$\gamma_{ji}^{S,C}$	$**$	28.57	14.29	0.00	90.00	28.57	0.00	0.00	0.00
	$**^{(-)}$	0.00	0.00	N/A	0.00	100.00	N/A	N/A	N/A
Panel B: Shock and volatility spillover effects									
$a_{ij}^{S,C}$	$**$	14.29	42.86	33.33	0.00	0.00	28.57	0.00	0.00
	$**^{(-)}$	33.33	33.33	100.00	N/A	N/A	50.00	N/A	N/A
$a_{ji}^{S,C}$	$**$	0.00	0.00	66.67	30.00	28.57	14.29	14.29	10.00
	$**^{(-)}$	N/A	N/A	50.00	33.33	0.00	0.00	0.00	100.00
$g_{ij}^{S,C}$	$**$	42.86	42.86	33.33	10.00	14.29	28.57	0.00	20.00
	$**^{(-)}$	66.67	66.67	100.00	0.00	100.00	100.00	N/A	50.00
$g_{ji}^{S,C}$	$**$	14.29	28.57	66.67	30.00	0.00	28.57	0.00	30.00
	$**^{(-)}$	0.00	0.00	50.00	100.00	N/A	0.00	N/A	66.67
Panel C: Restriction tests									
H_0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		85.71	85.71	66.67	100.00	100.00	85.71	100.00	90.00
H_0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		71.43	85.71	66.67	80.00	85.71	85.71	33.33	90.00
H_0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	100.00	100.00	85.71	100.00	100.00
No. of pairs		7	7	3	10	7	7	3	10

Table 6.8A: The averaged values of parameters for 5-year CDSs: home country sovereigns and foreign financial institutions

Parameters	East Asian sovereigns and financial institutions in other countries											
	Chinese pairings				Japanese pairings				South Korean pairings			
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects												
$\gamma_{ij}^{S,C}$	0.0619	0.0808	0.0371	0.1515	0.7006	0.9041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0217)	(0.0255)	(0.014)	(0.0521)	(0.3379)	(0.3974)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\gamma_{ji}^{S,C}$	0.0000	0.0000	0.0000	0.0232	0.0001	0.0003	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0099)	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Panel B: Shock and volatility spillover effects												
$a_{ij}^{S,C}$	-0.0109	0.0267	0.0000	-0.0165	0.0000	-0.0217	0.0000	0.0155	0.0056	0.0000	0.0000	0.0000
	(0.0190)	(0.0114)	(0.0000)	(0.0235)	(0.0000)	(0.0014)	(0.0022)	(0.0025)	(0.0011)	(0.0000)	(0.0000)	(0.0000)
$a_{ji}^{S,C}$	0.0379	0.0000	-0.0443	0.0054	-0.0399	-0.0390	0.0000	0.0007	-0.0244	-0.0133	-0.0320	0.0000
	(0.0317)	(0.0000)	(0.0187)	(0.0044)	(0.0035)	(0.0029)	(0.0000)	(0.0001)	(0.0060)	(0.0073)	(0.0086)	(0.0000)
$g_{ij}^{S,C}$	0.0064	-0.0063	0.0000	-0.0115	0.0003	0.0050	-0.0020	0.0083	-0.0007	-0.0071	-0.0263	0.0000
	(0.0018)	(0.0022)	(0.0000)	(0.0085)	(0.0001)	(0.0001)	(0.0008)	(0.0013)	(0.0001)	(0.0019)	(0.0047)	(0.0000)
$g_{ji}^{S,C}$	-0.0064	0.0000	0.0273	-0.0212	-0.0116	-0.0147	0.0000	-0.0439	0.0067	-0.0061	0.0293	0.0000
	(0.0020)	(0.0000)	(0.0103)	(0.0048)	(0.0038)	(0.0008)	(0.0000)	(0.0075)	(0.0002)	(0.0019)	(0.0030)	(0.0000)
Panel C: Annual correlations												
2009	0.12	0.48	0.14	0.56	-0.30	0.38	-0.18	0.04	0.09	0.02	0.14	0.13
2010	0.17	0.56	0.17	0.51	-0.19	0.41	-0.29	-0.02	0.00	0.05	0.14	-0.01
2011	0.20	0.60	0.26	0.52	-0.19	0.37	-0.30	-0.01	-0.03	0.07	0.17	0.00
2012	0.18	0.65	0.22	0.56	-0.22	0.49	-0.26	0.00	-0.05	0.06	0.14	-0.05
2013	0.17	0.69	0.31	0.57	-0.11	0.49	-0.26	-0.02	-0.07	0.05	0.13	-0.11
2014	0.16	0.72	0.37	0.57	-0.01	0.53	-0.29	-0.04	-0.04	0.02	0.14	-0.15

Note: The averaged values of parameters for the estimates from 5-year CDSs.

Table 6.8A: continued

Parameters	Southeast Asian sovereigns and financial institutions in other countries							
	Malaysian pairings				Singaporean pairings			
	MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects								
$\gamma_{ij}^{s,c}$	0.0113	0.0329	0.0000	-0.0155	0.1732	0.0548	0.1178	0.1057
	(0.0052)	(0.0123)	(0.00001)	(0.0052)	(0.0481)	(0.0163)	(0.0383)	(0.0412)
$\gamma_{ji}^{s,c}$	0.0402	0.0249	0.0000	0.2147	-0.0256	0.0000	0.0000	0.0000
	(0.0182)	(0.0109)	(0.00001)	(0.0645)	(0.0111)	(0.00001)	(0.00001)	(0.00001)
Panel B: Shock and volatility spillover effects								
$a_{ij}^{s,c}$	0.0137	0.0009	-0.0390	0.0000	0.0000	-0.0253	0.0000	0.0000
	(0.0058)	(0.0105)	(0.0003)	(0.0000)	(0.0000)	(0.0224)	(0.0000)	(0.0000)
$a_{ji}^{s,c}$	0.0000	0.0000	0.0047	0.0138	0.0106	0.0040	0.0136	-0.0226
	(0.0000)	(0.0000)	(0.0042)	(0.0160)	(0.0021)	(0.0015)	(0.0123)	(0.0067)
$g_{ij}^{s,c}$	0.0053	-0.0337	-0.0337	0.0021	-0.0031	-0.0409	0.0000	0.0051
	(0.0066)	(0.0246)	(0.0002)	(0.0003)	(0.0009)	(0.0119)	(0.0000)	(0.0013)
$g_{ji}^{s,c}$	-0.0106	0.0300	0.0020	-0.0231	0.0000	0.0217	0.0000	-0.0008
	(0.0027)	(0.0091)	(0.0025)	(0.0026)	(0.0000)	(0.0071)	(0.0000)	(0.0048)
Panel C: Annual correlations								
2009	0.45	0.34	0.24	0.47	0.32	-0.03	0.45	0.55
2010	0.49	0.36	0.31	0.45	0.40	0.12	0.44	0.55
2011	0.49	0.40	0.32	0.46	0.43	0.18	0.43	0.54
2012	0.49	0.36	0.30	0.43	0.38	0.16	0.44	0.56
2013	0.50	0.32	0.36	0.44	0.38	0.18	0.44	0.56
2014	0.50	0.33	0.34	0.42	0.40	0.20	0.44	0.52

