Financial Contagion

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Abstract

This study examines the transmission of shocks during the financial crisis, and particularly the transmission of shocks from one market to another, which we define as financial contagion. While the current contagion literature focusses solely on the effects of macroeconomic fundamentals on contagion, we argue that the element of shock, which cannot be directly explained by fundamentals, also plays a role. We first examine the contagion concept in this context and split overall shock into two segments: interdependence or common shock, which represents the elements that fundamentals can directly explain, and the pure contagion or idiosyncratic shock, which fundamentals cannot directly explain. The results support our hypothesis, and reveal that pure contagion is just as volatile as interdependence. Furthermore, we introduce two additional features into the analysis: the long and short memory feature, and heteroscedasticity. Past studies have considered heteroscedasticity in their research by adjusting it directly in the calculation. However, we instead examine this issue from another point of view, by using breakpoint tests. It emerges that adjusting for heteroscedasticity through breakpoint tests reduces the number of structural breaks detected. The long and short memory feature measures the persistence of the autocorrelation of the data. Our results show that the identification of contagion is highly sensitive to this feature while short memory processes are very sensitive to the models used. We then widen our analysis by taking trade and region into consideration. Our result is inconsistent with a number of past studies, thus suggesting that trade and region neither diminish our ability to identify contagion, nor affect the transmission of shocks. Finally, we look at financial contagion in a more comprehensive way by analysing the overall effect, the split effect and the duration of these effects together. By combining the investigations of overall effect and the split effect, we are able to gauge the role played by common and idiosyncratic shock, as well as how they contribute to the overall effect. Indeed, because of the impulse response analysis, we are able to assess how long the contagion effects last once they are identified. Finally, we reach a similar conclusion to those of previous studies, that is, the shocks last only a short period of time.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university. To the best of knowledge, this thesis contains no material previously published or written by another person, except where due reference has been made.

Any errors in the thesis are the author's own responsibility.

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Chapter 1 Introduction

There have been at least 11 financial crises since the Great Depression in 1929 (see appendix 1), roughly equating to 1.3 crises every 10 years. When it comes to financial crises, an interesting fact is that the shocks are usually not contained within the country of origin. Indeed, they spread through the whole continent, and sometimes even the whole world, especially when the US is involved. Research studies have offered theories relating to how financial crises developed and are transferred, as well as how they can be prevented or even predicted. At present there is no unanimous opinion, and as such we would like to focus on how shocks are transferred from country to country. It is hoped that our study can help countries to develop a better understanding of the transmission mechanism of shocks, hence informing them of what to expect or do when financial crises occur.

The word ‘Contagion’ has been introduced into the financial field to refer to the idea that financial crises may spread from one market to another. Moreover, financial contagion is usually used in the literature to describe the spillover effects from one or more markets or enterprises to others; it is also used to describe the susceptibility of markets or enterprises to shocks. However, there is no consensus regarding exactly how contagion should be defined. In fact, an examination of the relevant literature reveals 5 different definitions of ‘Financial Contagion’:

1. Significant increase in the probability of a crisis.
2. Volatility spillover of asset prices.
3. Jumping between multiply equilibriums.
4. Significant increase in co-movements.
5. Change in transmission channels.

After reviewing the definitional context of previous studies in Chapter 2, we noticed that research studies under definition 1 to 5 tend to include an increasing number of features and definitions. For instance, studies under definition 5 usually consider definition 3 and 4 too. This fact leads us to the conclusion that contagion studies should not focus solely on one single aspect but rather take a more comprehensive approach and attempt to encapsulate more new features as well. As a result, for the purposes of this study we define contagion as the transmission of shocks from one market to another. The results can be interpreted under each of the last 4 definitions (definition 2 to 5), although the increased probability of a crisis is not discussed in detail in our study. Indeed, one of the new features which we would like to examine is what we call the 'pure contagion'. While all previous literature has focussed only on the effect of macroeconomic fundamentals, we feel that the shock component which cannot be explained by fundamentals should also be considered. In other words, we argue that shock consists of two elements. The first element can be directly explained by fundamentals and is referred to as interdependence or common shock in this study. The second element cannot be directly explained by fundamentals, and is referred to as the pure contagion or idiosyncratic shock.

Chapter 3 reviews several representative methods from previous studies. We review the methodologies for 2 purposes. Firstly, although there are 5 different definitions of contagion, we must admit that they share certain similarities, with definitions 3 to 5 serving as fitting examples. Different kinds of co-movement can be interpreted as different equilibrium, while different equilibrium may suggest different channels of transmission. Research studies have occasionally defined similar contagions using different words due to the fact that they used different methods. Indeed, these results can be interpreted better under their own definitional context. As a result, a difference in terms of methods occasionally gives rise to a difference in the definition. The second purpose of this study is to compare the advantages and disadvantage of different methods in order to display our methodology interests. For instance, as revealed earlier, our interests lie in splitting shock into two segments, and as such we seek a method which can help us to achieve this. Following the comparison, we concluded that Herd Behaviour methods cannot be used to detect the reasons for contagion, nor the channels through which it is transferred. While Multivariate Regression methods are helpful when identifying the possible transmission channels of contagion, they cannot help us to examine pure contagion. Correlation methods are straight forward when analysing the overall effect, but again, the same methods are feeble if we wish to examine the effects of interdependence and pure contagion separately. 'Identification through Heteroscedasticity' seems to be the perfect match for our intention, although we would also like to bring in new features which, in our opinion, make this method more appropriate. The two new features we would like to examine include the long and short memory feature, and heteroscedasticity. No contagion study has ever assessed the long and short memory feature, yet we feel that the persistence of the autocorrelations will affect the transmission of shocks. Although some studies have already tried to adjust heteroscedasticity through direct calculation (Loretan and English, 2000; Forbes and Rigobon, 2002), it is our intention to try another, previously unused, approach by employing breakpoint tests.

Chapter 4 sets out the methodology used. Following the literature review in the last two chapters, we identified 3 new features to examine in order to fill the existing gaps: the pure contagion, the long and short memory feature, and heteroscedasticity. In order to address the first feature, it is necessary to split the shock into two segments as we planned. Indeed, the Gravelle, Kichian and Morley (2006) method seems to be an ideal choice, as these scholars successfully split shock into two segments: the common shock and the idiosyncratic shock. However, in terms of empirical study, they only examined the way in which common shock reacted and completely ignored idiosyncratic shock. Although the element which fundamentals cannot directly explain is slightly mystical, as a part of the overall effect, it should not be left out. We would like to further the study by taking idiosyncratic shock, the pure contagion, into consideration. Moreover, the result did support our hypothesis, with pure contagion proving just as volatile as interdependence. With regards the second feature, the long and short memory, we would like to achieve that through ARMA and ARFIMA models. The ARFIMA model distinguishes between long term memory and short term memory, while ARMA model confounds them. The 'Identification through Heteroscedasticity' method employed by Gravelle, Kichian and Morley (2006) is based on forecast errors (the residuals that represent the shock). However, they failed to explain how they came about this important element of the methodology framework. On the contrary, it is our contention that quantifying the shock is just as important as identifying the feature of the data. In order to achieve both at the same time, we use the ARFIMA model to make the forecast and obtain the forecast error while identifying the long and short term memory features of the data. With this said however, we would like to see the results when we do not consider all of these details, and thus we will also examine the results of the ARMA model. Indeed, it emerges that the results are highly sensitive to this feature, particularly when the data relates to the short term memory feature. As for heteroscedasticity, we would like to address this through the use of a different, and previously unused approach, the breakpoint tests. Our idea with this feature is quite similar to that of the last feature. We will compare the results of one model which fits heteroscedasticity (the Bai-Perron test) with another model which does not fit heteroscedasticity (the Andrews-Ploberger test). The Bai-Perron test and Andrews-Ploberger test are two commonly used breakpoint tests. Theoretically speaking, the Bai-Perron test fits heteroscedasticity better than the Andrews-Ploberger test as the Andrews-Ploberger test requires homoscedasticity while the Bai-Perron test allows heteroscedasticity. Our further accuracy test also confirms that the Bai-Perron test has a higher accuracy and deals more effectively with changes in variance. Hence, the Bai-Perron test is a better choice for the purposes of this study, although we would also like to see the results when we ignore this feature. With this last goal in mind, the results of the Andrews-Ploberger test are also considered. Moreover, by estimating the structural breaks exogenously, we can improve the power of the contagion test. In order to accomplish all of these targets, we use the new non-linear Iterative methods, as opposed to the Markov-Switching model used by Gravelle, Kichian and Morley (2006) did.

In Chapter 5, we put the above theories into test. Indeed, we also attempt to bring one more new idea into data selection. We only included countries with extremely low dependence on foreign trade with each other as our targets. Based on the equation of the balance of payments, we reduced the effect of interdependence and made pure contagion easier to identify. In terms of results, we reached almost the same conclusion to that reached by most previous studies focusing on interdependence. While many contagion effects were detected, the changes of the coefficients were more volatile. Furthermore, we found that pure contagion is just as volatile as interdependence. When a contagion effect in interdependence is identified, we would normally expect a pure contagion effect in the same direction. As for the other two features we examined, we concluded that the identification of contagion is highly sensitive to the long and short memory and heteroscedasticity feature, particularly when the data relates to the short memory feature. The results from the identification of contagion of short memory processes varies considerably for ARMA and ARFIMA models, while the results of the long memory process are much less volatile. This suggests that being aware of the data’s autocorrelation feature before the identification process is very important and we should be extra careful when dealing with short memory processes. In addition because of the superiority of the ARFIMA model to distinguish long memory process from short memory process, we prefer the results from the ARFIMA model. As for the heteroscedasticity feature, we found that adjusting it through a breakpoint test reduced the number of structural changes in all cases, and hence it has a significant effect on the identification process. Indeed, because of the higher accuracy and the capability to allow heteroscedasticity, we prefer the results of the Bai-Perron over the Andrews-Ploberger test.

In Chapter 6, we widen our study by considering trade linkages and region. As the last chapter used specifically selected targets with extremely low dependence on foreign trade with each other, we would like to test trade linkages in order to gauge whether or not our ability to identify contagion, especially pure contagion, is impaired when the trade link is high. As such, in this chapter, we select our targets among countries with a high degree of dependence on each other while also attempting to keep all of the other elements including the testing procedures exactly the same. This will aid in highlighting the change in trade linkages. In the last chapter, we chose 6 European countries with the lowest trade links. As such, here, on the contrary, we choose 6 countries with the highest trade linkages in Europe while trying to keep all other variables identical. As for the results, the higher trade links did not diminish our ability to identify contagion. We were still able to detect many contagion effects in all testing procedures and reached the same conclusion regarding the 3 features as that reached in the last chapter. This result differs from that of previous studies which argued the importance of trade linkages. Indeed, since trade link is the only altered element and we observe no differences in the breakpoint tests or the contagion identification procedures, we conclude that, regardless of the kinds of trade linkages countries have, shock transfers all the same. Hence, we can confirm our finding that trade does not play an important role in the identification of contagion.

After having fully examined the new features and establishing a more appropriate ‘Identification through Heteroscedasticity’ procedure, we move on to look at contagion from a more comprehensive point of view in Chapter 7. Now that we have examined interdependence and pure contagion separately, we are interested to know the possible contagion effects on overall shock and how interdependence and pure contagion contribute to this. Furthermore, we would also like to establish how long the contagion effects last once they are identified. We do this by combining our procedure with Forbes and Rigobon' s (2002) correlation method and Khalid and Kawai's (2003) impulse response analysis. In this chapter, we ask 3 questions. Firstly, what kind of contagion effect can we identify in the overall shock? Secondly, what role do interdependence and pure contagion play in the overall effect? Thirdly, if contagion is detected, how long will it last? In conclusion, first of all, we detect more contagion than Forbes and Rigobon (2002) did, and of course we reach a different conclusion. Second, by combining the overall effect and split effect together, we are able to identify the roles played by interdependence and pure contagion in the overall effect. It emerges that they vary in different groups of targets. Sadly, we cannot identify the reason for the variation. Last but not least, we find that when contagion effects are detected, they normally last less than 5 days, and occasionally longer than 10 days, which is a similar conclusion to that reached by Khalid and Kawai (2003).

Overall, this study examines 3 new features based on existing literature: the pure contagion, the long and short memory feature and heteroscedasticity. We split shock into two segments and employ ARMA, ARFIMA, the Bai-Perron test and the Andrews-Ploberger test to account for them. Indeed, our results strongly support our hypotheses. We then widen our study by bring trade links into our analysis and reach a different conclusion to that of certain previous studies. After having fully examined the split effects, we combine them with the overall effect to see how interdependence and pure contagion contribute to the overall shock. We also employ impulse response analysis to estimate the duration of the identified contagion effects, which is short and consistent with previous studies.

Chapter 2 Literature Review on the Definitions

This chapter reviews the definitional context of contagion studies, and particularly different definitions of contagion as well as the corresponding research frameworks. We will summarise the similarities and differences while also proposing possible ways in which these studies could be improved and suggesting approaches with which to expand the topic.

2.1 What is Financial Contagion

"Contagion" is usually used to describe an incident in which an infectious disease is transmitted from one person or organism to another in daily life. However, this word has now been introduced into the financial field, and vividly describes the spread of financial crisis, or more widely, the spillover effects from one, or more than one, market to the others. In other words, it describes the process or possibility of shocks transferring from one market/country to another. It is also used to describe the susceptibility of markets to shocks. A market/country that is sensitive to financial contagion is vulnerable to shocks. When it comes to shocks, most contagion studies focus on negative shocks, turmoil and crisis periods (De Gregorio and Valdes, 2001; Fratzscher, 2003). A few others argue that positive shocks should also be considered (Billio and Caporin, 2010) because their transmission nature could be identical to that of the negative ones, but in the opposite direction. Thus, a framework which takes into account both shocks would be more appropriate for the contagion study. Moreover, the spillover effects and the susceptibility of markets to shocks are comprehensive topics with many subfields. Consequently, the research frameworks of contagion studies vary as many of them head in different directions. Hence, the discussion of various definitions of contagion is as important as the research methods.

The definitions of contagion in previous literature can be summarised into 5 groups. Definition 1: Contagion is a substantial increase in the probability of crises in one country, if any another country is having one. Moreover, the countries involved do not have to be neighbours. Definition 2: Contagion refers to the process whereby the asset price volatility spills over from one country to the others. Studies usually take a crisis country as the origin of the contagion transmission. Definition 3: Contagion happens when the co-movement or the change of the co-movement between the asset prices of different countries cannot be explained by the fundamentals. We term this kind of contagion 'pure contagion', although it may carry different connotations in other studies. For instance, 'pure contagion' was once be defined as the result of the investors' behaviour (Masson, 1999). Definition 4: Contagion refers to a significant increase in the co-movements of asset prices and quantities across markets/countries when one or more than one of them are in a crisis. Despite the similarity between their literal meanings, definitions 3 and 4 are actually quite different. Although they have the same starting point, they head in very different directions. Both discuss co-movement between assets, although definition 3 focusses on the reason why some co-movements cannot be explained by fundamentals and significant changes are not always certain. In contrast, definition 4 focusses on the result instead of the reason for the detected contagion. As long as co-movement significantly fluctuates, contagion happens. Definition 5: Contagion occurs when there is a significant change in the transmission channels after a shock in one market. The original channel may cease to work and have a new substitute, or may still work, but with a significantly higher or lower role. Some studies also refer to this category of contagion as 'shift-contagion' (Rigobon, 2002). Although each definition provides a sound theoretical and empirical background, there is no conclusive answer as to which is the most accurate. With this in mind, we will now review studies under each definition.