Table 6.9A: A summary of the significant parameters for 5-year CDSs: home-county sovereigns and foreign non-financial firms

Parameters		East Asian sovereigns and non-financial firms in other countries											
		Chinese pairings				Japanese pairings				South Korean pairings			
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects													
$\gamma_{ij}^{S,C}$	$**$	24.07	80.00	40.00	72.22	0.00	0.00	0.00	16.67	0.00	3.70	0.00	0.00
	$**^{(-)}$	0.00	0.00	0.00	0.00	N/A	N/A	N/A	0.00	N/A	0.00	N/A	N/A
$\gamma_{ji}^{S,C}$	$**$	11.11	0.00	0.00	11.11	77.78	100.00	0.00	44.44	0.00	1.85	0.00	0.00
	$**^{(-)}$	0.00	N/A	N/A	100.00	0.00	0.00	N/A	0.00	N/A	0.00	N/A	N/A
Panel B: Shock and volatility spillover effects													
$a_{ij}^{S,C}$	$**$	18.52	40.00	20.00	16.67	0.00	100.00	60.00	66.67	0.00	22.22	0.00	0.00
	$**^{(-)}$	50.00	0.00	0.00	66.67	N/A	20.00	33.33	25.00	N/A	33.33	N/A	N/A
$a_{ji}^{S,C}$	$**$	48.15	40.00	40.00	27.78	55.56	40.00	20.00	22.22	33.33	24.07	20.00	20.00
	$**^{(-)}$	38.46	100.00	100.00	60.00	40.00	50.00	100.00	100.00	66.67	61.54	100.00	100.00
$g_{ij}^{S,C}$	$**$	29.63	60.00	60.00	38.89	11.11	100.00	20.00	83.33	0.00	38.89	20.00	0.00
	$**^{(-)}$	68.75	66.67	66.67	71.43	0.00	40.00	100.00	60.00	N/A	66.67	0.00	N/A
$g_{ji}^{S,C}$	$**$	59.26	20.00	20.00	33.33	44.44	40.00	20.00	44.44	44.44	35.19	20.00	0.00
	$**^{(-)}$	46.88	0.00	0.00	50.00	75.00	0.00	0.00	37.50	50.00	52.63	100.00	N/A
Panel C: Restriction tests													
H0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		100.00	100.00	100.00	94.44	88.89	100.00	100.00	94.44	88.89	98.15	80.00	80.00
H0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		92.59	60.00	60.00	88.89	88.89	80.00	60.00	77.78	100.00	92.59	80.00	80.00
H0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	94.44	100.00	100.00	100.00	100.00	100.00	98.15	100.00	100.00
No. of pairs		54	5	5	18	9	5	5	18	9	54	5	5

Note: This table shows the percentages of significant parameters and the percentages of significant negative parameters for the estimates from 5-year CDSs.

Table 6.9A: continued

Parameters		Southeast Asian sovereigns and non-financial firms in other countries							
		Malaysian pairings				Singaporean pairings			
		MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects									
$\gamma_{ij}^{S,C}$	$**$	11.11	18.52	20.00	16.67	66.67	18.52	100.00	77.78
	$**^{(-)}$	0.00	0.00	0.00	66.67	0.00	0.00	0.00	0.00
$\gamma_{ji}^{S,C}$	$**$	44.44	29.63	0.00	61.11	0.00	9.26	0.00	5.56
	$**^{(-)}$	0.00	0.00	N/A	0.00	N/A	0.00	N/A	100.00
Panel B: Shock and volatility spillover effects									
$a_{ij}^{S,C}$	$**$	22.22	46.30	0.00	27.78	33.33	44.44	0.00	16.67
	$**^{(-)}$	0.00	40.00	N/A	40.00	66.67	50.00	N/A	33.33
$a_{ji}^{S,C}$	$**$	0.00	11.11	20.00	33.33	0.00	9.26	0.00	22.22
	$**^{(-)}$	N/A	50.00	100.00	50.00	N/A	20.00	N/A	50.00
$g_{ij}^{S,C}$	$**$	11.11	48.15	20.00	38.89	33.33	35.19	40.00	16.67
	$**^{(-)}$	100.00	61.54	0.00	28.57	33.33	63.16	0.00	33.33
$g_{ji}^{S,C}$	$**$	0.00	11.11	0.00	55.56	22.22	7.41	0.00	16.67
	$**^{(-)}$	N/A	33.33	N/A	50.00	100.00	50.00	N/A	66.67
Panel C: Restriction tests									
H_0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		100.00	100.00	100.00	94.44	88.89	96.30	80.00	94.44
H_0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		88.89	92.59	80.00	94.44	77.78	90.74	80.00	83.33
H_0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	100.00	100.00	98.15	100.00	100.00
No. of pairs		9	54	5	18	9	54	5	18

Table 6.10A: The averaged values of parameters for 5-year CDSs: home-country sovereigns and foreign non-financial firms

Parameters	**East Asian sovereigns and non-financial firms in other countries**											
	Chinese pairings				Japanese pairings				South Korean pairings			
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects												
$\gamma_{ij}^{S,C}$	0.0298	0.1732	0.0328	0.3053	0.0000	0.0000	0.0000	0.2442	0.0000	0.0001	0.0000	0.0000
	(0.0107)	(0.0542)	(0.0107)	(0.0838)	(0.00001)	(0.00001)	(0.00001)	(0.1672)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
$\gamma_{ji}^{S,C}$	0.1588	0.0000	0.0000	-0.0276	0.0008	0.0009	0.0000	0.0003	0.0000	0.0147	0.0000	0.0000
	(0.4620)	(0.00001)	(0.00001)	(0.0095)	(0.0003)	(0.0003)	(0.00001)	(0.0001)	(0.00001)	(0.0068)	(0.00001)	(0.00001)
Panel B: Shock and volatility spillover effects												
$a_{ij}^{S,C}$	0.0141	0.0896	0.0022	0.0220	0.0000	0.0080	-0.0012	-0.0392	0.0000	0.0214	0.0000	0.0000
	(0.0086)	(0.0321)	(0.0002)	(0.0090)	(0.00001)	(0.0004)	(0.0065)	(0.0058)	(0.00001)	(0.0028)	(0.00001)	(0.00001)
$a_{ji}^{S,C}$	0.0066	-0.0784	-0.0194	-0.0075	0.0087	0.0256	-0.0022	-0.0320	-0.0010	-0.0033	-0.0172	-0.0096
	(0.0055)	(0.0144)	(0.0062)	(0.0090)	(0.0030)	(0.0272)	(0.0001)	(0.0066)	(0.0020)	(0.0051)	(0.0073)	(0.0047)
$g_{ij}^{S,C}$	-0.0134	-0.0082	-0.0184	-0.0099	0.0587	0.0000	-0.0322	-0.0283	0.0000	-0.0038	0.0018	0.0000
	(0.0018)	(0.0059)	(0.0095)	(0.0044)	(0.0231)	(0.0001)	(0.0001)	(0.0018)	(0.00001)	(0.0029)	(0.0008)	(0.0000)
$g_{ji}^{S,C}$	0.0112	0.0130	0.0070	-0.0020	0.0014	0.0754	0.0036	0.0186	-0.0008	0.0069	-0.0178	0.0000
	(0.0028)	(0.0025)	(0.0032)	(0.0101)	(0.0014)	(0.0076)	(0.0000)	(0.0026)	(0.0017)	(0.0022)	(0.0022)	(0.0000)
Panel C: Annual correlations												
2009	0.10	0.19	-0.02	0.49	0.08	0.18	0.12	-0.01	-0.02	-0.09	0.02	0.13
2010	0.08	0.16	-0.01	0.54	0.09	0.06	0.10	0.01	0.08	-0.07	0.08	0.12
2011	0.07	0.16	0.03	0.53	0.09	0.06	0.12	0.03	0.09	-0.05	0.09	0.12
2012	0.07	0.17	0.03	0.54	0.07	0.06	0.12	0.03	0.09	-0.09	0.08	0.12
2013	0.04	0.18	0.09	0.56	0.06	0.09	0.11	-0.02	0.09	-0.09	0.06	0.12
2014	0.02	0.18	0.13	0.57	0.05	0.03	0.08	0.00	0.10	-0.09	0.10	0.11

Note: This table shows the averaged values of the parameters for the estimates of 5-year CDSs.

Table 6.10A: continued

Parameters	Southeast Asian sovereigns and non-financial firms in other countries							
	Malaysian pairings				Singaporean pairings			
	MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
$\gamma_{ij}^{S,C}$	0.0029	0.0211	0.0029	-0.0004	0.1183	0.0379	0.2918	0.2471
	(0.0010)	(0.0075)	(0.0011)	(0.0116)	(0.0448)	(0.0129)	(0.0923)	(0.0683)
$\gamma_{ji}^{S,C}$	0.1089	0.1555	0.0000	0.1086	0.0000	0.5295	0.0000	-0.0043
	(0.0344)	(0.8919)	(0.00001)	(0.0407)	(0.00001)	(0.1926)	(0.00001)	(0.002)
Panel B: Shock and volatility spillover effects								
$a_{ij}^{S,C}$	0.0154	0.0079	0.0000	0.0267	0.0003	-0.0084	0.0000	0.0001
	(0.0058)	(0.0031)	(0.0000)	(0.0106)	(0.0049)	(0.0034)	(0.0000)	(0.0062)
$a_{ji}^{S,C}$	0.0000	0.0067	-0.0030	-0.0017	0.0000	0.0069	0.0000	0.0011
	(0.0000)	(0.0048)	(0.0014)	(0.0133)	(0.0000)	(0.0022)	(0.0000)	(0.0125)
$g_{ij}^{S,C}$	-0.0008	-0.0020	0.0184	-0.0069	0.0217	-0.0035	0.0780	0.0032
	(0.0003)	(0.0025)	(0.0078)	(0.0077)	(0.0124)	(0.0028)	(0.0165)	(0.0025)
$g_{ji}^{S,C}$	0.0000	-0.0036	0.0000	0.0386	-0.0231	0.0022	0.0000	-0.0079
	(0.0000)	(0.0046)	(0.0000)	(0.0160)	(0.0110)	(0.0019)	(0.0000)	(0.0025)
Panel C: Annual correlations								
2009	0.38	0.17	0.14	0.50	0.45	0.05	0.44	0.42
2010	0.35	0.16	0.14	0.53	0.27	0.02	0.44	0.46
2011	0.40	0.17	0.15	0.50	0.34	0.01	0.44	0.46
2012	0.36	0.14	0.12	0.53	0.35	0.03	0.43	0.48
2013	0.38	0.16	0.14	0.50	0.38	0.01	0.44	0.44
2014	0.40	0.16	0.14	0.53	0.38	0.02	0.44	0.45

Table 6.11A: A summary of the significant parameters for 5-year CDSs: home-country financial institutions and foreign non-financial firms

Parameters		**Financial institutions in East Asian countries and non-financial firms in other countries**											
		Chinese pairings				Japanese pairings				South Korean pairings			
		CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects													
$\gamma_{ij}^{S,C}$	$**$	19.58	11.43	20.00	8.73	7.94	8.57	11.43	7.14	47.78	23.52	46.00	36.00
	$**^{(-)}$	14.86	0.00	0.00	18.18	0.00	0.00	25.00	22.22	0.00	0.00	0.00	0.00
$\gamma_{ji}^{S,C}$	$**$	24.87	54.29	2.86	31.75	31.75	48.57	5.71	41.27	11.11	17.04	16.00	0.00
	$**^{(-)}$	1.06	0.00	100.00	10.00	10.00	0.00	0.00	0.00	0.00	2.17	0.00	N/A
Panel B: Shock and volatility spillover effects													
$a_{ij}^{S,C}$	$**$	21.69	28.57	20.00	27.78	26.98	22.86	17.14	29.37	27.78	55.56	26.00	24.00
	$**^{(-)}$	11.64	20.00	11.43	11.90	35.29	11.43	2.86	11.90	68.00	52.33	53.85	58.33
$a_{ji}^{S,C}$	$**$	46.30	34.29	20.00	23.02	23.81	17.14	40.00	20.63	21.11	21.85	12.00	8.00
	$**^{(-)}$	22.22	11.43	5.71	9.52	40.00	5.71	28.57	15.08	31.58	48.31	33.33	75.00
$g_{ij}^{S,C}$	$**$	39.42	31.43	34.29	30.95	41.27	42.86	31.43	34.92	26.67	55.93	24.00	30.00
	$**^{(-)}$	18.25	14.29	22.86	12.70	65.38	25.71	17.14	17.46	29.17	51.32	33.33	33.33
$g_{ji}^{S,C}$	$**$	54.50	37.14	31.43	35.71	34.92	37.14	45.71	32.54	15.56	35.37	26.00	12.00
	$**^{(-)}$	25.93	14.29	14.29	20.63	40.91	14.29	20.00	11.90	64.29	45.03	61.54	100.00
Panel C: Restriction tests													
H_0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		99.47	85.71	91.43	98.41	98.41	85.71	91.43	98.41	98.57	92.86	93.33	93.33
H_0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		94.18	82.86	91.43	88.89	87.30	85.71	82.86	94.44	94.29	80.00	83.33	86.67
H_0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	97.14	97.14	99.21	100.00	91.43	97.14	99.21	100.00	98.57	96.67	96.67
No. of pairs		378	35	35	126	63	35	35	126	70	70	30	30

Note: This table shows the percentages of significant and the percentages of significant negative parameters for 5-year CDSs.