2.2 Definition 1: Significant Increase in the Probability of Crisis

Literature related to the first definition mainly focusses on banking and stock markets and tends to use high frequency data (Aharony and Swary, 1983; Glick and Rose, 1999; Caramazza, Ricci and Salgado, 2000; Kaminsky and Reinhart, 2000; Hernández and Valdés, 2001; Van Rijckeghem and Weder, 2001; Kaminsky and Reinhart, 2002; Bae, Karolyi and Stulz, 2003; Furfine, 2003; Goldstein and Pauzner, 2004; Geršl, 2007; Gropp, Duca and Vesalac, 2009; Markwat, Kole and Van Dijk, 2009; Uhlig, 2010). Most of these studies investigate the time period from 1992 to 1999 or longer, covering at least three financial crises: the Mexican Crisis in 1995, the Asian Crisis in 1997 and the Russian Financial Crisis in 1998. Although the detailed assumptions are quite different from each other, some are similar: efficient market, rational behaviour and absolute competition. Most of the papers under this definition exclude the effect of heteroscedasticity, while those which consider it usually employ the GARCH model. For instance, Bae, Karolyi and Stulz (2003) took the GARCH effect as a sign of heteroscedasticity and compared the results of the abnormal returns with GARCH effect, multivariate normal and student distribution. Kaminsky and Reinhart (2002) calculated the conditional variance based on the GARCH models they built in order to establish whether there was any change in the volatility during or around the target time period.

Multivariate regression is one of the most popular methods under this definition. A discussion of possible transmission channels is usually provided in order to identify suitable variables for the multivariate regression. Although different papers use different regressions, they usually come to a similar point when the regressions are estimated: a hypothesis test, and more often than not a t-test, is applied to the estimated coefficients in order to examine if there is any significant change. Likewise, the ratio test is also a popular choice, but in another methodology framework. In a ratio test, the ratios of different macroeconomic variables are calculated before and after shock. These ratios represent the condition of the economy. The more ratios change, the higher the possibility of contagion. The ways in which previous studies have built the multivariate regression can be split into two categories: the same model applied within different time periods and different variables applied in the same period. Indeed, a few others bring in the idea of different weights for different variables (Hernández and Valdés, 2001).

Besides the multivariate regression, some studies employ the probability method. Their methods can be divided into two categories: the first calculates the possibility of the crisis directly (Glick and Rose, 1999; Kaminsky and Reinhart, 2000; Markwat, Kole and Van Dijk, 2009) while the second one deduces the possibility based on different macroeconomic indicators (De Gregorio and Valdes, 2001; Hernández and Valdés, 2001; Geršl, 2007). Despite the focus on the crisis, the studies in the first category have little in common and their approaches are quite different. While Kaminsky and Reinhart (2000) looked at the conditional probability of crises, Markwat, Kole and Van Dijk (2009) and Glick and Rose (1999) began with probability equations of crises which were built in different ways with different variables. Gómez-Puig and Sosvilla-Rivero (2014) directly compared the number of changes in causal relationships between stable and tranquil periods during the European Sovereign Debt Crisis. They found that the tranquil period has 70% more changes than that of the stable period. Naoui, Liouane and Brahim's (2010) dynamic conditional correlation approach suggested that compare to the emerging stock markets, the developed stock markets are far more easily affected by shocks during the subprime crisis. Studies under the second category are also quite different. The indicators are calculated with various kinds of fundamental factors including international and local borrows, fiscal budget and GDP growth, inflation and trade links etc. The probability method is quite controversial because its advantage is as obvious as its disadvantage. The advantage is that the result is much easier to understand and it provides ideas to predict contagion. If a crisis occurs in one country then the higher the probability of a crisis in another country, which can result in contagion. The disadvantage is that they usually assume contagion will happen, with different possibilities. However, they cannot determine the timing of previous and future contagion nor can they illustrate how long the contagion effect will last.

As for the evidence relating to contagion, the results usually conclude that contagion spreads through several channels including foreign capital flows and bank lending; however, there are those who disagree. For example, the results found by Aharony and Swary (1983) suggest that no contagion is observed under the capital market channel. Instead of the contagion effect, the downside turbulence of capital price is taken as an unfavourable signal by investors. Timing and geographic proximity are also proved to be important in financial contagion. From the geographic aspect, Glick and Rose (1999) and Hernandez and Valdes (2001) found evidence in favour of significant cross-border contagion. Using the bank credit to foreign countries of 17 countries around the world, Degryse, Elahi and Penas (2010) illustrated a cross-border contagion process where the stability of the whole financial system would be impaired as long as the shock affects the liability of one of the target countries. The cointegration and granger causality based approach of Gray (2009) also suggested that the cross-border links of the banking sector were the reason for the contagion among EU-8 countries during the subprime crisis. Timing issues under this definition relate not to breakpoints, but instead to the occurrence of specific issues. They do not usually assign the timing in their methodologies, but do use it for the implications. Gropp, Duca and Vesalac's (2009) study is a typical example. They blame the introduction of the Euro for the cross-border contagion they find. Kleimeier, Lehnert and Verschoor (2008) applied the similar method where they define Thailand's decision to float their currency on 2 July 1997 as the structural change. While Mondria and Quintana-Domeque (2013) used FT news to resemble public attention allocation during the Asia financial crisis. Since the specification of the factors which trigger the initial crisis and the spread is not relevant, this definition is consistent with many different views regarding the international transmission mechanism. However, our framework can provide an idea as to how contagion spreads among countries by combining the breakpoint test with impact coefficients.

2.3 Definition 2: Volatility Spillover of Asset Prices

Under the second definition, it is believed that financial turmoil is usually accompanied by an increase in return volatility (Baig and Goldfajn, 1999; Calvo, 1999; Masson, 1999; Allen and Gale, 2000; Calvo and Mendoza, 2000a; Calvo and Mendoza, 2000b; Schinasi and Smith, 2000; Nogués and Grandes, 2001; Gromb and Vayanos, 2009; Uhlig, 2010). Under this definition, contagion refers to the enhancement of volatility and the spread of uncertainty across international financial markets. Usually covering the period spanning 1994 to 1998, previous studies tend to look for the relationship between country risk and macroeconomic factors in their framework in different equilibriums. They always take asymmetric information into consideration, with one common conclusion being that rational but imperfectly informed investors could react strongly to signals implied by informed individuals. However, there is more than one reason for the simultaneous rise of volatility in different markets: the normal interdependence between these markets or the structural change which influences cross-market linkages or 'pure contagion'. Such a distinction is usually neglected in this definition. However, a few studies have noticed this. Indeed, Nogués and Grandes (2001) considered the possible structural change in cross-market linkages by introducing dummy variables and found even more transmission channels. Cross-border contagion is still a heated topic under this definition (Baig and Goldfajn, 1999) while capital market remains one of the most popular transmission channels (Calvo and Mendoza, 2000a). The disadvantage of the studies under this definition lies in the definition itself. Volatility is not the only feature which spills over. Change in mean should also be considered. A significantly higher volatility usually suggests turmoil, thus meaning it is easier to get people's attention. As a result, change in mean does not attract enough attention in the contagion literature. A framework which takes into account both change in volatility and mean would be more appropriate.

The methodologies included here are different, and share almost no similarities. The common methods include correlation analysis (Baig and Goldfajn, 1999), portfolio analysis (Schinasi and Smith, 2000) and logistic regressions (Masson, 1999). Baig and Goldfajn (1999) calculated and compared the correlation of tranquil and turmoil periods in order to identify contagion. Their study covers foreign debt market and stock markets. Significant changes in correlations are detected by the t-test. High volatility is evaluated by rolling correlation and good news as well as bad news is employed to represent shocks, which are presented through dummy variables. Calvo and Mendoza (2000a) examined whether or not the security markets were becoming more volatile or sensitive to contagion using an international portfolio diversification model. They concluded that globalisation of securities markets can reduce incentives for information gathering. As a result, high volatility is produced in capital flows. With a more comprehensive study, Masson (1999) used the macroeconomic model to illustrate several possible transmission channels, including fiscal deficits, foreign debt, international interest rate and political noise. With the US as a benchmark, Chiang, Jeon and Li (2007) employed a dynamic conditional-correlation model on 9 Asian countries to analyse the Asian financial crisis. They found that the international sovereign credit-rating agencies play an important role in contagion. A similar source of contagion was illustrated by Mink and De Haan (2013). By using the bank exposure to Greece of 48 European banks, they conclude that the news about the Greek bailout has a significant effect on the contagion during the European Sovereign Debt Crisis. Arghyrou and Kontonikas (2012) employed a principal components analysis to analyse the European countries as well. They found an increasing number of contagion during the sovereign debt crisis and argued that there are multiple sources for contagion, for instance, the shift in fundamentals and the change in country-specific market expectations.

More evidence related to contagion can be found in other studies. Indeed, Allen and Gale (2000) found that small liquidity preferences shocks were highly transferable. The completeness of the structure of interregional claims plays an important role in the transmission process. Baur (2012) examined the excessive volatility of 25 developed and emerging countries and reached a similar conclusion regarding the financial sector. However, they also found that some sectors, such as healthcare, telecommunication, are much less affected by crisis. Calvo and Mendoza (2000b) found that globalisation promoted contagion by weakening the incentive to gather costing information and strengthening the incentive to imitate arbitrary portfolios.

2.4 Definition 3: Jumping between Multiply Equilibriums

Literature under the third previous definition tends to focus on two aspects: Explaining contagion by fundamentals (Frankel and Schmukler, 1998; Calvo, 1999; Majnoni and Chang, 2000; Kodres and Pritsker, 2002) and jumping between multiple equilibriums (Baig and Goldfajn, 1999; Masson, 1999; De Gregorio and Valdes, 2001). These studies usually build their models based on macroeconomic factors, and again tend to focus on the Mexican and Asian crises (1994 to 1998). Interestingly, although they define contagion by this definition, most of the studies conclude that fundamentals can more effectively explain contagion, with only a few concluding that the role of fundamentals is relatively weak (De Gregorio and Valdes, 2001). Relative papers also use the ideas from the first two definitions, discussing the effects of various macroeconomic variables (usually ratios) and different transmission channels. However, the reason is to find possible links between contagion and the fundamentals rather than identifying the variables which should be used in the model. The Granger Causality test is introduced to examine the relationship between different assets and to calculate the correlation between asset prices and fundamental ratios (Frankel and Schmukler, 1998). These statistical relationships and correlations are used to represent different equilibriums.

Another important feature is that the shock is split into smaller segments (Kodres and Pritsker, 2002). In their attempts to find different reasons for the shocks, studies under the first two definitions discuss different macroeconomic variables and transmission channels. However, the fact that the shock may consist of different components is not recognised. On occasions, the reasons found only focus on one of the possible components, mostly the macroeconomic fundamentals, which is not sufficient to cover the effects of others. The jumps between equilibriums are usually assumed to be stochastic. An additional assumption is that there are two sets of investors – informed and uninformed, who are assumed to behave competitively. For example, Masson (1999) argued that a crisis in one country readjusts investors' expectations and shifts them from one equilibrium to another. He also found that it might be useful to formulate models which do not imply a unique equilibrium mapping between those fundamentals and crisis expectations. Asymmetric information makes a country more vulnerable to contagion from abroad. One possible protection against undesired, excessive price movements is a reduction in informational asymmetries through increased transparency and more open access to information underlying the value of assets. As informational asymmetries shrink in developed country markets, these countries begin to transmit contagion among emerging market countries instead of refraining it.

Majnoni and Chang (2000) argued that different combinations of fundamentals will cause different contagions, thus correspondingly impacting the effectiveness of international rescue packages. Frankel and Schmukler (1998) described contagion as a result from herd behaviour; a description which is fairly similar to that put forth by Masson (1998). Their causality-based test also suggested that fundamentals influence the sensitivity of markets to shocks. Yiu, Ho and Choi's (2010) asymmetric dynamic conditional correlation model illustrated that the impacts of bad news and good news on contagion among Asia countries are not very different from 1993 to 2009. De Gregorio and Valdés (2001) discovered a strong neighbourhood effect. Meanwhile, trade links and similarity in pre-crisis growth are also proven to be effective transmission channels of contagion. Debt composition and exchange rate flexibility have less of an influence on contagion, while no definite link was observed between capital control and contagion.

2.5 Definition 4: Significant Increase in Co-Movements

Despite much less literature, the forth definition is said to be most commonly accepted (Forbes and Rigobon, 2001; Kaminsky and Reinhart, 2002; Kodres and Pritsker, 2002; Bae, Karolyi and Stulz, 2003; Fratzscher, 2003; Bekaert, Harvey and Ng, 2005; Cifuentes, Ferrucci and Shin, 2005; Baur and Lucey, 2009). Studies usually convey the notion of contagion as 'excessive co-movements'. The unique time period studied is more recent, generally from 1994 to 2006. The bond market is the favourite one, and is allegedly the most easily affected by contagion in these studies. This is true according to the review of the last three definitions. The open issue is thus how to draw a distinction between normal co-movements. Indeed, this is difficult because of simple interdependence and excessive co-movements in prices and quantities due to certain structural breaks in the data. The former refers to a significantly strengthened or weakened correlation while the emphasis of the latter is on the vanishing and substituting of the original correlation. In other words, the structural break we discuss here is the structural change mentioned in the fifth definition. Definition 5 is a combination of definition 3 and 4. However, reasons for the changes in co-movement are seldom discussed in this definition. The research interest here is the detection of contagion.

The methodologies used to identify breakpoints and structural changes are quite different in the literature. Indeed, the Markov-Switching model was more widely used (Fratzscher, 2003). A small group of studies noticed the importance of heteroscedasticity. Forbes and Rigobon (2002) found that tests for contagion that do not correct for heteroscedasticity are biased, especially during recent financial crises. They measured contagion via correlation coefficients and corrected it for heteroscedasticity. They found that the correction of heteroscedasticity significantly affects the detection of contagion. Contagion is usually identified using different criteria depending on their methodologies.

Bae, Karolyi and Stulz (2003) found that the return volatility of one market is related with the conditional variance of other markets. Bekaert, Harvey and Ng (2005) used correlations among the model residuals as an indicator of contagion. Their two-factor asset pricing model contained time-varying expected returns and time-varying risk loadings. Surprisingly, they found no evidence of contagion during the Mexican Crisis. However, economically meaningful contagions were detected during the Asian Crisis period. As we have already established from the results of the last three definitions, economic fundamentals are not the only reason for the contagion transmission. Indeed, financial links also play a role in this. Fratzscher's (2003) study confirmed that it is not only countries with similar economic fundamentals which are vulnerable to contagion, but also countries which are closely linked financially. The panel data models in his study found evidence of contagion in the Latin American Crisis and the Asian Crisis, thus suggesting that real and financial interdependence is an important indicator when it comes to identifying and predicting contagion. However, a possible loophole here lies with the question of, what if the interdependence cannot explain the estimated contagion? Or what if interdependence is only part of the reasons of contagion? If so, what are the other reasons?