Table 6.11A: continued

Parameters		Financial institutions in Southeast Asian countries and non-financial firms in other countries							
		Malaysian pairings				Singaporean pairings			
		MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects									
$\gamma_{ij}^{S,C}$	$**$	48.15	21.60	33.33	38.89	3.70	21.60	0.00	3.70
	$**^{(-)}$	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00
$\gamma_{ji}^{S,C}$	$**$	33.33	17.28	0.00	46.30	37.04	15.43	40.00	44.44
	$**^{(-)}$	0.00	7.14	N/A	4.00	0.00	0.00	0.00	0.00
Panel B: Shock and volatility spillover effects									
$a_{ij}^{S,C}$	$**$	25.93	46.30	13.33	20.37	11.11	25.31	13.33	33.33
	$**^{(-)}$	71.43	37.33	6.67	16.67	66.67	53.66	50.00	20.37
$a_{ji}^{S,C}$	$**$	22.22	20.37	46.67	16.67	14.81	41.98	40.00	12.96
	$**^{(-)}$	33.33	51.52	13.33	9.26	25.00	35.29	66.67	5.56
$g_{ij}^{S,C}$	$**$	37.04	54.32	0.00	44.44	37.04	33.33	26.67	37.04
	$**^{(-)}$	60.00	64.77	0.00	16.67	70.00	46.30	50.00	5.56
$g_{ji}^{S,C}$	$**$	33.33	34.57	26.67	31.48	33.33	45.68	40.00	22.22
	$**^{(-)}$	55.56	39.29	20.00	18.52	44.44	50.00	66.67	14.81
Panel C: Restriction tests									
H_0: $\gamma_{ji}^{S,C} = \gamma_{ij}^{S,C}$		100.00	98.77	93.33	96.30	96.30	99.38	100.00	100.00
H_0: $a_{ij}^{X,C} = a_{ji}^{X,C}$		81.48	89.51	80.00	92.59	81.48	95.06	80.00	70.37
H_0: $g_{ij}^{X,C} = g_{ji}^{X,C}$		100.00	100.00	100.00	98.15	100.00	100.00	100.00	100.00
No. of pairs		27	162	15	54	27	162	15	54

Table 6.12A: The averaged values of parameters for 5-year CDSs: home-country financial institutions and foreign non-financial firms

Parameters	**Financial institutions in East Asian countries and non-financial firms in other countries**											
	Chinese pairings				Japanese pairings				South Korean pairings			
	CN:JP	*CN:MY*	*CN:SG*	*CN:SK*	*JP:CN*	*JP:MY*	*JP:SG*	*JP:SK*	*SK:CN*	*SK:JP*	*SK:MY*	*SK:SG*
Panel A: Mean spread changes spillover effects												
$\gamma_{ij}^{s,c}$	0.0178	0.0146	0.0192	0.0102	0.0065	0.0112	0.0034	0.0091	0.0422	0.0230	0.0717	0.0244
	(0.0078)	(0.0057)	(0.0081)	(0.0069)	(0.0029)	(0.0051)	(0.0022)	(0.0061)	(0.0163)	(0.0086)	(0.0272)	(0.0088)
$\gamma_{ji}^{s,c}$	0.5007	0.0826	-0.0021	0.0310	0.0202	0.0565	0.0385	0.0489	0.0267	0.8791	0.0418	0.0000
	(0.6188)	(0.0271)	(0.0008)	(0.0120)	(0.0216)	(0.0184)	(0.0189)	(0.0198)	(0.0104)	(0.7374)	(0.0163)	(0.0000)
Panel B: Shock and volatility spillover effects												
$a_{ij}^{s,c}$	-0.0043	-0.0239	-0.0096	0.0056	0.0092	0.0095	0.0408	0.0178	-0.0143	-0.0002	0.0010	0.0024
	(0.0095)	(0.0100)	(0.0062)	(0.0092)	(0.0065)	(0.0045)	(0.0069)	(0.0130)	(0.0104)	(0.0067)	(0.0127)	(0.0087)
$a_{ji}^{s,c}$	-0.0038	0.0119	0.0059	0.0001	0.0197	0.0082	-0.0177	-0.0232	0.0028	0.0024	0.0038	-0.0061
	(0.0070)	(0.0174)	(0.0031)	(0.0117)	(0.0167)	(0.0064)	(0.0132)	(0.0098)	(0.0123)	(0.0078)	(0.0085)	(0.0044)
$g_{ij}^{s,c}$	0.0124	-0.0027	-0.0355	0.0071	-0.0064	0.0067	0.0007	0.0028	0.0061	-0.0005	0.0049	0.0118
	(0.0069)	(0.0028)	(0.0132)	(0.0026)	(0.0027)	(0.0069)	(0.0012)	(0.0074)	(0.0025)	(0.0031)	(0.0024)	(0.0040)
$g_{ji}^{s,c}$	0.0048	0.0039	-0.0042	-0.0051	0.0077	-0.0222	0.0093	0.0075	-0.0062	0.0017	0.0017	-0.0197
	(0.0037)	(0.0061)	(0.0032)	(0.0070)	(0.0056)	(0.0069)	(0.0059)	(0.0127)	(0.0037)	(0.0065)	(0.0034)	(0.0044)
Panel C: Annual correlations												
2009	0.05	0.24	0.06	0.20	-0.07	0.10	0.13	0.06	0.23	0.03	0.49	0.07
2010	0.04	0.27	0.02	0.20	-0.09	0.04	0.13	0.06	0.21	0.02	0.53	0.07
2011	0.03	0.25	0.01	0.17	-0.07	0.04	0.15	0.08	0.23	0.03	0.54	0.07
2012	0.03	0.23	0.00	0.15	-0.08	-0.01	0.13	0.06	0.22	0.03	0.55	0.06
2013	0.03	0.26	0.01	0.16	-0.07	-0.03	0.14	0.06	0.23	0.03	0.53	0.06
2014	0.03	0.26	0.00	0.17	-0.06	-0.04	0.15	0.06	0.22	0.03	0.52	0.06

Note: This table shows the averaged values of parameters for the estimates from 5-year CDSs.

Table 6.12A: continued

Parameters	Financial institutions in Southeast Asian countries and non-financial firms in other countries							
	Malaysian pairings				Singaporean pairings			
	MY:CN	*MY:JP*	*MY:SG*	*MY:SK*	*SG:CN*	*SG:JP*	*SG:MY*	*SG:SK*
Panel A: Mean spread changes spillover effects								
$\gamma_{ij}^{s,c}$	0.0524	0.0244	0.0211	0.0908	0.0131	0.0360	0.0000	0.0212
	(0.0208)	(0.0088)	(0.0092)	(0.0354)	(0.0053)	(0.0155)	(0.0000)	(0.0092)
$\gamma_{ji}^{s,c}$	0.0402	0.9675	0.0000	0.0292	0.0296	0.5285	0.0285	0.0170
	(0.0153)	(0.388)	(0.0000)	(0.0116)	(0.0123)	(0.2168)	(0.0100)	(0.0066)
Panel B: Shock and volatility spillover effects								
$a_{ij}^{s,c}$	-0.0066	0.0060	0.0013	-0.0208	-0.0070	0.0003	-0.0003	-0.0138
	(0.0055)	(0.0074)	(0.0008)	(0.0074)	(0.0020)	(0.0070)	(0.0015)	(0.0084)
$a_{ji}^{s,c}$	0.0121	0.0030	0.0243	0.0052	0.0074	0.0050	-0.0124	0.0048
	(0.0088)	(0.0082)	(0.0179)	(0.0097)	(0.0020)	(0.0058)	(0.0109)	(0.0047)
$g_{ij}^{s,c}$	-0.0092	-0.0065	0.0000	0.0068	-0.0126	0.0066	0.0098	0.0108
	(0.0029)	(0.0037)	(0.0000)	(0.0066)	(0.0057)	(0.0032)	(0.0027)	(0.0031)
$g_{ji}^{s,c}$	-0.0035	0.0080	-0.0140	-0.0017	0.0123	-0.0012	-0.0059	-0.0290
	(0.0050)	(0.0052)	(0.0035)	(0.0062)	(0.0061)	(0.0048)	(0.0037)	(0.0103)
Panel C: Annual correlations								
2009	0.24	-0.04	0.09	0.26	0.17	0.03	0.08	0.14
2010	0.19	-0.05	0.10	0.27	0.11	0.02	0.12	0.14
2011	0.19	-0.04	0.10	0.30	0.14	0.02	0.16	0.16
2012	0.18	-0.05	0.10	0.29	0.13	0.01	0.15	0.15
2013	0.18	-0.05	0.10	0.29	0.12	0.01	0.15	0.15
2014	0.18	-0.05	0.10	0.28	0.11	0.00	0.16	0.16

Table 6.13A: The pairings of CDS reference entities having significant spillover effects: domestic intra-sectoral spillover effects

	China		Japan		Malaysia		Singapore		South Korea	
Parameters	*F*	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*	*F*	*NF*
Panel A: Short-term credit risk interdependence										
Mean	HW:ICB	SP:WL	AC:TC	AJ: SHC	CB:GBK	IOI:TMB	DBS:OBK	PSA:SPL	HBK:SBK	KGC:SKT
Shocks	ABC: BOC	JM:MC	AC:OC	CA: HO	CB:MB	IOI:MBR	DBS:OBK	SPP:STE	SBK:TKB	KGC:KMP
Volatility	CIB: EIB	CN:JM	TB:TC	MMC: SY	CB:GBK	N/A	OBK:TH	CAL:STE	SBK:TKB	GSC:KMP
Panel B: Long-term credit risk interdependence										
Mean	BOC:EIB	MC:SP	AC:TC	NP:SH	N/A	MBR:PNB	DBS:OBK	CAL:STE	EIBK:SBK	KGC:SKT
Shocks	BOC:HW	JM:WL	AC:OC	AJ:CH	GBK:MBK	IOI:TMB	DBS:TH	PSA:SPL	KBK:KEB	KCC:POS
Volatility	CIB:EIB	CM:SP	AC:TC	NCC:NP	GBK:MBK	TMB:TNB	N/A	CAL:SPL	KBK:WOB	KGC:KTG

Note: This table displays the names for the pairings of firms exhibiting the strongest cross-transmission of credit risk in each giving sub-groupings.

Table 6.14A: The pairings of CDS reference entities having significant spillover effects: domestic cross-sectoral spillover effects

	China			Japan			Malaysia			Singapore			South Korea		
	SOV:F	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*	*SOV:F*	*SOV:NF*	*F:NF*
Panel A: Short-term credit risk interdependence															
Mean	CN:HW	CN:SP	HW:WL	JP:TB	JP:TYC	OC:CH	N/A	MY:IOI	CBK:MBR	N/A	N/A	DBS:SPP	SK:EIBK	SK:KGC	IBK:POS
Shocks	CN:HW	CN:PT	CIB:CNO	JP:TC	JP:SHI	DI:CA	MY:GBK	MY:IOI	CBK:PNB	N/A	SG:SPL	TH:SPP	SK:HBK	SK:SKC	WBK:GSC
Volatility	CN:CIB	CN:CNM	CKH:JM	JP:AC	JP:TO	TB:NEC	MY:GBK	MY:MBR	MB:IOI	SG:TH	SG:SPL	TH:SPP	SK:EIBK	SK:SKC	WBK:WR
Panel B: Long-term credit risk interdependence															
Mean	CN:HW	CN:MC	EIBK:JM	JP:OC	JP:MAC	OC:SH	MY:CBK	MY:PNB	CBK:PNB	SG:DBS	SG:CAL	OBK:CAL	N/A	SK:GSC	SBK:KGC
Shocks	CN:HW	CN:PT	ABC:SP	JP:AC	JP:MM	AC:PC	MY:GB	MY:IOI	MBK:IOI	SG:TH	SG:SPP	TH:CAL	SK:KDBK	SK:POS	IBK:KCC
Volatility	CN:EIBK	CN:JM	ABC:SP	JP:TB	JP:KR	DI:SCC	MY:MBK	MY:TNB	GB:PNB	SG:DBS	SG:PSA	TH:PSA	SK:SBK	SK:KEW	IBK:KCC

Note: This table displays the names for the pairings of firms exhibiting the strongest cross-transmission of credit risk in each giving sub-groupings.

Table 6.15A: The pairings of CDS reference entities, by regional interdependence

	F	*NF*	*SOV*	*SOV:F*	*SOV:NF*	*F:NF*
Panel A: Short-term credit risk interdependence						
Mean	BOC:CB	AJ:IOI	MY:SK	JP:ICB	JP:KGC	SBK:TE
Shocks	TB:MBK	MBR:STE	CN:JP	JP:HBK	JP:IOI	MBK:SPP
Volatility	BOC:OBK	WL:IOI	JP:SG	SK:CIB	MY:SKT	SBK:CAL
Panel B: Long-term credit risk interdependence						
Mean	ABC:MB	HO:SKT	JP:MY	JP:GBK	SG:SH	SBK:SH
Shocks	ABC:CBK	WL:PSA	MY:SG	CN:CBK	CN:IOI	BOC:IOI
Volatility	DBS:HBK	CM:SPP	MY:SG	CN:HBK	SG:MBR	CIB:SPL

Note: This table displays the names for the pairings of firms exhibiting the strongest cross-transmission of credit risk in each giving sub-groupings.