2.6 Definition 5: Change in Transmission Channels

Studies under the fifth definition have, more often than not, associated their result with political issues, while it is easy to observe from their findings that political instability usually results in structural changes (Corsetti, Pericoli and Sbracia, 2001; Rigobon, 2002; Gravelle, Kichian and Morley, 2006; Marais and Bates, 2006; Rodriguez, 2007; Billio and Caporin, 2010). Research studies occasionally still examine the time period during the Mexican Crisis and the Asian Crisis (1994 to 1998). Previous results have often concluded that the international transmission mechanism may change in response to a crisis in one country. For instance, some channels of transmission might be active only during financial crises (Gravelle, Kichian and Morley, 2006). Some studies even view strengthened transmission mechanism as shift contagion; however, we prefer to consider it as a breakpoint in time series but not as a structural change. Shift contagion can also be measured by the jump between multiple equilibriums and excessively strong co-movement. Different methodologies have one thing in common: they all consider structural change to some extent. As discussed previously, the fifth definition is the combination of the third and fourth, which are even the same under specific conditions. Although the literal meaning of definition 5 seems narrow, it is actually the most comprehensive definition of all, with a research area covering most features of the other 4 definitions. Billio and Caporin (2010) modelled stock market returns with a simultaneous equation system and volatility with a special multivariate GARCH model. They identified the mean relationship and volatility spillover at the same time, and thus addressed the disadvantage of definition 2. More importantly, their study detected evidence of contagion and loss of interdependence at the same time, which suggests that interdependence may not be the only reason for contagion. It is important that research studies under this definition begin to realise that non-existent links may also play a role in the estimation of contagion. Marais and Bates (2006) concluded that non-existent links during the tranquil period play a key role during the crisis, thus helping to answer the questions we raise in definition 4 and encouraging us to explicitly distinguish between interdependence and pure contagion. Their study is based on a causal relationship system. Elasticity calculated from a VAR model is used to identify contagion with evidence from the South Korean Crisis. The elasticity they calculated is a good indicator of the overall contagion effect. Although they noticed the importance of the non-existent links, their framework was not able to separate it from the overall effect. However, Gravelle, Kichian and Morley (2006) successfully split the contagion effect into two segments, namely interdependence and idiosyncratic shock, using the 'Identification through Heteroscedasticity' process. However, their interest lies only in the interdependence. The idiosyncratic shocks were not studied. Another example that distinguished contagion and interdependence is Gallegati (2012). They accomplished that by using the frequency domain analysis where the higher frequency domain is associated to contagion and lower frequency domain is associated to interdependence. Their further correlation analysis provided strong evidence of international contagion initiated from the US during the subprime crisis. One of the purposes of Rigobon's (2002) study was to examine multiple techniques with which to measure contagion. The methods used in the study include: OLS, principal components analysis, correlation and probit-logit models. He concluded that if the data suffers from heteroscedasticity, omitted variables and simultaneous equation problems, the estimation could be biased. The second purpose of his study was to detect contagion in bond and stock markets. He found evidence of contagion and concluded that regional variables and trade links are very important transmission channels for contagion in bond markets, but not as important in stock markets.

2.7 Conclusion

We have reviewed the definitions, research frameworks and main findings of previous contagion studies, during which time we have begun to notice the evolution of contagion studies. Research studies tend to include an increasing number of features and definitions. We are convinced that the trend of contagion research will become increasingly comprehensive, encapsulating all previous features as well as many additional ones. Financial contagion is a wide topic which covers many subfields. Although the estimation of contagion and its transmission channel has been repeatedly examined in previous studies, there remain many unsolved questions and details to be nuanced. While certain studies have focussed on the residuals (Bekaert, Harvey and Ng, 2005; Gravelle, Kichian and Morley, 2006), we see no discussion relating to the features of the residuals. Do different forecasting models have different impacts on the final results? Is there any criterion we can use to determine which model fits our framework? Data-mining bias is very common in econometric studies. One way in which to deal with this is to fully understand the features of the data used. For instance, do the low/high auto-correlation and long/short memory features of the data used affect the estimation of contagion? If so, what impact will they create? Timing is another factor which should imply economical and statistical significance while also fitting the contagion identification process. How do we detect an appropriate one? Is there any more appropriate way to illustrate how contagion spreads? How long does it last when we detect one? The remainder of this study attempts to address the above questions in a more detailed level and suggests directions for further study.

Chapter 3 Literature Review on the Methodologies

3.1 Introduction

Given the multiple definitions of contagion from previous studies, we can further summarise them into two categories: Category 1 includes definitions which focus on the significant increase in the probability of the crisis. Only definition 1 fits this category. Category 2 covers definitions which focus on the significant changes in co-movement and structural changes, including all of the other four definitions. In our study, we focus on the second category. The issues facing us include, what kind of co-movement can be identified as contagion and what role do structural changes play? Based on the 5 previously discussed definitions, the co-movements considered in previous studies are the price and returns movements caused by another market or country, the co-movement, which cannot be explained by fundamental reasons, the excess co-movement, which no one expected, and co-movement, which is purely caused by information asymmetries. Indeed, as we explained in the last chapter, in order to distinguish between these similar kinks of co-movements, people should define and detect contagion in different ways. What we should also consider is that the definition of contagion is not the only definition to which we should pay attention. Indeed, if only the above co-movements are defined as contagion, what about the others? Two usual terms used by the literature to describe the non-contagion co-movements are common shock and interdependence. Indeed, changes in common shock or interdependence are also occasionally defined as contagion, although they are usually referred to as changes in transmission channels. Indeed, because there are many different ways in which to define and detect contagion, these two terms are also defined and detected in different ways. However, regardless of how different they are, they always boil down to one problem: what fundamentals can explain and what fundamentals cannot explain. The former sums up how previous studies like to define common shock and interdependence while the latter is a fitting summary of what is usually referred to an idiosyncratic shock or speculative attack.

Indeed, one problem with the previous literature is that scholars always focus on only one of these, which, in our opinion, should be seen as a limitation. Another problem is that co-movement is always treated as a whole, and can either be explained by fundamentals or not. We argue that one single co-movement, or shock, can contain different information. There is information which can be explained by fundamentals and there is information which cannot be explained by fundamentals. Treating co-movement as a whole (either can or cannot be explained by fundamentals) will overemphasise the effect of one kind of information much while ignoring the other completely. As a result, we define contagion as a significant change in both common shock and idiosyncratic shock. Crises are usually treated as structural changes. A significant change following a crisis is usually identified as contagion, thus suggesting a change in transmission channels. The previous channels are either wider, less, or are replaced by new ones.

When we talk about contagion, another thing which attracts our interest is the reason behind it. What starts it and how does it spread? It may be because of the change in exchange rate, interest rate and equity market returns (Bae, Karolyi and Stulz, 2003). However, it may also stem from trade links and region (Glick and Rose, 1999), or be triggered by international portfolios and investments (Goldstein and Pauzner, 2004) as well as financial competition in banking centres (Hernández and Valdés, 2001). It may be a result of political noise (Nogués and Grandes, 2001) and liquidity shocks (Corsetti, Pesenti and Roubini, 1999), while certain studies have argued that information asymmetries and herd behaviour (Calvo and Mendoza, 2000b) also play a role. We can summarise 5 kinds of reasons from previous studies: Political reasons, information asymmetries, trading links, financial links and region. Normally, there are two ways in which to examine these factors. The first is to include the suspected factors in the modelling process and assess how these factors or their corresponding coefficients behave together in the co-movement. The second is to apply the same tests to data relating to different factors and to detect contagion in different variables separately. However, the number of factors included is limited. Moreover, because many factors are linked by the economic system, change in one element may transfer to another and continue to spread along the existing linkage. As a result, the factors which seem to be behind co-movement may actually be part of the transmission process. In addition, the existing linkages may occasionally break or change into another one due to the structural changes in the corresponding areas of the economic system. In view of the above reasons, we feel that there is a limitation when it comes to the capability of the economic models and system designed for specific economic factors. Indeed, it is more appropriate to identify the structural changes first when we are looking for the reasons behind contagion.

Based on Gravelle, Kichian and Morley's (2006) study, we propose a new approach, and consider the more appropriate algorithm of 'Identification through Heteroscedasticity' with a more comprehensive definition of contagion. We also try to address the following issues: First, we illustrate how we can split co-movement into common shock and idiosyncratic shock using the technique 'Identification through Heteroscedasticity' and put the new algorithm into practice. Second, we examine the effect of two features of the data: the long memory and short memory feature, and Heteroscedasticity. No contagion study has yet focussed on the former yet, and although Heteroscedasticity has already been considered, we examine its effect from a totally different angle. Third, we would like to shed light on the reasons behind the occurrence of contagion and how it spreads. We will do this by using the breakpoint tests. We review 4 main methodologies used in the literature from Section 2 to section 5. They are correlation method, weighted multivariate OLS regression, herd behaviour and portfolio diversification and identification through heteroscedasticity.

3.2 Correlation Method

The transmission of financial crisis are often accompanied by the substantial devaluation of financial assets. Moreover, the panic caused by such devaluation are generally not contained within a single market. The behaviour of different markets appears to be linked during crises. For instances, the 2008 subprime crisis quickly spread through the banking system, the real estate markets, the stock markets and it caused varying degrees of sovereign debt defaults across nations as well. In order to gain a more rational view regarding the dissemination of financial crisis, many techniques were applied to study the linkages among different markets. One commonly used method to capture the overall effect of financial shocks is the correlation method.

While there are various kinds of correlation methods, they are all generated from the most basic definition of correlation. The basic process of computing correlation is as follows:

This is the relationship between variable X and Y:

$$y_t = \beta_1 + \beta_2 x_t + \varepsilon_t \qquad (1)$$

Their correlation is calculated as:

$$\rho = \frac{\sigma_{xy}}{(\sigma_x \sigma_y)} = \beta_2 \frac{\sigma_x}{\sigma_y} \qquad (2)$$

Since σ_x and σ_y are known, so the problem is how to compute and adjust β_2. Here we use the study of Marais and Bates (2006) to illustrate how this can be achieved.

Marais and Bates (2006) used the concept of 'elasticity' to measure relation intensity, which is representative of financial contagion. The elasticity is defined as follows:

$e_{XY} = \frac{X_t}{Y_t}$, the data used here are in logarithm.

We can see that it is actually another version of β_2.

The basic theory is as follows:

First we need to estimate the VAR model:

$$\begin{aligned} X_t &= \sum_{i=1}^{k} a_{1i} X_{t-i} + \sum_{j=k+1}^{p} a_{1j} X_{t-j} + \sum_{i=1}^{k} b_{1i} Y_{t-i} + \sum_{j=k+1}^{p} b_{1j} Y_{t-j} + \varepsilon_{Xt} \\ Y_t &= \sum_{i=1}^{k} a_{2i} X_{t-i} + \sum_{j=k+1}^{p} a_{2j} X_{t-j} + \sum_{i=1}^{k} b_{2i} Y_{t-i} + \sum_{j=k+1}^{p} b_{2j} Y_{t-j} + \varepsilon_{Yt} \end{aligned} \qquad (3)$$

Once the causal relation is identified, the elasticity of X related to Y must be calculated from the first equation in the system using backward operator L:

$$X_t\left(1-\sum_{i=1}^{k}a_{1i}L^i-\sum_{j=k+1}^{p}a_{1j}L^j\right)=Y_t\left(\sum_{i=1}^{k}b_{1i}L^i-\sum_{j=k+1}^{p}b_{1j}L^j\right)\text{, where L=1} \quad (4)$$

The backward operator is used for lag-shift, L=1 means shift lag for one period, for instance:

L: Lag-shift one period $\quad L(X_t)=X_{t-1}$

L^2 : Lag-shift two periods $\quad L^2(X_t)=L(L(X_t))=X_{t-2}$

From equation (2) we can obtain the following:

$$e_{XY}=\frac{X_t}{Y_t}=\frac{\sum_{i=1}^{k}b_{1i}+\sum_{j=k+1}^{p}b_{1j}}{1-\sum_{i=1}^{k}a_{1i}-\sum_{j=k+1}^{p}a_{1j}} \quad (5)$$

The bootstrap estimation is employed to obtain the statistical distribution of e_{XY} , and the higher the level of e_{XY} , the more intense the causal relationship, and the higher the likelihood that contagion will spread.

There are other correlation methods besides this one. For instance, Forbes and Rigobon (2002) and Corsetti, Pericoli and Sbracia (2005) adjusted the basic definition of correlation for Heteroscedasticity, thus meaning that their new correlation is less biased. However, some potential problems with these previous studies are that: first, they do not consider structural changes very well. What they did was to assign a breakpoint to a specific date and estimate the correlation prior to and following this date before identifying significant changes. Second, their method does not deal with transmission channels. It is hard to see how contagion spreads based on their results. Third, they do not split shocks into smaller segments. Indeed, they fail to even consider different kinds of shocks. Their study tracks the overall movement of the market, which lacks more detailed analysis.

Another more direct example of the adjusted correlation method is Forbes and

Rigobon's (2002) study. They define the unadjusted correlation as a conditional correlation and the adjusted (adjusted for Heteroscedasticity) correlation as the unconditional correlation. Their equation for the adjusted correlation is:

$$\rho^* = \frac{\rho}{\sqrt{1+\delta[1-\rho^2]}}, \text{ where } \delta = (\sigma_{xH}^2 / \sigma_{xL}^2) - 1 \quad (6)$$

H represents high volatility and L represents low volatility. They argued that correlation that is not adjusted for heteroscedasticity is biased, and that one can only identify the occurrence of contagion when significant change in the adjusted correlation is detected.

The correlation methods have an advantage when analysing the overall effect of shocks. They calculate the correlation coefficients before and after shocks, and the comparison is very straight forward. However, this method only illustrates a very general picture, it's not suitable for more detailed analysis. In addition to the changing correlation among asset values, another concern is what factors are responsible for it. Although the correlation method can be used to illustrate the changes of the relationship among different markets, it is not appropriate to identify the reasons behind them.

3.3 Weighted Multivariate OLS Regression

As soon as the changes in the correlation between different markets are detected, further detailed questions are raised as well. What have caused the financial crisis and the changes in correlation? Which market factors facilitated the transmission of the crisis? With these questions in mind, research techniques start to include more and more economic factors into consideration, for example, the weighted multivariate OLS regressions.

In this methodology framework, the performance of contagion is explained in a single or multivariate OLS regression. In particular, specific countries and markets are picked as transmission channels of contagion, and serve as variables in the regression. Contagion is assumed to transfer through the picked markets among the picked countries. A general single variable model is as follows:

$$X_{i,c} = \beta_0 + \beta_1 \sum_j m_{i,j} X_{j,c} + \varepsilon_{i,c} \tag{7}$$

where X is the picked market, the transmission channel of contagion. $m_{i,j}$ is a set of weights from country i to j that add up to one. c represents crisis. They are used to measuring the importance of each country in this specific transmission channel. $\varepsilon_{i,c}$ is the stochastic shock. The existence of contagion is tested by evaluating whether or not β_1 is significantly different from 0. If it is 0, there is no contagion. If it is not 0, there is contagion. Change the transmission channel and a new β_1 is estimated. Since β_1 is measured in a weighted average regression, we can directly compare the size of β_1 in each country. Indeed, the greater the size the more important the transmission channel in that country. Although the OLS estimation of this regression has a positive bias (De Gregorio and Valdes, 2001), it is proportional to the true β_1, and thus it is 0 when $\beta_1 = 0$. Since the hypothesis test is $\beta_1 = 0$ against $\beta_1 \neq 0$, this bias does not affect the identification of contagion, nor the importance of each transmission channel because the bias is proportional to the true β_1.

However, the possibility that contagion is transferred through only one transmission channel is quite low. When one country's performance affects that of other countries, the other countries will in turn affect the origin country. When one market is changed, the previous balance is impaired and the system will adjust to a new equilibrium. Thus, we might want to include more than one transmission channel in the regression. A general model of multivariate regression is as follows:

$$X_{i,c} = \beta_0 + \beta_1 \sum_j m^1_{i,j} X^1_{j,c} + \beta_2 \sum_j m^2_{i,j} X^2_{j,c} + \cdots + \varepsilon_{i,c} \tag{8}$$

where $m^1_{i,j}$ and $m^2_{i,j}$ are the weights of each transmission channel and the significance of both β_1 and β_2's is tested and compared.

Finally, on occasions, a mutual variable that is assumed to affect all countries simultaneously is added to the regression. It is either called interdependence or common shock, and is not weighted. An expression of this kind of variable is as follows:

$$X_{i,c} = \beta_0 + \beta_1 \sum_j m_{i,j}^1 X_{j,c}^1 + \beta_2 \sum_j m_{i,j}^2 X_{j,c}^2 + \cdots + \beta_n Y_t + \varepsilon_{i,c} \qquad (9)$$

where Y_t is the common shock that affects all countries; it is usually measured by index data which covers an industry.

Another issue relating to this framework is how to evaluate the weights of the transmission channels in each country. Trade links are usually measured by taking each country's export and import and dividing them by the sum of exports and imports. Region and political variables are usually measured by assigning dummy variables.