Appendices 7.1

Table 7.1A: The aggregate effects of variables on long-term domestic correlations

	Sign	(1)	(2)	(3)	(4)
		$\rho_{ij,t}^{ALL,X}$	$\rho_{ij,t}^{ALL,X}$	$\rho_{ij,t}^{ALL,X}$	$\rho_{ij,t}^{ALL,X}$
Intercept	+	0.175**	0.171**	0.174**	0.172**
		(0.026)	(0.026)	(0.024)	(0.025)
$Sector_{NF}$	-	-0.040	-0.037	-0.037	-0.049
		(0.029)	(0.025)	(0.025)	(0.029)
$Sector_{F:NF}$	-	-0.031	-0.035	-0.036	-0.026
		(0.024)	(0.024)	(0.024)	(0.024)
Panel A: Firm differences					
$\left\lvert D_{SIZE}{}_{(i,j),t}^{ALL,C_i} \right\rvert$	+/-	0.001			0.002
		(0.001)			(0.001)
$\left\lvert D_{ROE}{}_{(i,j),t}^{ALL,C_i} \right\rvert$	+/-	-0.017			-0.014
		(0.014)			(0.014)
$\left\lvert D_{CR}{}_{(i,j),t}^{ALL,C_i} \right\rvert$	+/-	-0.002			-0.003**
		(0.001)			(0.001)
$\left\lvert D_{DE}{}_{(i,j),t}^{ALL,C_i} \right\rvert$	+/-	0.001			0.002
		(0.001)			(0.001)
$\left\lvert D_{ATR}{}_{(i,j),t}^{ALL,C_i} \right\rvert$	-	-0.024**			-0.022**
		(0.005)			(0.005)
$\left\lvert D_{PE}{}_{(i,j),t}^{ALL,C_i} \right\rvert$	-	0.004			0.004
		(0.002)			(0.002)
$\left\lvert D_{DY}{}_{(i,j),t}^{ALL,C_i} \right\rvert$	-	-0.004			-0.004
		(0.006)			(0.006)
$\left\lvert D_{VOL}{}_{(i,j),t}^{ALL,C_i} \right\rvert$	+/-	0.007			0.001
		(0.027)			(0.027)
Panel B: Country economic risk					
$\Delta GDPg_t^{C_i}$	-		-0.073	0.036	0.019
			(0.123)	(0.141)	(0.143)
$\Delta IR_t^{C_i}$	-		-0.706**	-0.669**	-0.759**
			(0.211)	(0.226)	(0.227)
$\Delta DTG_t^{C_i}$	+		-0.043	-0.053	-0.050
			(0.066)	(0.067)	(0.069)
$\Delta UER_t^{C_i}$	+		-0.803**	-0.448**	-0.295**
			(0.402)	(0.223)	(0.133)
$\Delta EXP_t^{C_i}$	-		-0.401**	-0.423**	-0.415**
			(0.096)	(0.097)	(0.098)
$\Delta BDT_t^{C_i}$	-		0.008	0.003	0.007
			(0.019)	(0.02)	(0.02)
$\Delta BTB_t^{C_i}$	-		-0.231	-0.249**	-0.243**
			(0.068)	(0.069)	(0.069)
Panel C: Regional credit risk					
$\Delta CDS_t^{F,JP}$	+/-			0.001	-0.003
				(0.029)	(0.029)
$\Delta CDS_t^{F,JP}$	+/-			0.030	0.033
				(0.021)	(0.021)
Panel D: Global market risk					
$S\&P500_t$	-			0.047	0.055
				(0.066)	(0.067)
ΔVIX_t	+/-			-0.071**	-0.071**
				(0.022)	(0.023)
$\Delta iTraxx_t$	+/-			0.0001	0.0001
				(0.0001)	(0.001)
$\Delta Slope_t$	+/-			-0.005**	-0.005**
				(0.001)	(0.001)
Observations		13,391	13,391	13,391	13,391
Adjusted R^2		0.39	0.39	0.39	0.39
Log likelihood		7340.06	7375.06	7357.65	7334.89
LR tests		-10.344	-80.34	-45.52	

Note: Robust standard errors are reported in parentheses. ** denotes significance at 5%

Table 7.2A: The effects of variables on long-term domestic correlations, by sector

	Sign	(1)			(2)			(3)			(4)		
		$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$	$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$	$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$	$\rho_{ij,t}^{F,C_i}$	$\rho_{ij,t}^{NF,C_i}$	$\rho_{ij,t}^{F:NF,C_i}$
Intercept	+	0.223**	0.138**	0.159**	0.169**	0.151**	0.13**	0.222**	0.151**	0.145**	0.268**	0.149**	0.164**
		(0.050)	(0.011)	(0.023)	(0.032)	(0.021)	(0.013)	(0.034)	(0.010)	(0.009)	(0.048)	(0.012)	(0.023)
Panel A: Firm differences													
$\left\|D_{SIZE\,(i,j),t}^{S_{i,j},C_i}\right\|$	+/-	-0.048**	0.034**	0.001							-0.048**	0.023**	0.001
		0.014	(0.011)	(0.001)							(0.013)	(0.012)	(0.001)
$\left\|D_{ROE\,(i,j),t}^{S_{i,j},C_i}\right\|$	+/-	-0.051	0.001	-0.013							-0.069	0.008	-0.022
		0.056	(0.026)	(0.015)							(0.054)	(0.026)	(0.015)
$\left\|D_{CR\,(i,j),t}^{S_{i,j},C_i}\right\|$	+/-	-0.003	-0.005	-0.001							-0.002	0.010**	0.001
		0.003	(0.003)	(0.001)							(0.003)	(0.003)	(0.001)
$\left\|D_{DE\,(i,j),t}^{S_{i,j},C_i}\right\|$	+/-	-0.014	-0.035**	-0.001							-0.013	-0.024**	-0.001
		0.007	(0.011)	(0.001)							(0.007)	(0.012)	(0.001)
$\left\|D_{ATR\,(i,j),t}^{S_{i,j},C_i}\right\|$	-	-0.076	-0.025**	-0.016							-0.102	-0.024**	-0.016
		0.245	(0.006)	(0.01)							(0.238)	(0.006)	(0.01)
$\left\|D_{PE\,(i,j),t}^{S_{i,j},C_i}\right\|$	-	0.054**	0.003	0.006							0.062**	0.003	0.009
		0.019	(0.003)	(0.005)							(0.019)	(0.003)	(0.005)
$\left\|D_{DY\,(i,j),t}^{S_{i,j},C_i}\right\|$	-	0.060	0.000	-0.030							0.059	0.000	-0.029**
		0.048	(0.007)	(0.012)							(0.047)	(0.007)	(0.012)
$\left\|D_{VOL\,(i,j),t}^{S_{i,j},C_i}\right\|$	+/-	0.545**	-0.023	0.037							0.494**	-0.020	0.002
		0.178	(0.224)	(0.048)							(0.202)	(0.032)	(0.048)
Panel B: Country economic risk													
$\Delta GDPg_t^{C_i}$	-				-0.056	0.269	-0.420**	-0.647	0.430	-0.512**	-0.542	0.447**	-0.056
					(0.367)	(0.189)	(0.156)	(0.532)	(0.204)	(0.186)	(0.494)	(0.205)	(0.367)
$\Delta IR_t^{C_i}$	-				-0.630	-0.833**	-0.478	-0.523	-0.742**	-0.550	-0.382	-0.739**	-0.630
					(0.751)	(0.307)	(0.278)	(0.927)	(0.318)	(0.306)	(0.815)	(0.319)	(0.751)
$\Delta DTG_t^{C_i}$	+				-0.079	-0.326**	0.080	0.002	-0.340**	0.088	-0.090	-0.270**	-0.079
					(0.236)	(0.103)	(0.082)	(0.249)	(0.104)	(0.084)	(0.237)	(0.108)	(0.236)
$\Delta UER_t^{C_i}$	+				-0.577**	-0.622**	-0.443**	-0.565**	-0.525**	-0.407**	-0.453**	-0.879**	-0.577**
					(0.233)	(0.219)	(0.219)	(0.222)	(0.228)	(0.192)	(0.192)	(0.336)	(0.233)
$\Delta EXP_t^{C_i}$	-				-0.468	-0.558**	-0.233**	-0.401	-0.587**	-0.247**	-0.490	-0.489**	-0.468
					(0.274)	(0.154)	(0.115)	(0.290)	(0.156)	(0.117)	(0.258)	(0.160)	(0.274)
$\Delta BDT_t^{C_i}$	-				-0.017	-0.057**	0.052**	-0.031	-0.066**	0.053**	0.015	-0.058**	-0.017
					(0.069)	(0.028)	(0.025)	(0.075)	(0.029)	(0.026)	(0.066)	(0.029)	(0.069)
$\Delta BTB_t^{C_i}$	-				-0.223	-0.403**	-0.076	-0.149	-0.432**	-0.079	-0.079	-0.403**	-0.223
					(0.197)	(0.112)	(0.081)	(0.203)	(0.113)	(0.082)	(0.191)	(0.113)	(0.197)
Panel C: Regional credit risk													
$\Delta CDS_t^{F,JP}$	+/-							-0.552**	0.129**	-0.192**	-0.511**	0.113**	-0.198**
								(0.141)	(0.04)	(0.043)	(0.125)	(0.04)	(0.043)
$\Delta CDS_t^{F,JP}$	+/-							0.323**	-0.026	0.125**	0.294**	-0.012	0.125**
								(0.100)	(0.029)	(0.030)	(0.090)	(0.029)	(0.031)
Panel D: Global credit risk													
$S\&P500_t$	-							-0.192	0.054	-0.017	-0.048	0.078	-0.027
								(0.238)	(0.095)	(0.087)	(0.214)	(0.095)	(0.088)
ΔVIX_t	+/-							0.406**	-0.160**	0.048	0.463**	-0.141**	0.048
								(0.115)	(0.031)	(0.033)	(0.102)	(0.032)	(0.034)
$\Delta iTraxx_t$	+/-							0.001**	0.001	0.0001**	0.001**	0.0001	0.0001**
								(0.00001)	(0.001)	(0.00001)	(0.0001)	(0.0001)	(0.00001)
$\Delta Slope_t$	+/-							-0.006	-0.005**	-0.006**	-0.004	-0.005**	-0.006**
								(0.004)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)
Observations		147	10,759	2,485	147	10,759	2,485	147	10,759	2,485	147	10,759	2,485
Adjusted R^2		0.68	0.39	0.37	0.61	0.39	0.38	0.61	0.39	0.38	0.67	0.39	0.38
Log likelihood		99.13	5572.19	1743.69	107.34	5597.19	1782.25	94.21	5584.00	1765.25	135.75	5645.94	1813.94
LR tests		73.24	147.51	63.38	56.82	97.50	63.38	83.10	123.88	97.38			