De Gregorio and Valdes (2001) proposed the following method:

First, a similarity index between country i and j is calculated:

For regressions with a single variable, the similarity index is:

$$\theta_{i,j} = \exp(-|X_i - X_j|) \qquad (10)$$

For regressions with multiple variables, the similarity index is:

$$\theta_{i,j} = \exp(-\sum_s |X_{i,s} - X_{j,s}|) \qquad (11)$$

The weight of country j to i is calculated as follows:

$$M_{i,j} = \frac{\theta_{i,j} - \min(\theta_{i,j}^a)}{\max(\theta_{i,j}^a) - \min(\theta_{i,j}^a)} \qquad (12)$$

where $\theta_{i,j}^a$ represents all the $\theta_{i,j}$.

However, this is not the only way to calculate weights. This topic is quite controversial. Different studies have used different methods to measure weights. For instance, Hernández and Valdés (2001) measured the weights in financial competition as follows:

$$m_{i,j}^{abs} = \sum_c \frac{b_{jc}+b_{ic}}{b_j+b_i}\left(1-\frac{\left|b_{jc}-b_{ic}\right|}{b_{jc}+b_{ic}}\right)$$

$$m_{i,j}^{rel} = \sum_c \frac{b_{jc}+b_{ic}}{b_j+b_i}\times\left(1-\frac{\left|b_{jc}/b_j-b_{ic}/b_i\right|}{b_{jc}/b_j+b_{ic}/b_i}\right) \quad (13)$$

where $m_{i,j}^{abs}$ is the absolute competition and $m_{i,j}^{rel}$ is the relative competition. b_{ic} represents the stock of debt of country i in banking centre c and $b_i = \sum_c b_{ic}$. The absolute competition suggests that countries on a larger scale have more competition while the relative competition measures the competition by scaling countries according to their size.

One advantage of this framework is its simplicity. It is fairly easy to find countries and markets to test while the classic OLS estimation is not statistically difficult. Although the calculation of weights is controversial, it brings in many possibilities and new thoughts while also providing a relatively straight forward way to illustrate the importance of different countries. The disadvantage is also quite obvious: there is no guarantee that the picked variables are definitely the reasons that contagion occurred. Indeed, as previously explained, the transmission of contagion is caused by a string of changes in different variables. What we chose as the reason behind contagion may in fact be the result of it. Although this framework considers the possible transmission channels by including multiple variables in the regression, it neglects the fact that when the transmission channel changes, the variables included in the regression may no longer play any role in it, and thus keeping them in the regression will most certainly create a bias. The variables included in this framework are rather fixed, and a more flexible way to analyse the possible reasons is needed. Last but not least, the variables analysed under this framework are usually macroeconomic factors. As a result, the effect of idiosyncratic shock, or stochastic shock cannot be considered in this framework.

3.4 Herd Behaviour and Portfolio Diversification

As the research regarding the reasons and dissemination of the financial crisis keep developing, more and more research studies start to realize that the macroeconomic fundamentals are not enough to explain the behaviour of markets during financial crisis. As a result, researchers start to seek other reasons for the excess co-movement. One of the widely considered factor is the herd behaviour.

We use Calvo and Mendoza's (2000b) study to illustrate this kind of methodology. Indeed, Calvo and Mendoza (2000b) investigated the role played by rational expectation and globalisation in contagion. They argued that globalisation weakens incentives to gather costly information and strengthens incentives to imitate arbitrary market portfolios, thus promoting contagion.

In their study, contagion is defined as "a situation in which utility-maximizing investors choose not to pay for information that would be relevant for their portfolio decision – thereby making them susceptible to react to country-specific rumours – or in which investors optimally choose to mimic arbitrary 'market' portfolios". Using a basic framework of mean-variance portfolio diversification, they considered two characteristics of imperfect information: a fixed cost of gathering and processing country-specific information and a variable cost or gain that depends on the mean return of their portfolios relative to that of a given market portfolio.

They started by assuming a globalised securities market consisting of J countries $(2 \le J \le \infty)$ and a large number of identical investors. The countries were divided into $J-1$ identical countries and a country i with different asset return characteristics. All countries with the exception of i pay asset returns that follow i.i.d. processes with mean ρ and variance σ_J^2. Each one of the $J-1$ countries will be allocated an identical share in the portfolio. Country i pays expected return r^* with variance σ_i^2, while the correlation coefficient between country i and the $J-1$ countries is η. The share of the portfolio invested in the $J-1$ identical countries is θ. The following expected utility function is given to characterise investors' preferences:

$$EU(\theta) = \mu(\theta) - \frac{\gamma}{2}\sigma(\theta)^2 - \kappa - \lambda(\mu(\Theta) - \mu(\theta)), \quad (14)$$

where $\gamma, \kappa > 0$

γ is the coefficient of absolute risk aversion, μ and σ are the mean and standard deviation of the portfolio as a function of θ, κ represents a fixed cost of acquiring country-specific information and $\lambda(\mu(\Theta) - \mu(\theta))$ represents the variable performance cost (benefit) of obtaining a mean portfolio return lower (higher) than the mean return of an arbitrary portfolio Θ. Contagions under two circumstances were considered after giving the expected utility function.

The first type of contagion is driven by fixed information costs and short-selling constraints. They assumed an initial equilibrium in which all countries are identical to the rest and asset returns are uncorrelated $(\eta = 0)$, thus meaning that the investor allocates an equal amount to each country. The investor then hears a rumour indicating that country i has a lower return yet its variance remains unchanged. Now the investor faces two choices. The first is whether to acquire country-specific information at the fixed cost κ in order to evaluate the veracity of the rumour, while the other is whether to choose not to pay κ and simply believe that the rumour is true. In their study, they focus solely on the case that the investor pays κ to acquire precise information. By paying κ, the investor will earn a new return r^I with zero variance. Clearly, the investor will only pay for the information when expected utility conditional on costly information EU^I exceeds that conditional on free information EU^U, which means the gain from costly information $S \equiv EU^I - EU^U$ must be positive. A new expected utility function is given as follows:

$$EU^U = \theta^U \rho + (1-\theta^U) r - \frac{\gamma}{2}\left[\frac{(\theta^U)^2}{J-1} + (1-\theta^U)^2\right]\sigma^2 \quad (15)$$

where θ^U and θ^I represent the portfolio shares chosen by the investor if he decides to be uninformed or informed respectively. The corresponding first-order condition implies that the optimal portfolio and θ^U for the optimal portfolio is:

$$\theta^U = (\frac{J-1}{J})[1+\frac{\rho - r}{\gamma\sigma^2}] \tag{16}$$

They assumed that optimal portfolios may reflect corner solutions (the quantity of one of the arguments in the maximised function is zero) because of short-selling constraints. They also assumed that $-a \le \theta^U \le b, 0 \le a < \infty, 1 \le b < \infty$, $-a \le \theta^U \le b$, a and b are given constants. The case $a = 0, b = 1$ is the extreme, whereby the short position in country i and the $J-1$ identical countries are ruled out. Short-selling constraints imply that:

$$\theta^U = b \text{ for } r \le r^{\min}, \tag{17}$$

$$\theta^U = -a \text{ for } r \ge r^{\max}, \tag{18}$$

With (3), (4) and (5), we can get:

$$\begin{aligned} r^{\min} &= \rho - \frac{\gamma\sigma^2[J(b-1)+1]}{J-1} \\ r^{\max} &= \rho + \frac{\gamma\sigma^2[J(a+1)+1]}{J-1} \end{aligned} \tag{19}$$

As J goes to ∞, the interval of returns that supports internal solutions for θ^U shrinks and converges to $r^{\max} - r^{\min} = \gamma\sigma^2(a+b)$.

They then simplified the model by assuming the information is free (i.e. $\kappa = 0$). For r in the interval $r^{\min} < r < r^{\max}$, EU^U valued at the maximum is:

$$EU^U = (r - \frac{\gamma}{2}\frac{\sigma^2}{J} + \frac{(\rho - r)}{2}\frac{J-1}{J}[2+\frac{(\rho - r)}{\gamma\sigma^2}]) \tag{20}$$

They then examined the portfolio problem under the assumption that the investor pays information cost κ and earns r^I. State-contingent utility $U^I(r^I)$ is:

$$U^I(r^I) = \theta^I\rho + (1-\theta^I)r^I - \frac{\gamma}{2}[\frac{(\theta^I)^2}{J-1}]\sigma^2 - \kappa \tag{21}$$

Taking first-order condition, $\theta^I(r^I)$ for the optimal state-contingent portfolio is:

$$\theta^I(r^I) = (J-1)[\frac{(\rho - r^I)}{\gamma\sigma^2}] \tag{22}$$

Short-selling constraints imply: $\theta^I(r^I)=a$ if $r^I \geq r^I_{\max}$ and $\theta^I(r^I)=b$ if $r^I \leq r^I_{\min}$, then we can get:

$$r^I_{\min}=\rho-\frac{b\gamma\sigma^2}{J-1}$$
$$r^I_{\max}=\rho+\frac{a\gamma\sigma^2}{J-1} \qquad (23)$$

As we can see in the equations, as J grows infinitely large, optimal portfolios conditional on costly information always hit the short selling constraints.

The other case they considered is contagion driven by performance-based incentives. The performance-based incentive is one of the reasons why price correction may fail to undo the effects of rumours.

They assumed that information cost $\kappa=0$ and considered the situation in which investors, or mutual fund managers face the variable cost or benefit of obtaining mean returns that deviate from the mean return of an arbitrary market portfolio. They stated that the cost function $\lambda(\mu(\Theta)-\mu(\theta))$ satisfies the following properties:

$\lambda>0$ if $\mu(\theta)<\mu(\Theta)$, $\lambda\leq 0$ if $\mu(\theta)>\mu(\Theta)$, $\lambda(0)=0$,

$\lambda^{'}\geq 0$ with $\lambda^{'}(x)>\lambda^{'}(-x)$ for all $x=\mu(\Theta)-\mu(\theta)>0, \lambda^{'}\leq 0$. (24)

The conditions here imply that investors or managers pay a cost (earn a benefit) when the mean return of their portfolios is smaller (larger) than that of the market portfolio, and that the marginal cost exceeds the marginal benefit.

The expected utility function which investors and managers must optimise is:

$$EU(\theta)=\theta\rho+(1-\theta)r-\lambda(\mu(\Theta)-\mu(\theta))-\frac{\gamma}{2}[\frac{(\theta\sigma_J)^2}{J-1}+((1-\theta)\sigma_i)^2+2\sigma_j\sigma_i\theta(1-\theta)\eta]$$

Since $\mu(\theta)=\theta\rho+(1-\theta)r, \mu(\Theta)=\Theta\rho+(1-\Theta)r$, it follows that

$\lambda(\mu(\Theta)-\mu(\theta))=\lambda((\Theta-\theta)(\rho-r))$. Within a certain range of values of Θ, choosing $\theta=\Theta$ is optimal for a representative investor and is also a rational-expectations equilibrium in which all investors select the same portfolio. Any rumour in that range calling for a different Θ results in a herding panic whereby all investors re-set their portfolios to that new Θ .

This method emphasises the effect of information and human behaviour on contagion. It effectively illustrates that they indeed play a role in the whole process. However, that is all this method is capable of. First of all, one of the key variables, the information, or the rumour, is very hard to quantify. It is a very subjective variable and therefore more susceptible to errors arising from personal subjective opinion. Secondly, information and human behaviour play a role in the whole process doesn't mean they caused contagion. This method cannot be used to detect the reasons for contagion, nor the channels through which it is transferred. Because instead of being the reason for contagion, we argue that human behaviour caused by the information, or rumour, is merely a result of contagion. It is more like a side effect which increases the volatility and instability.

3.5 Identification through Heteroscedasticity

In order to provide a more flexible way to analyse both fundamental and non-fundamental related factors, we illustrate a more comprehensive technique which allows us to capture more features in the economy. The process we illustrate here is referred to as 'Identification through Heteroscedasticity' (Rigobon, 2003; Gravelle, Kichian and Morley, 2006).

The idea behind this method is to build nonlinear equation sets from a covariance matrix to measure structural shocks. Although they share the same idea, the difference between the studies of Rigobon (2003) and Gravelle, Kichian and Morley (2006) is clear from the very beginning. Rigobon (2003) started with simultaneous equations while Gravelle, Kichian and Morley (2006) started with a return estimation. They used forecast error to reflect shock and then further split it into two parts: common shock and idiosyncratic shock. Our contagion test follows that used by Gravelle, Kichian and

Morley (2006), although we look at a different variable.

They combined two approaches from previous literature. The first approach is also referred to as “identification through heteroscedasticity” in Rigobon’s (2003) study, while the other approach is the Markov switching model developed by Hamilton (1989). Although their methodology is quite similar to these previous studies, they slightly revised the model. The first approach helped to identify the parameters related to the structural transmission of common shocks in the presence of regime-switching volatility in common shocks, which is their first contribution. The second approach helped to estimate the timing of changes endogenously, which is their second contribution.

Indeed, the reduced form of the covariance matrix was first considered after giving two simultaneous equations (Rigobon, 2003):

Simultaneous equations: $\begin{bmatrix} p_t = \beta q_t + \varepsilon_t \\ q_t = \alpha p_t + \eta_t \end{bmatrix}$, residuals ε_t and η_t represent the structural shocks which have σ_ε^2 and σ_η^2 variance.

Based on the definition of covariance and the general expression of a covariance matrix:

$$\mathrm{cov}(X_i, X_j) = E[(X_i - \mu_i)(X_j - \mu_j)]$$

$$\Sigma = \begin{pmatrix} E[(X_1-\mu_1)(X_1-\mu_1)] & E[(X_1-\mu_1)(X_2-\mu_2)] & \cdots & E[(X_1-\mu_1)(X_n-\mu_n)] \\ E[(X_2-\mu_2)(X_1-\mu_1)] & E[(X_2-\mu_2)(X_2-\mu_2)] & \cdots & E[(X_1-\mu_1)(X_1-\mu_1)] \\ \vdots & \vdots & \ddots & \vdots \\ E[(X_n-\mu_n)(X_1-\mu_1)] & E[(X_n-\mu_n)(X_2-\mu_2)] & \cdots & E[(X_n-\mu_n)(X_n-\mu_n)] \end{pmatrix}$$

The generated covariance matrix from the above simultaneous equations is:

$$\hat{\Omega} = \frac{1}{(1-\alpha\beta)^2} \begin{pmatrix} \beta^2\sigma_\eta^2 + \sigma_\varepsilon^2 & \beta\,\sigma_\eta^2 + \alpha\sigma_\varepsilon^2 \\ \beta\,\sigma_\eta^2 + \alpha\sigma_\varepsilon^2 & \sigma_\eta^2 + \alpha^2\sigma_\varepsilon^2 \end{pmatrix} \qquad (25)$$

However, the unknowns α, β, σ_η^2 and σ_ε^2 cannot be solved since there are only three moments: the variance of p_t, the variance of q_t and the covariance of p_t and q_t.

As such, the author then employed a state variable $S = \{1, 2\}$ to the new matrix, with the covariance matrix becoming:

$$\hat{\Omega} \equiv \begin{pmatrix} \omega_{11,s} & \omega_{12,s} \\ \omega_{21,s} & \omega_{22,s} \end{pmatrix} = \frac{1}{(1-\alpha\beta)^2} \begin{pmatrix} \beta^2\sigma_{\eta,s}^2 + \sigma_{\varepsilon,s}^2 & \beta\ \sigma_{\eta,s}^2 + \alpha\sigma_{\varepsilon,s}^2 \\ \beta\ \sigma_{\eta,s}^2 + \alpha\sigma_{\varepsilon,s}^2 & \sigma_{\eta,s}^2 + \alpha^2\sigma_{\varepsilon,s}^2 \end{pmatrix} \tag{26}$$

Now there are six unknowns: α , β , $\sigma_{\eta,1}^2$, $\sigma_{\eta,2}^2$, $\sigma_{\varepsilon,1}^2$ and $\sigma_{\varepsilon,2}^2$, and six conditions, meaning that the problem can be solved.