Note: Robust standard errors are reported in parentheses. ** denotes significance at 5%

Table 7.3A: The aggregate effects of variables on long-term regional correlations

	Sign	(1) $\rho_{ij,t}^{ALL,C_{i,j}}$	(2) $\rho_{ij,t}^{ALL,C_{i,j}}$	(3) $\rho_{ij,t}^{ALL,C_{i,j}}$	(4) $\rho_{ij,t}^{ALL,C_{i,j}}$
Intercept	+	0.177**	0.366**	0.349**	0.337**
		(0.017)	(0.016)	(0.012)	(0.013)
$Sector_{NF}$	-	-0.071**	-0.069**	-0.069**	-0.041**
		(0.016)	(0.011)	(0.011)	(0.014)
$Sector_{F:NF}$	-	-0.076**	-0.049**	-0.049**	-0.04**
		(0.014)	(0.010)	(0.010)	(0.011)
Panel A: Firm differences					
$\left\|D_{SIZE}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	0.003			0.003
		(0.004)			(0.004)
$\left\|D_{ROE}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	-0.001			-0.001**
		(0.001)			(0.0001)
$\left\|D_{CR}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	0.003**			0.001
		(0.0001)			(0.001)
$\left\|D_{DE}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	-0.0001			0.0001
		(0.001)			(0.001)
$\left\|D_{ATR}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	-	0.0001			-0.001**
		(0.0001)			(0.0001)
$\left\|D_{PE}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	-	-0.003			-0.003
		(0.002)			(0.002)
$\left\|D_{DY}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	-	-0.002			-0.001
		(0.004)			(0.003)
$\left\|D_{VOL}{}_{(i,j),t}^{ALL,C_{i,j}}\right\|$	+/-	0.055**			0.048**
		(0.016)			(0.015)
Panel B: Country differences					
$\left\|D_{GDP}{}_{g,t}^{C_{i,j}}\right\|$	+/-		0.008	0.004	0.016
			(0.041)	(0.042)	(0.042)
$\left\|D_{IR}{}_{t}^{C_{i,j}}\right\|$	+/-		-0.001	-0.001	-0.001
			(0.0001)	(0.0001)	(0.0001)
$\left\|D_{DTG}{}_{t}^{C_{i,j}}\right\|$	-		-0.106**	-0.106**	-0.106**
			(0.003)	(0.003)	(0.003)
$\left\|D_{UER}{}_{t}^{C_{i,j}}\right\|$	+/-		-0.908**	-0.829**	-0.843**
			(0.248)	(0.248)	(0.250)
$\left\|D_{EXP}{}_{t}^{C_{i,j}}\right\|$	+/-		-0.026**	-0.027**	-0.03**
			(0.005)	(0.005)	(0.005)
$\left\|D_{BDT}{}_{t}^{C_{i,j}}\right\|$	+/-		0.022**	0.022**	0.023**
			(0.005)	(0.005)	(0.005)
$\left\|D_{BTB}{}_{t}^{C_{i,j}}\right\|$	+/-		0.005	0.005	0.009
			(0.007)	(0.007)	(0.007)
Panel C: Regional credit risk					
$\Delta CDS_t^{F,JP}$	+/-			0.326**	0.324**
				(0.014)	(0.014)
$\Delta CDS_t^{F,JP}$	+/-			-0.246**	-0.243**
				(0.012)	(0.012)
Panel D: Global market risk					
$S\&P500_t$	-			-0.164**	-0.159**
				(0.016)	(0.016)
ΔVIX_t	+/-			-0.331**	-0.33**
				(0.014)	(0.014)
$\Delta iTraxx_t$	+/-			0.0001**	0.0001**
				(0.0001)	(0.0001)
$\Delta Slope_t$	+/-			0.002**	0.002**
				(0.0001)	(0.0001)
Observations		19,166	19,166	19,166	19,166
Adjusted R^2		0.62	0.62	0.62	0.62
Log likelihood		13,870	14,427	14,410	14,523
LR tests		1,306.12	192.89	226.34	

Note: Robust standard errors are reported in parentheses. ** denotes significance at 5%

Table 7.4A: The effects of variables on long-term regional correlations, by sector

	Sign	(1)			(2)			(3)			(4)		
		$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$	$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$	$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$	$\rho_{ij,t}^{F,C_{i,j}}$	$\rho_{ij,t}^{NF,C_{i,j}}$	$\rho_{ij,t}^{F:NF,C_{i,j}}$
Intercept	+	0.149**	0.105**	0.109**	0.499**	0.398**	0.187**	0.496**	0.370**	0.189**	0.468**	0.375**	0.203**
		(0.032)	(0.013)	(0.011)	(0.040)	(0.016)	(0.013)	(0.036)	(0.009)	(0.010)	(0.043)	(0.010)	(0.013)
Panel A: Firm differences													
$\left\|D_{SIZE}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right\|$	+/-	0.003	0.002**	0.007							0.004	0.002**	0.005
		(0.006)	(0.0001)	(0.005)							(0.005)	(0.0001)	(0.005)
$\left\|D_{ROE}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right\|$	+/-	0.021	0.133**	-0.001**							0.019	-0.132**	-0.001**
		(0.037)	(0.021)	(0.0001)							(0.036)	(0.021)	(0.0001)
$\left\|D_{CR}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right\|$	+/-	0.003**	0.003**	0.001							0.0001	-0.002	0.001
		(0.0001	(0.0002)	(0.001)							(0.001)	(0.002)	(0.001)
$\left\|D_{D/E}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right\|$	+/-	0.002	0.002	0.033**							0.002	0.001	0.026**
		(0.005)	(0.001)	(0.012)							(0.005)	(0.001)	(0.012)
$\left\|D_{ATR}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right\|$	-	0.174	0.007	0.001**							0.220	-0.001	0.0001
		(0.166)	(0.005)	(0.0001)							(0.137)	(0.004)	(0.0001)
$\left\|D_{PE}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right\|$	-	-0.024	-0.002	0.001							-0.007	-0.001	-0.001
		(0.016)	(0.003)	(0.004)							(0.016)	(0.002)	(0.004)
$\left\|D_{DY}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right\|$	-	-0.017	0.005	-0.017**							-0.017	0.008	-0.017**
		(0.024)	(0.005)	(0.006)							(0.024)	(0.004)	(0.006)
$\left\|D_{VOL}{}_{(i,j),t}^{S_{i,j},C_{i,j}}\right\|$	+/-	0.304**	0.004	0.040							0.133	0.015	0.032
		(0.094)	(0.022)	(0.023)							(0.089)	(0.021)	(0.023)
Panel B: Country differences													
$\left\|D_{GDP}{}_{g,t}^{C_{i,j}}\right\|$	+/-				-0.218	-0.046	0.052	-0.292	-0.052	0.035	-0.303	-0.056	0.015
					(0.242)	(0.054)	(0.066)	(0.245)	(0.054)	(0.066)	(0.243)	(0.054)	(0.242)
$\left\|D_{IR}{}_{t}^{C_{i,j}}\right\|$	+/-				-0.005	-0.001	-0.001	-0.006**	-0.001	-0.001	-0.006**	-0.001**	-0.001
					(0.003)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.003)	(0.0001)	(0.001)
$\left\|D_{DTG}{}_{t}^{C_{i,j}}\right\|$	-				-0.136**	-0.150**	-0.041**	-0.135**	-0.150**	-0.041**	-0.140**	-0.150**	-0.042**
					(0.017)	(0.004)	(0.004)	(0.017)	(0.004)	(0.004)	(0.017)	(0.004)	(0.004)
$\left\|D_{UER}{}_{t}^{C_{i,j}}\right\|$	+/-				-0.607**	-0.097**	-0.838**	-0.867**	-0.726**	-0.809**	-0.162**	-0.117**	-0.917**
					(1.527)	(0.316)	(0.410)	(1.534)	(0.316)	(0.412)	(1.595)	(0.317)	(0.416)
$\left\|D_{EXP}{}_{t}^{C_{i,j}}\right\|$	+/-				-0.008	-0.041**	-0.016	-0.014	-0.042**	-0.016	-0.007	-0.045**	-0.014
					(0.032)	(0.007)	(0.008)	(0.032)	(0.007)	(0.008)	(0.033)	(0.007)	(0.009)
$\left\|D_{BDT}{}_{t}^{C_{i,j}}\right\|$	+/-				-0.007	0.035**	0.004	-0.002	0.036**	0.005	-0.004	0.035**	0.012
					(0.032)	(0.006)	(0.008)	(0.032)	(0.007)	(0.008)	(0.032)	(0.007)	(0.009)
$\left\|D_{BTB}{}_{t}^{C_{i,j}}\right\|$	+/-				-0.002	-0.007	0.024**	0.008	-0.007	0.025**	-0.008	-0.003	0.018
					(0.040)	(0.009)	(0.011)	(0.041)	(0.009)	(0.011)	(0.042)	(0.009)	(0.012)
Panel C: Regional credit risk													
$\Delta CDS_t^{F,JP}$	+/-							0.557**	0.409**	0.176**	0.532**	0.421**	0.165**
								(0.079)	(0.019)	(0.022)	(0.080)	(0.019)	(0.023)
$\Delta CDS_t^{F,JP}$	+/-							-0.452**	-0.297**	-0.15**	-0.426**	-0.307**	-0.143**
								(0.066)	(0.016)	(0.019)	(0.068)	(0.016)	(0.019)
Panel D: Global market risk													
$S\&P500_t$	-							-0.435**	-0.129**	-0.201**	-0.405**	-0.147**	-0.193**
								(0.102)	(0.020)	(0.027)	(0.105)	(0.021)	(0.027)
ΔVIX_t	+/-							-0.579**	-0.388**	-0.216**	-0.544**	-0.405**	-0.204**
								(0.072)	(0.018)	(0.021)	(0.075)	(0.019)	(0.022)
$\Delta iTraxx_t$	+/-							0.0001**	-0.001**	0.0001	0.0001**	-0.001**	0.0001
								(0.00001)	(0.00001)	(0.001)	(0.00001)	(0.0001)	(0.001)
$\Delta Slope_t$	+/-							0.0001	0.003**	-0.001**	0.0001	0.003**	-0.001**
								(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)
Observations		693	11,921	6,552	693	11,921	6,552	693	11,921	6,552	693	11,921	6,552
Adjusted R^2		0.69	0.68	0.41	0.70	0.67	0.42	0.70	0.67	0.42	0.70	0.67	0.42
Log likelihood		286	8852	4916	340	9376	4983	327	9361	4965	374	9457	5042
LR tests		175.35	120.96	251.93	67.58	209.90	116.63	93.31	192.08	153.03			

Note: Robust standard errors are reported in parentheses. ** denotes significance at 5%.