We combine this approach with Hamilton's (1989) study, assuming the volatility regimes are Markov switching and the value of the state variable $S = \{0,1\}$. The switching models we can obtain are as follows:

$$\begin{aligned} &\Pr[S_{jt} = 0 \mid S_{jt-1} = 0] = q_j \\ &\Pr[S_{jt} = 1 \mid S_{jt-1} = 1] = p_j \end{aligned} \tag{27}$$

The four moments are displayed (Hamilton, 1989):

$$\begin{aligned} &\text{Prob}[S_t = 1 \mid S_{t-1} = 1] = p, \\ &\text{Prob}[S_t = 0 \mid S_{t-1} = 1] = 1 - p, \\ &\text{Prob}[S_t = 0 \mid S_{t-1} = 0] = q, \\ &\text{Prob}[S_t = 1 \mid S_{t-1} = 0] = 1 - q, \end{aligned} \tag{28}$$

Referring back to Gravelle, Kichian and Morley's (2006) study, one of their main research questions related to whether or not there is any shift-contagion between assets associated with different countries. In order to address this research question, they considered the following hypotheses:

$$H_0 : \frac{\sigma_{c1}^*}{\sigma_{c2}^*} = \frac{\sigma_{c1}}{\sigma_{c2}} \quad \text{vs.} \quad H_1 : \frac{\sigma_{c1}^*}{\sigma_{c2}^*} \neq \frac{\sigma_{c1}}{\sigma_{c2}}, \tag{29}$$

where σ_{c1}^* and σ_{c2}^* corresponds to high volatility, σ_{c1} and σ_{c2} correspond to low volatility (i.e. $|\sigma^*| > |\sigma|$). σ_{c1}, σ_{c2} , σ_{c1}^* and σ_{c2}^* determine the impact of the structural shocks on the asset returns.

Their process of identification through heteroscedasticity was almost identical to that of Rigobon (2003). They also provided two return functions at the beginning, although the difference can only be seen in the next step. Differing from Rigobon (2003), they decomposed the residual into two segments: common structural shocks and the idiosyncratic structural shocks.

Return function: $r_{it} = \mu_i + u_{it}$ (30)

Decomposition of residuals: $u_{it} = \sigma_{cit} z_{ct} + \sigma_{it} z_{it}$, where $i = 1, 2$. (31)

where μ_i is the expected return on asset i ,(i =1,2), r_{1t} and r_{2t} denote continuously compounded returns on the two assets. z_{ct} is the common shock, z_{it} is the idiosyncratic shock, and σ_{cit} and σ_{it} determine the impact of the structural shocks on the asset returns. The model assumes serially uncorrelated returns, while the expected return is constant and the forecast error has mean zero and is uncorrelated across time.

A common shock is a result of interdependence. Gravelle, Kichian and Morley (2006) defined contagion as a structural transmission, by which they mean different scales of assets return movement before and after turmoil. They felt that a change in interdependence is a signal of contagion by which is measured by $\sigma_{c1t} / \sigma_{c2t}$. σ_{it} was ignored in their study, and they felt that idiosyncratic shock has nothing to do with contagion. However, we feel that not only co-movement caused by interdependence, but also co-movement caused by idiosyncratic shock should be identified as contagion.

It is our contention that there are three sources of co-movement: change in interdependence, contagion which cannot be explained by the fundamentals and coincidence. Interdependence is measured by σ_{cit} , contagion which cannot be explained by the fundamentals and coincidence is measured by σ_{it} . Instead of measuring only $\sigma_{c1t} / \sigma_{c2t}$, we should focus on both $\sigma_{1t} / \sigma_{2t}$ and $\sigma_{c1t} / \sigma_{c2t}$.

The covariance matrix for residual u_{it} can be easily represented in terms of the σ coefficients:

$$\Sigma_t = \begin{pmatrix} \sigma_{c1t}^2 + \sigma_{1t}^2 & \sigma_{c1t} * \sigma_{c2t} \\ \sigma_{c1t} * \sigma_{c2t} & \sigma_{c2t}^2 + \sigma_{2t}^2 \end{pmatrix} \tag{32}$$

We share the same assumption to that put forth by Gravelle, Kichian and Morley (2006). We assume that σ_{c1} and σ_{c2} have a correlation coefficient of nearly 1 and that σ_1 and σ_2 are independent of σ_{cit} and each other. This matrix can provide us with 3 moments while we have 4 variables. In order to solve the problem, we introduce a state variable, just as Gravelle, Kichian and Morley (2006) did: First, the state variable in their model has the value of $\{0,1\}$ (before and in crisis). Second, two functions are constructed to represent regime switching:

$$\begin{aligned} \sigma_{cit} &= \sigma_{ci}(1-S_{ct}) + \sigma^*_{ci}S_{ct} \\ \sigma_{it} &= \sigma_i\,(1-S_{it}) + \sigma^*_i S_{it} \end{aligned} \qquad (33)$$

When S=0, there is no σ^*_{cit} and σ^*_{it} in the functions, which represent the moment before crisis or shocks. When S=1, they stated that this represented an increase in volatility and σ^*_{cit} and σ^*_{it} were used to represent higher variance. However, we feel that a change in volatility could be both positive and negative, and thus σ^*_{cit} and σ^*_{it} in our framework are only used to measure the shock after the breakpoints. In our study, $S_{ct}=1$ means the change in co-movement comes from common shock, while $S_{it}=1$ means that the change in co-movement comes from the idiosyncratic shock.

Based on the covariance matrix and the state variable, we now have 8 variables and 8 moments:

$$\begin{cases} \mathrm{var}(u_{1t}) = \sigma^2_{c1} + \sigma^2_1 \\ \mathrm{var}(u_{2t}) = \sigma^2_{c2} + \sigma^2_2 \\ \mathrm{cov}(u_{1t}, u_{2t}) = \sigma_{c1}\sigma_{c2} \\ \mathrm{var}(u_{1t} \mid S_{ct}=1) = \sigma^{*2}_{c1} + \sigma^2_1 \\ \mathrm{var}(u_{2t} \mid S_{ct}=1) = \sigma^{*2}_{c2} + \sigma^2_2 \\ \mathrm{cov}(u_{1t}, u_{2t} \mid S_{ct}=1) = \sigma^*_{c1}\sigma^*_{c2} \\ \mathrm{var}(u_{1t} \mid S_{1t}=1) = \sigma^2_{c1} + \sigma^{*2}_1 \\ \mathrm{var}(u_{2t} \mid S_{2t}=1) = \sigma^2_{c2} + \sigma^{*2}_2 \end{cases} \qquad (34)$$

By solving this non-linear equation set, we can obtain the impact coefficients we need to measure contagion. Gravelle, Kichian and Morley (2006) solved this system under a Markov-Switching model. The drawback is that they had to endogenously estimate the structural change. We improved the power of the test by introducing breakpoint tests.

By splitting the shock into two sections, this framework allows us to analyse fundamental and non-fundamental related factors separately. The timing of the structural changes are interpreted as the timing of the contagion effects. The corresponding events are usually interpreted as the possible reasons and transmission channels. Therefore, this method works better when combined with a Chronology that includes the major global economy events and country specific incidents. As a result, the fixed variable bias suffered by weighted multivariate OLS regressions is dealt with and more economic features can be included.

Our study is based on Gravelle, Kichian and Morley's (2006) model using a new algorithm. We will provide a more detailed analysis under a more comprehensive definition and estimate the structural changes in a more appropriate way while also examining the role played by the new features in contagion.

Chapter 4 Methodology Design

We aim to provide a more comprehensive analysis of contagion, which encapsulates most of the features included in the previous study. We also try to make them more appropriate. As our aim is to thoroughly examine the reasons behind contagion, we will not focus on Herd behaviour methods. We would instead like to examine the overall effect as well as the details it implies. Our method mainly focusses on co-movement, although it also sheds light on the changes of equilibrium.

This thesis is consistent with 3 empirical studies, while the main methodology used is 'Identification through Heteroscedasticity'. We start with Gravelle, Kichian and Morley's (2006) idea of splitting the co-movement into two segments, although we make the following changes based on their framework: First, we use two different forecasting models to obtain the residuals and to examine the effect of long memory and short memory features. Second, we estimate the breakpoints before proceeding with the contagion test. We want statistically significant breakpoints with practical significance and also wish to examine the effect of Heteroscedasticity. This is accomplished by employing multiple breakpoint tests and building a chronology. Third, we estimate the coefficients using a different approach: iterative least square method. Fourth, we also examine the change in idiosyncratic shock.

4.1 Forecasting model:

When we try to estimate the expected return, we consider models that have two different features: short memory and long memory. The property of long/short memory is very important. A long memory process suggests that the observations have statistically significant correlations even they are a large distance apart, which implies better forecasting performance. Long and short memory processes react very differently under the same shock. Therefore, it is reasonable for us to expect that short memory models and long memory models will affect the identification of contagion differently.

The short memory and long memory models we consider in this study are the ARMA (Auto Regressive Moving Average) and ARFIMA (Auto Regressive Fractionally Integrated Moving Average) models.

4.1.1 What is Long Memory and Short Memory

Long-memory processes are stationary processes whose autocorrelation functions decay more slowly than short-memory processes. Because the autocorrelations die out so slowly, long-memory processes display a type of long-run dependence. The autoregressive fractionally integrated moving average (ARFIMA) model provides a parsimonious parameterisation of long-memory processes. This parameterisation nests the autoregressive moving-average (ARMA) model, which is widely used for short-memory processes (Granger and Joyeux, 1980).

The ARFIMA model also generalises the autoregressive integrated moving-average (ARIMA) model with integer degrees of integration. The ARFIMA model provides a solution for the tendency to overdifferentiate stationary series that exhibit long-run dependence. With the ARIMA approach, a nonstationary time series is differenced in terms of times until the differenced series is stationary, where d is an integer. Such series are said to be integrated of order d, denoted I(d), with not differencing, I(0), being the option for stationary series. Many series exhibit too much dependence to be I(0) but are not I(1), and ARFIMA models are designed to represent these series.

The ARFIMA model allows for a continuum of fractional differences, $-0.5 < d < 0.5$. The generalisation to fractional differences allows the ARFIMA model to handle processes that are neither I(0) nor I(1), to test for overdifferencing, and to model long-run effects that only die out at long horizons.

There are several possible definitions of the property of 'long memory'. Given a discrete time series process y_t with autocorrelation function ρ_j at lag j, then according to McLeod and Hipel (1978), the process possesses are long memory if the quantity:

$$\lim_{n\to\infty} \sum_{j=-n}^{n} \left|\rho_j\right| = \infty \tag{34}$$

A stationary and invertible ARMA process has autocorrelations which are geometrically bound, i.e., $|\rho_k| \leq cm^{-k}$, for large k, where 0 < m < 1 and is hence a short memory process.

In particular, the process y_t is said to be integrated of order d, or I(d), if:

$$(1-L)^d y_t = u_t \quad (36)$$

where L is the lag operator, -0.5 < d < 0.5, and u_t is a stationary and ergodic process with a bound and positively valued spectrum at all frequencies.

For 0 < d < 0.5, the process is long memory in the sense of the condition (l), while its autocorrelations are all positive and decay at a hyperbolic rate. For -0.5 < d < 0, the sum of absolute values of the processes autocorrelations tends to be constant, thus meaning that it has short memory according to equation (35). In this situation the ARFI MA(0, d, 0) process is said to be 'antipersistent' or to have 'intermediate memory', while all its autocorrelations, excluding lag zero, are negative and decay hyperbolically to zero (Hosking, 1981; Qiao, Chiang and Wong, 2008).

Alternatively, the memory of a process y_t can be expressed in terms of the behaviour of its partial sum:

$$S_T = \sum_{t=1}^{T} y_t \quad (37)$$

Rosenblatt (1956) defined short range dependency in terms of a process that satisfies strong mixing, thus meaning that the maximal dependence between two points of a process becomes trivially small as the distance between these points increases. More concretely, a process y_t can be defined as having short memory if:

$$\sigma^2 = \lim_{T\to\infty} E(T^{-1} S_T^2) \quad (38)$$

exists and is nonzero, and:

$$[1/\sigma T^{1/2}] S_{[rT]} \Rightarrow B(r) \text{ for all } r \in [0,1] \quad (39)$$

where [*rT*] is the integer part of *rT*, *B(r)* is standard Brownian motion, and $\Rightarrow$ denotes convergence in distribution.

A wider definition of long memory is to include any process which possesses an autocovariance function for large k, such that:

$$\gamma_k \approx \Xi(k)k^{2H-2} \quad (40)$$

where $\approx$ denotes approximate equality for large k and where $\Xi(k)$ is any slowly varying function at infinity. Helson and Sarason (1967) showed that any process with $H > 0$ and autocovariance function given by (40) violates the strong mixing condition, and hence is long memory or long range dependent.

We follow McLeod and Hipel's (1978) definition. Indeed, if we define long memory features as those whose autocorrelations decay at the hyperbolic rate as the second one did, then all ARFIMA models are long memory processes regardless of what value d holds. Thus, in order to make things easier, we select the first one.

4.1.2 The Difference between Short Memory and Long Memory

Long-memory processes are stationary processes whose autocorrelation functions decay more slowly than short-memory processes. The ARFIMA model provides a parsimonious parameterisation of long-memory processes that nests the autoregressive moving-average (ARMA) model, which is widely used for short-memory processes. By allowing for fractional degrees of integration, the ARFIMA model also generalises the autoregressive integrated moving-average (ARIMA) model with integer degrees of integration.

Granger and Joyeux (1980) showed that the autocorrelations from an ARMA model decay exponentially, whereas the autocorrelations from an ARFIMA process decay at a much slower hyperbolic rate. Box, Jenkins and Reinsel (2013, pp. 260-262) defined short-memory processes as those whose autocorrelations decay exponentially fast and long-memory processes as those whose autocorrelations decay at the hyperbolic rate.

In our study, we use the ARMA model to represent the short memory models and the ARFIMA model to represent the long memory models and some of the short memory models. Because long-memory processes are stationary, one might be tempted to approximate the processes with many terms in an ARMA model. However, these approximate models are difficult to fit and to interpret because ARMA models with many terms are difficult to estimate and the ARMA parameterisation has an inherent short-run nature. In contrast, the ARFIMA model has the d parameter for the long-run dependence and ARMA parameters for short-run dependence. Using different parameters for different types of dependence facilitates estimation and interpretation, as discussed by Sowell (1992). Granger and Joyeux (1980) also argued that the ability of ARFIMA models to capture this long-range dependence, which cannot be captured by stationary ARMA models, is an important advantage of ARFIMA models over ARMA models when modelling long-memory processes.

4.1.3 The Features of ARFIMA Model and How to Model It

The general ARFIMA (p, d, q) model is defined as:

$$\phi(L)(1-L)^d (y_t - \mu) = \theta(L)\varepsilon_t, \quad \varepsilon_t \sim nid(0, \sigma_\varepsilon^2) \qquad (41)$$

where

$$(1-L)^d = 1 - dL + \frac{d(d-1)}{2!}L^2 - \frac{d(d-1)(d-2)}{3!}L^3 ... \qquad (42)$$

For $0 < d < 0.5$, the ARFIMA process is said to possess a long memory or long-range dependence. The correlations and partial correlations are all positive and decay monotonically and hyperbolically to zero as the lag increases. When d=0, an ARFIMA process can be reduced to the conventional ARMA process. For $-0.5 < d < 0$, it has a short memory and is 'antipersistent'. The correlations and partial correlations of the process are all negative and decay monotonically and hyperbolically to zero. The model is nonstationary for $d \geq 0.5$ as it possesses infinite variance. For $0.5 < d < 1$, the process is mean-reverting because there exists a non-long-run effect of an innovation on the future values of the process. For $d > 1$, the process is not mean-reverting, since any shock to the process could make it drift away from its equilibrium permanently. In this case, the data is usually handled by differencing (Qiao, Chiang and Wong, 2008).

There are two approaches to the estimation of an ARFIMA (p, d, q) model: exact maximum likelihood estimation, as proposed by Sowell (1992), and semiparametric approaches. Sowell's approach requires specification of the p and q values, while estimation of the full ARFIMA model is conditional on those choices. The semiparametric approaches assume that the short memory or ARMA components of the time series are relatively unimportant, so that the long memory parameter d may be estimated without fully specifying the data generating process. We follow Sowell's

(1992) approach in our study. The best fitting ARMA model is estimated first, followed by the maximum likelihood estimation of d. The exact order is as follows: 1. $p \times q$ ARMA models are built and ranked based on AIC (Akaike info criterion) excluding those with insignificant coefficients. The one with the lowest AIC is the best fitting model. 2. Estimate d for the best fitting ARMA model. 3. If the result is significant and lies within the boundary of $-0.5 < d < 0.5$, accept the result. For $0 < d < 0.5$, the model is a long memory process. For $-0.5 < d < 0$, the model is a short memory process and decays at hyperbolical rate. If the result is insignificant or lie out of the boundary of $-0.5 < d < 0.5$, abandon the model and estimate d for the next one. Repeat the process until a significant estimation which lies within the boundary is found. If no such estimation is found, conclude that the data is best described using the ARMA model, and its short memory process decays exponentially.

4.2 Dealing with Structural Changes:

The ways in which previous studies have considered breakpoints include: 1. Pick one point as the breakpoint based on a specific property, for instance, a dummy variable based on date. 2. Pick the timing of real life events as the breakpoint, treat the breakpoints as known. There are a few drawbacks when it comes to these methods. Firstly, it is very likely that there is more than one breakpoint and it may not occur due to the property picked; the reason for the breakpoint is debatable. It may be because of financial liberalisation or bank activities, changes in interest rate and exchange rate regimes, or new government policies and changes in political environment. Secondly, the date of breakpoint may not correspond to the exact date of real life events. Although we know that the breakpoint is very likely to occur around that time period, this may be reflected differently in the data. Breakpoint tests in other studies are often used to solve the timing problem only, although they serve three purposes in our framework. First, it they are used to detect the timing of shocks. Endogenous estimation of timing will lower the power of the contagion test (Gravelle, Kichian and Morley, 2006), and thus we want to determine the breaks at the beginning of our framework. Second, the result from the breakpoint test will help us to explore how contagion or interdependence spread through countries. Third, breakpoint tests in our study should fit the heteroscedasticity situation as the contagion test requires. When choosing suitable breakpoint tests, we consider two aspects: 1. Do the features or the assumptions of the tests fit our framework well? 2. Are the tests accurate enough to properly identify the structural changes.

4.2.1 Testing for Structural Change Known a Priori

The Chow test is a classic test dealing with a single breakpoint known a priori. It splits the target sample into two sub-periods and estimates the parameters of each sub-period under the null hypothesis that they have the same parameters for every regressor. The equality of the two sets of coefficients is tested by a classic F statistic:

$$F = \frac{(ESS_c - ESS_1 - ESS_2)/(P)}{(ESS_1 + ESS_2)/(N_1 + N_2 - 2P)} \sim F(P, N_1 + N_2 - 2P) \qquad (43)$$

where ESS_c is the sum of squared residuals of the whole sample; ESS_1 is the sum of squared residuals of the first sub-period; ESS_2 is the sum of squared residuals of the second sub-period; N_1 and N_2 are the number of observations in the first and second sub-period respectively; P is the total number of the parameters.

An important limitation of the Chow test is that the breakpoint must be known a priori. A researcher only has two choices: 1. Choose an arbitrary observation as possible breakpoint and perform the test. 2. Pick an observation with the timing of some significant issues. There are a number of clear problems which can make the test insignificant with both these choices. Firstly, the possibility of identifying the true breakpoint is very low for the first choice since one only randomly chooses an observation as a possible breakpoint, thus leading to the break being ignored. Secondly, choice 2 seems to be better as it provides a criterion to pick a possible breakpoint. However, one can identify a breakpoint falsely when it is actually not a true breakpoint. Finally, the result is very sensitive to the choice of breakpoint, and thus the arbitrary choices are very misleading.

Due to these problems with the Chow test, researchers (such as Quandt, 1960; Andrews and Ploberger, 1994; Bai and Perron, 2003; Perron and Qu, 2006) came up with a solution: treat the breakpoint as unknown.

4.2.2 Testing for Structural Change with Unknown Timing

4.2.2.1 Quandt's statistics (1960)

Quandt (1960) performed the Chow test on all observations. This procedure is not specifically designed for a single breakpoint because it can track all possible breaks, although one can always find the break date with the largest Chow statistic through this procedure. These are the Quandt's statistics. However, if the break date is unknown a priori, then the chi-square critical values are inappropriate (Hansen 2000). If this is the case then what critical value should be used instead?

4.2.2.2 Andrews-Ploberger Test (1993, 1994)

Andrews (1993) and Andrews and Ploberger (1994) provided some elegant and general statements. The statement in Andrews (1993) covered Wald, Lagrange multiplier (LM), and likelihood-ratio (LR)-like tests based on the generalised method of moments (GMM) estimators. The data used in this test may be stationary or non-stationary under the null hypothesis of parameter stability.

The null hypothesis of interest here is:

$$H_0 : \beta_t = \beta_0, \tag{44}$$

The on-time change alternative with change point π is:

$$H_{1T}(\pi) : \beta_t = \begin{cases} \beta_1(\pi) & t = 1, \ldots, T\pi \\ \beta_2(\pi), & t = T\pi + 1, \ldots \end{cases} \tag{45}$$

Here T is the sample size, $\pi \in (0,1)$. $T\pi$ is the time of change, and for simplicity π.

Because π is unknown, one must construct test statistics that do not take π as given. Doing so is complicated by the fact that the problem of testing for structural change with an unknown change point does not fit into the standard 'regular' testing framework. The reason is that the parameter π only appears under the alternative hypothesis and not under the null.

The assumption on the break dates ($T\pi$, where $\pi \in (0,1)$) is very helpful. This assumption specifies that the break dates are asymptotically distinct. An asymptotic analysis is often viewed as a thought experiment about what would happen if we were able to collect increasing amounts of data in the future. If one adheres to this view, then the last regime should increase in length (assuming no other break will occur in the future) and all other segments then become a negligible proportion of the total sample. Hence, as the sample increases, we would find ourselves with a single break, in which case the framework becomes useless. However, with the assumed condition, when the sample size increases, all segments increase in length in the same proportions to each other.

This test adopts a common method used in this scenario and considers test statistics of the form:

$\sup_{\pi \in \Pi} W_T(\pi)$, $\sup_{\pi \in \Pi} LM_T(\pi)$ and $\sup_{\pi \in \Pi} LR_T(\pi)$,

where Π is some pre-specified subset of [0,1] whose closure lies in (0,1). Π is required to be bound away from zero and one. This requirement is made to ensure that the estimators upon which the test statistics are based are uniformly consistent for $\pi \in \Pi$ and to ensure that the functions are continuous. One rejects H_0 for large values of $\sup_{\pi \in \Pi} W_T(\pi)$, $\sup_{\pi \in \Pi} LM_T(\pi)$ and $\sup_{\pi \in \Pi} LR_T(\pi)$.

The $\sup W_T(\pi)$ and $\sup LR_T(\pi)$ tests are not optimal, except in a very restrictive sense. Andrews and Ploberger (1994) considered a class of tests that are optimal, in the sense that they maximise a weighted average power. The tests are called (average) exponential LM, $Wald$ and LR tests, denoted $Exp-LM$, $Exp-Wald$ and $Exp-LR$ respectively. The authors also showed that the asymptotic properties of these three tests are the same under the null and local alternatives.

Despite all the advantages, there are four things we must know about this test. Firstly, this procedure is designed for a single unknown breakpoint. What should we do when the issue is about multiple structural changes? Secondly, the test $Exp-Wald$ is optimal in finite samples with fixed regressors and known variance of the residuals. What should we do under heteroscedasticity？ Thirdly, for a fixed sample size, the power of the test can rapidly decrease to zero as the change in mean increases. This is again because the variance of the errors is estimated under the null hypothesis of no change. Finally, this test is not designed for heteroscedasticity situations, thus potentially rendering it inappropriate for our framework.

4.2.2.3 Bai-Perron Test (2003)

Bai and Perron (2003) provided a method which is performed under heteroscedasticity and which follows a multiple linear regression with m breaks:

$$y_t = x_t^{'}\beta + z_t^{'}\delta_j + u_t,\ t = T_{j-1}+1,...,T_j \tag{46}$$

In this model, $j = 1,...,m+1$, y_t is the dependent variable at time t, while $x_t\,(p\times 1)$ and $z_t\,(q\times 1)$ are vectors of covariates, x is the matrix of regressors whose coefficients do not change across regimes, z is the matrix of regressors whose coefficient are allowed to change. β and $\delta_j\,(j = 1,...,m+1)$ are the corresponding vectors of coefficients. The indices $(T_1,...,T_m)$, or the breakpoints, are treated as unknown. If $p \neq 0$, then we have a partial structural change model because the parameter vector β is not subjected to shift and is estimated using the entire sample. When $p = 0$, we have a pure structural change model since all coefficients are subject to change. The variance of u_t should not be constant (i.e. heteroscedasticity).

The method considered is based on the least-squares principle. For each m-partition $(T_1,...,T_m)$, the associated least-squares estimates of β and δ_j are obtained by minimising the sum of squared residuals:

$$(Y - X\beta - \overline{Z}\delta)'(Y - X\beta - \overline{Z}\delta) = \sum_{i=1}^{m+1}\sum_{t=T_{i-1}+1}^{T_i}[y_t - x_t{'}\beta - z_t{'}\delta_i]^2 \tag{47}$$

The breakpoints are estimated sequentially rather than simultaneously. Let $SSR(\{T_{r,n}\})$ be the sum of square residuals associated with the optimal partition containing r breaks using the first n observations. Let $SSR(i, j)$ be the SSR obtained by applying OLS to a segment that starts at i and ends at j. Let $h = \gamma T$ ($\gamma \in (0,1)$) be the minimal permissible length of a segment. The optimisation procedure is based on solving the following recursive problem:

$$SSR(\{T_{r,n}\}) = \min_{rh\le j\le n-h}[SSR(\{T_{r-1,j}\}) + SSR(j+1, n)] \tag{48}$$

1. Compute and save $SSR(i, j)$ for pairs satisfying $j - i \ge h$
2. Compute and store $SSR(\{T_{1,n}\})$ for $2h \le n \le T-(m-1)h$ by solving the following

problem: $SSR(\{T_{1,n}\}) = \min_{h \le j \le n-h} [SSR(1, j) + SSR(j+1, n)]$

3. Sequentially compute and store $SSR(\{T_{r,n}\})$ for $r = 2, \ldots, m-1$. For each r, n ranges from $(r+1)h$ to $T-(m-r)h$.
4. The estimates of the break dates are then obtained by solving: $SSR(\{T_{m,T}\}) = \min_{mh \le j \le T-h} [SSR(\{T_{m-1,j}\}) + SSR(j+1, T)]$

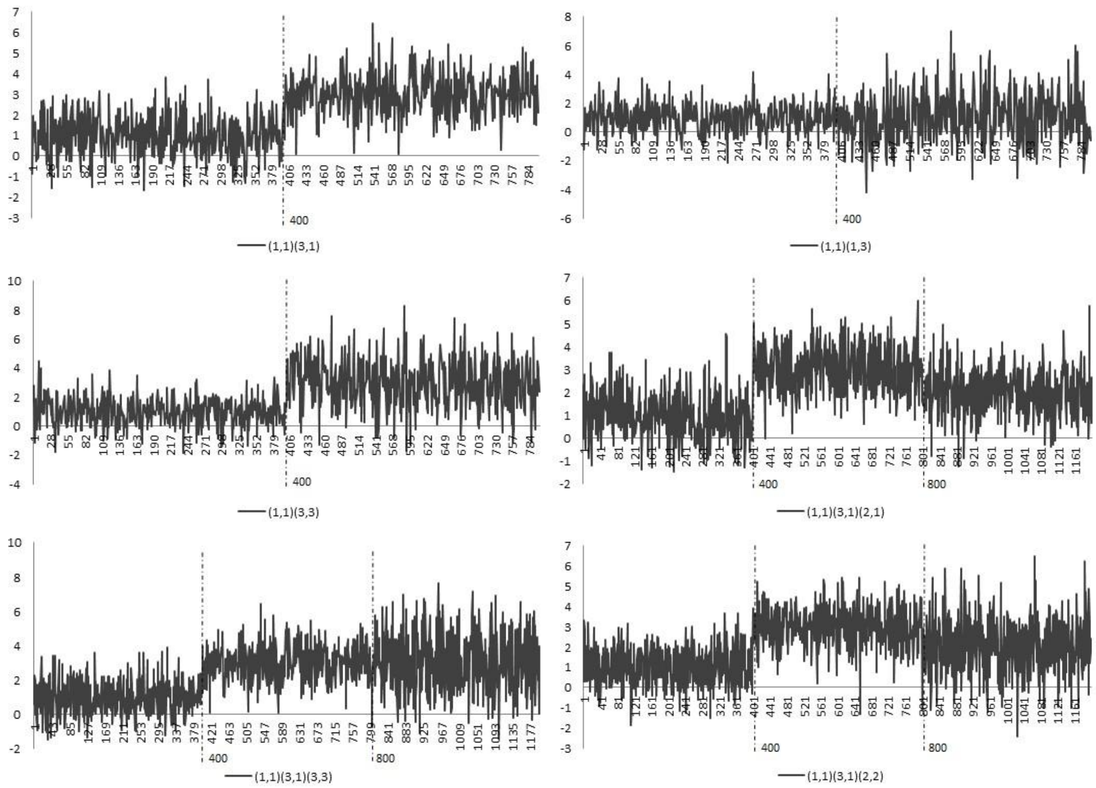
There are two things that we should know about the Bai-Perron test: 1. Due to the fact that the lease-squares method imposes equal weights on all residuals, even changes in the variance of residuals are allowed, thus meaning that this test is not sensitive to changes in variance (which needs different weights). 2. Although restrictions can be imposed, this method cannot be applied directly to models with restrictions since the SSR for a segment cannot be computed independently of other segments.

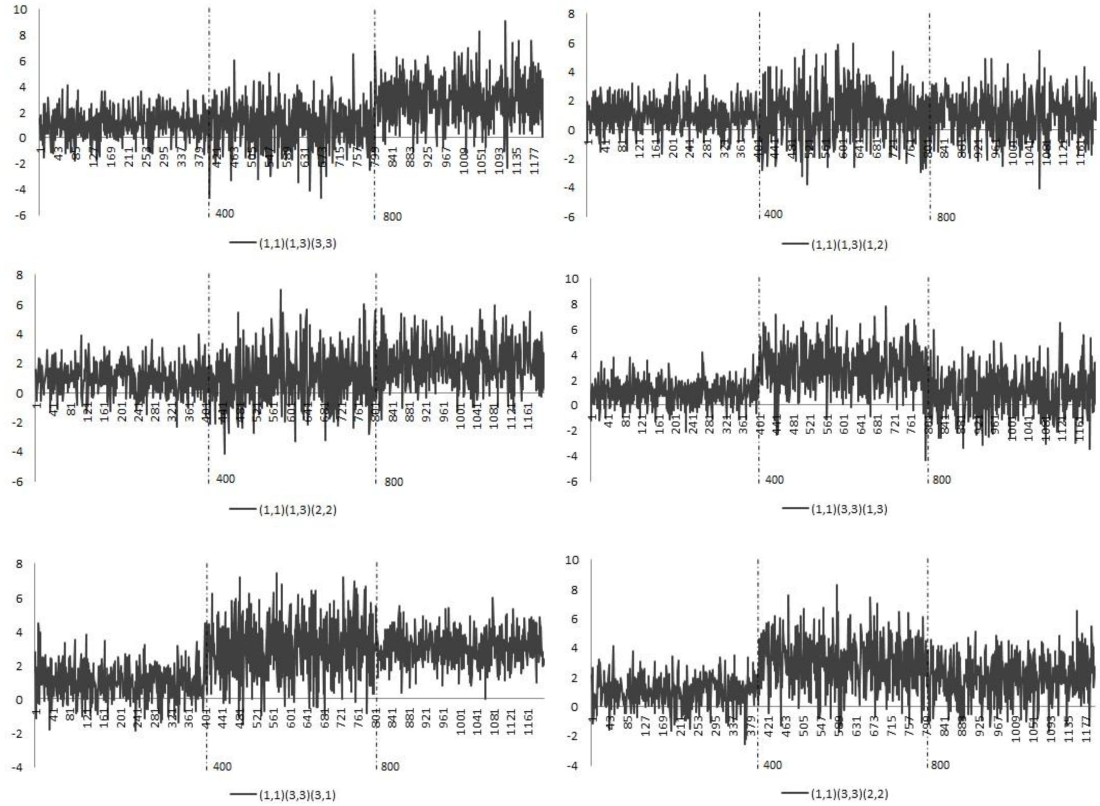
We consider two breakpoint tests here: the Bai-Perron test and the Andrews-Ploberger test. Although the Andrews-Ploberger test has many disadvantages compared to the Bai-Perron test, we still use it to detect structural changes in order to gauge whether or not a breakpoint test that ignores heteroscedasticity affects the identification of contagion.

4.2.2.4 Model Accuracy

Combining breakpoint tests with other techniques to study financial crisis is an idea employed in other empirical work as well (e.g. Guesmi, Kaabia and Kazi, 2013; Gómez-Puig and Sosvilla-Rivero, 2014; Ismail and Isa, 2008; Fei, Tsui and Zhang, 2011). Usually more than one breakpoint tests are included in order to increase the accuracy. The Andrews-Ploberger test and the Bai-Perron test are the mostly used methods among all the identification techniques. The standard procedure in the above literature is to employ the Andrews-Ploberger test first to identify a single breakpoint, and Bai-Perron test is used later to confirm it and identify the other possible breakpoints. Unlike previous work, we applied the breakpoint tests to some simulated data in order to compare their accuracy first, especially against the change in the variance before we apply them on our target data sample. The data generated are all stochastic processes with x mean, y variance (i.e. (x, y)) and 400 data length, namely: (1, 1), (1, 2), (1, 3), (2, 1), (2, 2), (3, 1) and (3, 3). When the data are simulated, 12 conditions are created by combining series with different mean and/or variance to reflect the change in mean, change in variance and change in both mean and variance. These 12 conditions are: [(1,1)(3,1)], [(1,1)(1,3)], [(1,1)(3,3)], [(1,1)(3,1)(2,1)], [(1,1)(3,1)(3,3)], [(1,1)(3,1)(2,2)], [(1,1)(1,3)(3,3)], [(1,1)(1,3)(1,2)], [(1,1)(1,3)(2,2)], [(1,1)(3,3)(1,3)], [(1,1)(3,3)(3,1)] and [(1,1)(3,3)(2,2)]. The idea here is to establish how these tests perform under each different kind of change in mean and variance. Since we created the breakpoints when simulating the data, we are able to measure the accuracy of both tests. When the condition is one single change in mean or variance, the data length is 800 (two series combined together) and the breakpoint we are expecting is 400. When the condition involves two changes in mean and/or variance, the data length is 1200 (three series combined together) and the breakpoints we are expecting are 400 and 800. Among all the 21 changing moments in the 12 conditions, we have 7 moments of change in mean, 7 moments of change in variance and 7 moments of change in both mean and variance. The plots of the simulated data are presented in Figure 1.

Figure 1: Plots of the Simulated Data





We first look at the results from the Andrews-Ploberger test which are presented in Table 1. We can see that the results of the 7 changes in mean moments are very accurate and significant, while the results of the 7 changes in both mean and variance moments have an equally good performance. However, the results of the 7 changes in variance moments are much worse. 6 of the 7 changes in variance moments are insignificant and not at all accurate. As such, we reach the conclusion that the AP test is more sensitive to a change in mean. A change in only the variance is usually not clearly identified as a breakpoint. If there is a shift included in the overall change, it is more likely that it will detect a significant and accurate breakpoint. However, if the overall change is only a change in slope and/or curvature, the AP test will not perform as well as it does against a shift in the overall change.

Table 1: Andrews-Ploberger Test Results on Stochastic Process

	Possible Breakpoint	**P-value**	**Is it a break at 5%? (1 yes, 0 no)**
ΔM: [(1,1)(3,1)]	401	0	1
ΔM+ΔM:[(1,1)(3,1)(2,1)]	401	0	1
	802	0	1

ΔM+ΔV:[(1,1)(3,1)(3,3)]	401	0	1
	932	0.42488	0
ΔM+ΔMV:[(1,1)(3,1)(2,2)]	401	0	1
	800	0	1
ΔV: [(1,1)(1,3)]	519	0.15786	0
ΔV+ΔM:[(1,1)(1,3)(3,3)]	519	0.50388	0
	801	0	1
ΔV+ΔV:[(1,1)(1,3)(1,2)]	519	0.15786	0
	802	0	1
ΔV+ΔMV:[(1,1)(1,3)(2,2)]	519	0.15786	0
	801	0	1
ΔMV: [(1,1)(3,3)]	401	0	1
ΔMV+ΔM:[(1,1)(3,3)(1,3)]	401	0	1
	802	0	1
ΔMV+ΔV:[(1,1)(3,3)(3,1)]	401	0	1
	532	0.39285	0
ΔMV+ΔMV:[(1,1)(3,3)(2,2)]	401	0	1
	787	0	1

ΔM: Change in mean; ΔV: Change in variance; ΔMV: Change in mean and variance; (x, y): Stochastic process with x mean and y variance.

There are two ways in which to estimate breakpoints using the Bai-Perron test. The first method is to put all series with the same data length in a unique linear regression. The second method is to estimate the breakpoints for each series separately. Both methods involve purely structural change. The first method captures the structural change of the whole group while the second method focusses on the features of each series individually. The results of the first method are presented in Table 2 and Table 3 while the results of the second method are presented in Table 4. 1 significant breakpoint was detected in Table 2, and was as we expected. A total of 2 breakpoints were detected in Table 3, although this was not in keeping with our expectations. The breakpoints we expected are 400 and 800, although the results obtained, as seen in Table 3, are 400 and 735. These results are significant, although the second estimated breakpoint is downward biased. Compared to the performance of the Andrews-Ploberger test, we feel that this is an improvement in terms of accuracy. Table 4 shows what we get if we wish to capture the feature of each series individually. We see that the Bai-Perron test reported significant and accurate results for changes in mean and changes in both mean and variance. With this said however, all 7 moments of change in variance are insignificant, albeit 5 of them are more accurate than the Andrews-Ploberger test.

Table 2: Bai-Perron Result of Data with 800 Observations

Specifications					
z_t ={(1,1)(3,1), (1,1)(3,3)}	q =2	p =0	h =120	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
67.03*	42.61*	31.12*	23.53*	18.86*	10.50
$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$	
6.161.39	1.39	0.00	67.03*	67.03*	
Number of breaks selected					
Sequential Procedure:	1				
LWZ:	0				
BIC:	1				
Breakpoint found					
396					
Note					
m **: maximum number of breakpoint;** h **: minimum length of distance; *: significant at 5% level**					

Table 3: Bai-Perron Result of Data with 1200 Observations

Specifications					
y_t ={(1,1)(1,3)(1,2)}	q =8	p =0	h =180	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
115.98*	83.02*	65.53*	75.08*	67.51*	30.39*
$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$	
22.15	5.600.00	0.0000	115.98*	115.98*	
Number of breaks selected					
Sequential Procedure:	2				
LWZ:	0				
BIC:	0				
Breakpoint found					
400, 735					
Note					
m **: maximum number of breakpoint;** h **: minimum length of distance; *: significant at 5% level**					

Table 4: Bai-Perron Results of Individual Series

Number of breaks selected			
(1,1)(1,3)	**(1,1)(3,1)**	**(1,1)(3,3)**	**(1,1)(1,3)(1,2)**
1	1	1	2
(397)	(399*)	(400*)	(446, 697)
(1,1)(1,3)(2,2)	**(1,1)(1,3)(3,3)**	**(1,1)(3,1)(2,1)**	**(1,1)(3,1)(2,2)**
1	1	2	2
(369, 800*)	(380, 800*)	(401*, 800*)	(400*, 800*)
(1,1)(3,1)(3,3)	**(1,1)(3,3)(1,3)**	**(1,1)(3,3)(2,2)**	**(1,1)(3,3)(3,1)**
1	2	2	1
(400*, 855)	(400*, 797*)	(400*, 786*)	(400*, 797)

***indicates significant at 5% level**

We can see that both tests did well in terms of change in mean, although when it comes to change in variance the tests perform poorly and tend to detect different breakpoints. However, we did notice certain improvements in the Bai-Perron test when it comes to changes in variance. Since they are both very accurate, with regard to any changes which include a change in mean, they usually detect similar breakpoints when there is a shift included in the overall change. However, if the overall change only includes change in slope and/or curvature, they usually report different answers, and the Bai-Perron test has a higher accuracy. As a result of this, we place more trust in the breakpoints detected using the Bai-Perron test. However, we will still include the Andrews-Ploberger test in our structure so as to examine whether or not the feature of Heteroscedasticity affects the final result. As for the Bai-Perron test, we will apply the second method to the real data so that we can examine the features of each series and include all the possible breakpoints.

4.3 Iterative Least Square Method

After having obtained the residual breakpoints and constructing the nonlinear equation system, we use the iterative least square method to compute the coefficients.
In order to perform the iterative least square method, we first slightly reorganised the equation system by moving the variance and covariance to the right hand side of the equations, giving us:

$$y_j = f(\bar{V}, \bar{\sigma}) + \varepsilon_j, (j = 1, 2, ..., 8) \quad (49)$$

where $\bar{V}$ is the matrix of variance and covariance, $\bar{\sigma}$ is the matrix of impact coefficients ($\sigma_{it}, \sigma_{cit}, \sigma_{it}^*$ and σ_{cit}^*), $y_j = (1,0,0,0,0,0,0,0)'$ and ε_j is the residual. The idea of this procedure is to estimate the value of $\bar{\sigma}$ that can give us the minimum sum of squared residuals:

$$\min SSR(\bar{\sigma}) = \sum_{j=1}^{8} \varepsilon_j^2 = \sum_{j=1}^{8} \left[y_j - f(\bar{V}, \bar{\sigma}) \right]^2 \quad (50)$$

In order to solve (50), we must take the first derivative:

$$\frac{\partial SSR(\bar{\sigma})}{\partial \bar{\sigma}} = -2 \sum_{j=1}^{8} \left[y_j - f(\bar{V}, \bar{\sigma}) \right] \frac{\partial f(\bar{V}, \bar{\sigma})}{\partial \bar{\sigma}} = 0 \quad (51)$$

(51) can be simplified to:

$$\sum_{j=1}^{8} \left[y_j - f(\bar{V}, \bar{\sigma}) \right] \frac{\partial f(\bar{V}, \bar{\sigma})}{\partial \bar{\sigma}} = \sum_{j=1}^{8} \varepsilon_j \frac{\partial f(\bar{V}, \bar{\sigma})}{\partial \bar{\sigma}} = 0 \quad (52)$$

This is a nonlinear equation system with 8 equations and 8 variables. As we cannot obtain an analytical solution, the iterative method is instead used. All of the iterative methods have the same weakness, namely their inability to find the best initial values for the variables. This is a drawback we share, while the initial value we use for all of our impact variables is 1.

4.4 The Structure of the Empirical Studies

In terms of the first study, we focus on the contagion effects among countries with low degrees of dependence on foreign trade. Because of the low dependence, it is easier for us to observe the contagion effects from the idiosyncratic shocks. Because we want to split the movement into two segments, the method employed here is 'Identification through Heteroscedasticity'. The data used is risk premium in interbank rate. The target countries all come from Europe.

The second empirical study is identical to the first, although the focus is instead on the countries with a high degree of dependence. The reason for high dependence is that we are interested in the role played by trade in financial contagion. Besides this, we also wish to gauge how idiosyncratic shock responds to high dependence. The data used is still risk premium in interbank rate, while the target countries all come from Europe.

In the third empirical study, we look at three markets in order to examine more possible transmission channels: exchange rate market, interest rate market and stock market. As for the methods, except for ‘Identification through Heteroscedasticity’, we include Forbes and Rigobon’s (2002) adjust correlation, as well as Granger’s causality and impulse response analysis. The ‘Identification through Heteroscedasticity’ procedure can help us to examine interdependence and idiosyncratic shock separately, but cannot explain the combined effect. This is why we brought in the adjusted correlation. Besides this, by combining the results of the split effect and the overall effect together, we are able to see how the split shocks contribute to the overall shock. In addition, the reason for the Granger causality and impulse response analysis is that we would like to see if there are any changes in the statistical equilibrium and how long the contagion effects last after each shock.

Chapter 5 Contagion in Risk Premium - Low Trade Links

5.1 Introduction

Contagion is defined as the transmission of shocks from one market to another in this study. These shocks may be transferred through the fundamentals, as suggested by studies, or through other links which cannot be directly explained. Based on the review in Section 2, trade and financial linkages are the primary transmission channels considered. On this basis, we define fundamental using the balance of payments. Assuming there is no surplus or deficit, the balance of payments equation is:

Current Account + Capital Account = 0, where

Current Account = Inflows of goods and services
+ Outflows of goods and services

Capital Account = Foreign direct investment
+ Portfolio investment
+ Other investment
+ Reserve account

We define fundamental as the elements of the current account and the capital account. In our study, current account is measured by trade link, which is calculated as the sum of total export and total import. We would also like to use net capital flows to represent capital account, although this is not involved in the modelling process.

As mentioned in the previous section, the methodology of this chapter is based on 'Identification through Heteroscedasticity', whereby we split the shock into two segments: common shock, which represents the shock component caused by fundamentals (henceforth referred to as interdependence), and the idiosyncratic shock, which is the part of the shock which cannot be directly explained (henceforth referred to as pure contagion). Indeed, since all past studies have examined interdependence, we would like to pay more attention to pure contagion. We do this by splitting shock into two segments and choosing countries with low trade links. Based on the balance of payments, when the trade link is low, the net capital flows must also be low, assuming no surplus or deficit. When the effect of interdependence between countries is not so significant, the pure contagion is easier to observe.

The rest of this chapter is organised as follows: Section 2 describes the data, explains how we chose the countries with low trade links and how the market behaved. Section 3 presents the result of forecasting, and compares the differences between the ARMA and ARFIMA models. Section 4 provides the findings of two breakpoint tests: the Andrews-Ploberger test and the Bai-Perron test. Section 5 then presents the results of 4 procedures of contagion test based on the forecasting and breakpoint models, following which Section 6 concludes the paper.

5.2 Data

The most widely used interest rate data in previous studies are government bond yields. Constancio (2012) examined the contagion phenomena among 7 European countries during the sovereign debt crisis using the daily 10-year government bond yields. The study detected contagion effect among those countries and suggested that central bank should contribute to the stability of the financial markets. The other studies that employed government bond yields include Arghyrou and Kontonikas (2012) and Missio and Watzka (2011). European countries were still the research targets and large proportion of contagion were detected in both studies. We follow the previous studies and choose 7 European countries as research targets, namely, Greece, Latvia, Iceland, Bulgaria, Romania and Lithuania, with Germany serves as a benchmark. Government bond yields are good measure of country risk and easier to collect. However, they lack the capacity to measure the market risk due to the macroeconomic regulation and control. As a result, daily interbank rates are employed in this study instead of government bond yields.

The subprime crisis was well analysed by many previous work. Contagion effects were usually identified, however, many different possible reasons were provided. For instance, contagion may come from the volatility changes caused by the transmission of the instantaneous information (Peng and Ng, 2012), or the central banks failed to keep the financial stability of the markets (Constancio, 2012), or even the changes in the monetary variables (Syllignakis and Kouretas, 2011). The reason for contagion effects is one of our research interests. Therefore we follow previous work and build our data sample around the subprime crisis. We are interested to see what possible reasons for contagion our result can illustrate.

We look at the premium of 6 European countries' interbank rate over the benchmark. The 7 countries are divided into 3 groups. Group 1 is made up of Greece, Latvia and Germany, while group 2 contains Iceland, Bulgaria and Germany, and group 3 is composed of Romania, Lithuania and Germany. The similarity between these three groups is that they all contain Germany. Indeed, the other two countries' degree of dependence on foreign trade is very low with each other but considerably higher with Germany. The degree of dependence on foreign trade is calculated as follows:
Between country A and B:
The degree of dependence on foreign trade of country $A = (E_{AB} + I_{AB})/GDP_A$

E_{AB} is export from A to B, I_{AB} is import from B to A. GDP_A is country A's GDP. The degrees of dependence on foreign trade of the selected countries are presented in Table 5 (Please see Appendix 2 for detailed results):

Table 5: Degrees of Dependence on Foreign Trade

	Bulgaria	Germany	Greece	Iceland	Latvia	Lithuania	Romania
Bulgaria		0.001361	0.009238	0.000044	0.001071	0.001385	0.013988
Germany	0.118494		0.039717	0.024121	0.107001	0.123488	0.112227
Greece	0.070401	0.003426		0.000378	0.001051	0.001483	0.011360
Iceland	0.000052	0.000344	0.000066		0.001961	0.002685	0.000076
Latvia	0.000608	0.000672	0.000075	0.002449		0.070522	0.000141
Lithuania	0.001192	0.001198	0.000113	0.005718	0.106473		0.000355
Romania	0.048204	0.004335	0.004777	0.000200	0.000883	0.001448	

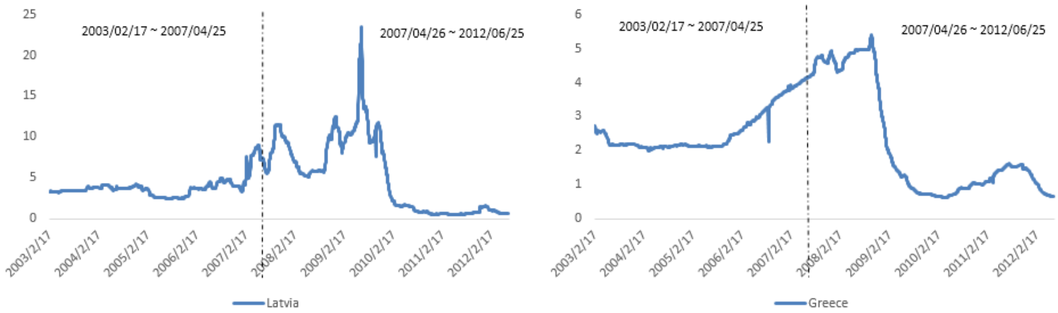
(Source: Data are collected with DataStream in Newcastle University. GDP are collected from Oxford Economics. Export and Import are collected from IMF - Direction of Trade Statistics.)

The aim is to select countries with a low degree of dependence on foreign trade in order to reduce the effect of interdependence and thereby make it easier for pure contagion to be detected. Since the other two countries in each group have relatively lower GDP than Germany, although their degrees of dependence on foreign trade are higher with Germany, Germany's degree of dependence on foreign trade with them is much lower. This means that it is almost impossible for a change in interdependence of one country to spread through Germany to the other country, and thereby pure contagion is easier to detect. However, they can both be simultaneously affected by changes in Germany. With this in mind, each group is studied individually.

We assume that a German investor has invested in the other two countries in each group and the data we want to analyse is not exchange rate or interest rate data, but the risk premium: $r_D - r_F$. Where r_D is the domestic interest rate (we use Germany interbank rate here) and r_F is the foreign interest rate. The interest rate data used to calculate the risk premium is each country's interbank rate at daily frequency and is extended from February 17, 2003 to June 25, 2012. After having obtained the risk premium, we calculate the increment by differencing the data. Data from February 17, 2003 to April 25, 2007 are treated as the stable period and used to build the forecasting model while data from April 26, 2007 to June 25, 2012 are the turbulent period and used for contagion identification.

Figure 2 present the plots of the interbank rates. It is very clear that the interbank rates had an upward trend during February 17, 2003 to April 25, 2007, with the exception of Romania. Moreover, this trend changed from upward to downward, starting at the beginning of 2009. As a matter of fact, when the interbank rate in one country is raised, banks in that country will begin to reduce the amount of loans in order to keep sufficient capital for daily operation. The decrease of loans will then result in tight market liquidity and slow the growth of the economy while repressing inflation. It seems that all countries are trying to repress inflation before the crisis, again with the exception of Romania. Indeed, when the crisis occurred in 2008, all of the banks started to take out more loans in order to stimulate the economy.

Figure 2: Plots of the Data in Level



(Source: Data are collected with DataStream in Newcastle University. Germany from Thomson Reuters, Latvia from Bank of Latvia, Bulgaria from Bulgarian National Bank, Greece from Bank of Greece, Iceland from Central Bank of Iceland, Romania from National Bank of Romania, Lithuania from Bank of Lithuania.)

After a quick view of the plots, we now proceed to the descriptive statistics. The statistics include the mean, the standard deviation, skewness, kurtosis, normality and the ADF unit root test. The test regression for the ADF test is:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t$$

In order to properly perform the ADF test, the intercept, the trend variable and the proper length of the lag terms must be considered. The 1st differenced data are flat and have close to zero mean in all cases, therefore no intercepts and trend variables are included in the test regressions. The regressions with lag length from 1 to 16 are estimated and the best fitting lag length is determined by the AIC criteria. The statistics information is summarised in Table 6 and Table 7.

Table 6: Descriptive Statistics (February 17, 2003 to April 25, 2007)

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	ADF
Latvia	0.0034	0.0977	-3.8041	164.7485	1193031**	-10.51**[11]
Greece	3.30e-5	0.0442	-0.0608	489.6254	10774596**	-16.55**[12]
Iceland	-0.0067	0.0604	0.1034	117.5700	597247**	-31.76**[4]
Bulgaria	-9.34e-5	0.0432	0.6848	102.5499	450998**	-18.74**[5]
Romania	0.0092	0.1176	1.7672	39.6658	61737**	-19.81**[3]
Lithuania	0.0002	0.0206	1.2281	28.8109	30586**	-15.39**[15]

****denotes significance at 1%. The number in [] are the best fitting lag terms for the ADF test.**

Table 6 summarises the statistics for the time period prior to April 25, 2007. The ADF unit root test reaches the conclusion that all data are stationary. The Jarque-Bera test strongly rejects the hypothesis of normality in all cases while we can also see that although the skewness of all samples is not far from 0, the kurtosis is too much bigger than normal distribution. However, because we have a large sample, we assume that the data are normally distributed based on the Central Limit Theorem. Although normality the hypothesis is strongly rejected, stationary data represent a strong basis from which to forecast the expected return.

Table 7: Descriptive Statistics (April 26, 2007 to June 25, 2012)

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	ADF
Latvia	0.0032	0.2484	-0.9228	86.6079	1190605**	-11.25**[13]
Greece	2.97e-6	0.0079	-0.3863	193.0428	7806688**	-21.63**[14]
Iceland	0.0038	0.2434	-4.3834	403.2913	32944330**	-18.10**[8]
Bulgaria	-0.0007	0.0256	-0.5159	11.9691	1883170**	-13.46**[8]
Romania	-0.0008	0.4025	-3.7456	317.9020	1983086**	-22.55**[10]
Lithuania	8.46e-5	0.0843	4.4351	116.9328	3110226**	-7.43**[15]

****denotes significance at 1%. The number in [] are the best fitting lag terms for the ADF test**

Table 7 summarises the statistics for the time period following April 25, 2007. The means of all samples remain close to 0 while the standard deviation has increased significantly, especially Latvia, Iceland and Romania. The Jarque-Bera test still strongly rejects the hypothesis of normality in all cases. All samples are stationary judging by the ADF unit root test, while we also assume that the data are normally distributed based on the Central Limit Theorem.

5.3 A Retrospect of Methodology

As stated in Chapter 4, while we employ Gravelle, Kichian and Morley's (2006) idea, we also introduce 3 new elements. Firstly, we use two different models (ARMA model and ARFIMA model) to obtain the forecast error, which is interpreted as the shock. By doing so, we are able to quantify the shock and discuss the effect of long memory and short memory features on contagion. Secondly, we exogenously estimate the structural breaks using two different breakpoint tests (Andrews-Ploberger Test and Bai-Perron Test), thus allowing us to overcome one of Gravelle, Kichian and Morley's (2006) flaws and improve the power of the contagion test while also examining the effect of heteroscedasticity. Last but not least, we use a different method to solve the equation set of the contagion test, namely the iterative least square method. This section provides a retrospect of the methods involved in the present chapter.

5.3.1 Purpose of the Forecasting Models

The target of the contagion test is the forecast error, which contains information that the market participants have no knowledge of. This unanticipated information brought about unexpected changes in the market, and hence shock occurred. With this in mind, the first task of the ARMA and ARFIMA models is to quantify the shock. In order to do so, we must bring in the forecasting methods. Once we have the forecast value, we can calculate the forecast error and quantify the shock. Out of sample forecast is used in this study. The in sample forecasts usually suffer from the over fitting problem, where irrelevant regressors are included and lead to overly optimistic forecasting results. Such in sample results cannot guarantee the quality of the out of sample forecasting performance. Furthermore, the parameters and regressors may vary with the extension of time. Due to the above limitations, the results from in sample forecasts cannot be considered useful for policy guidance. No literature has yet provide a method to properly estimate the features of markets (recent papers - see Campbell and Thompson, 2008; Li, Tsiakas and Wang, 2015 and references within). As a result, we treat the future actual value as the shock and employ out of sample forecast.

The second task of the forecasting models is to measure the effect of long memory and short memory on contagion. As previously discussed, long memory and short memory measure the autocorrelation of the data. The autocorrelation of a long memory process decays at a slower rate and never reaches 0 as the distance increases. In contrast, the autocorrelation of a short memory process decays faster and eventually reaches 0. As a result, a time series that possesses the long memory feature is more stable and predictable than a short memory process. However, here it is important to highlight a very interesting question: if the long memory and short memory feature only measures the autocorrelation of the data, will it change anything when our research target is the forecast error? The answer is no. Indeed, if we split the data into two elements, the first element is one which can be perfectly forecast based on the autocorrelation, while the other is the forecast error. Given that the data itself is constant as we know it, when the autocorrelation part is stable and predictable, the error part must be as stable and predictable as the autocorrelation part. When the stability and predictability of the autocorrelation drops, so will that of the forecast error. As a result, the forecast errors possess the same long memory and short memory feature as the data itself. When the feature of the data is identified by the forecasting models, we then also know the feature of the shock. As such, we expect the long memory processes to behave in a more stable fashion when we identify contagion and short memory processes which are more stochastic.

5.3.2 Purpose of the Breakpoint Tests

Previous studies examine regime shifts or structural breaks in two ways. Either choose the date of the breakpoints base on known knowledge of the markets (see Kleimeier, Lehnert and Verschoor, 2008; Mondria and Quintana-Domeque, 2013), or treat the break date as unknown and employ techniques to estimate the timing (see Guesmi, Kaabia and Kazi, 2013; Gómez-Puig and Sosvilla-Rivero, 2014). In this study, we follow the latter solution and combine it with chronology. The identified breakpoints are treated as regime shifts or structural breaks, which represent a significant change in the behaviour of the markets (Ismail and Isa, 2008). The corresponding events in the chronology are interpreted as the possible source where contagion occur or transmission channels it spread through.

Gravelle, Kichian and Morley (2006) stated in their study that the power of their test was impaired because they estimated the structural breaks endogenously. Indeed, this is something which we intend to improve and make more appropriate by employing two breakpoint tests and exogenously estimating the breaks before the contagion test. We also build a chronology to give the statistically identified breaks practical or economic meanings. Another aim here is to examine the effect of heteroscedasticity. It is now crucial to recall the detailed discussion pertaining to the Andrews-Ploberger test and the Bai-Perron test in Section 4.2. Indeed, it was stated that the Bai-Perron test deals with heteroscedasticity while the Andrews-Ploberger test does not. Moreover, many studies (Claessens and Forbes, 2001; Forbes and Rigobon, 2002; Billio and Caporin, 2010) argued that heteroscedasticity must be properly accounted for when identifying contagion. We expect that these two tests will generate very different answers. Indeed, with the addition of the Bai-Perron test's improved accuracy (see Section 4.2), when differences are observed, the result of the Bai-Perron test shall prevail.

5.3.3 The Contagion Test

Once the shock has been quantified, the feature of the data estimated and the structural breaks detected, we proceed to the contagion test. The contagion test presented in this chapter consists of 5 sections. The first section addresses the co-integration and Granger Causality test, while the other four relate to procedures based on the two forecasting models and two breakpoint tests.

5.3.3.1 The Co-integration and Granger Causality Tests

Co-integration and Granger Causality tests in previous contagion literatures are mainly used as a tool to identify contagion (see Gray, 2009; Gómez-Puig and Sosvilla-Rivero, 2014). A regime shift is usually assigned or estimated first, then the statistical relationship in every regimes are modelled. A significant change between regimes is interpreted as contagion. The shift is usually interpreted as the possible source or transmission channel of contagion. This application of the co-integration and granger causality tests will be re-examined in chapter 7.

Different from the previous studies, the purpose of these tests in this chapter is to eliminate the possibility of coincidental co-movement and illustrate that certain linkages exist among research targets. The way to achieve this is to show that statistical linkages exist among the data throughout the sample. We want to ensure that when we detect a contagion, it is because the original linkages between the data have changed and not because the research targets have no correlation at all and a stochastic jump just occurred. The research targets are studied in pairs.

However, the question seems to be, do the results of this section provide more hints rather than statistical relationships? Indeed, we split shock into two segments, namely common shock, which represents the changes in fundamentals and idiosyncratic shock, which represents the mystical content that cannot be directly explained. So, does this mean that when there is causal relationship, common shock prevails, with the shock only coming from the change in fundamentals? Does it also mean that when there is no causal relationship, idiosyncratic shock prevails and only pure contagion can be identified? Sadly, the answer to all these questions is no. Although the co-integration and Granger Causality tests, as members of the statistical test family, share the advantage of being able to explain the relationship between economic data when fundamentals fail to do so, they must also bear the drawback of lacking the power of economic explanation. The reason behind causal relationships can come from idiosyncratic shocks as well as common shocks. Indeed, when no causal relationships are detected, the only conclusion we can make is that no statistical causal relationship exists among the countries involved in the tests. However, this does not eliminate the possibility that the co-movements between these countries come from a mutual third party, in our case, Germany. Hence, shocks can still be transferred between countries through fundamentals, even when there are no statistical causal relationships. As a result, other than statistical relationships, the most we can get from the results of this section is that shocks are more likely to be transferred through a mutual third party to different countries rather than directly between them when there is no causal relationship.

5.3.3.2 The 4 Contagion Test Procedures

5.3.3.2.1 The Forming of the System

Other than the new elements which we attempt to incorporate, we also form our equation set for the contagion test just like Gravelle, Kichian and Morley (2006) did. The dependent variables of their study are the weekly exchange rate and bond spread yield. We focus on interbank rate in this study. Recall how we split the shocks:

$$u_{it} = \sigma_{cit} z_{ct} + \sigma_{it} z_{it}$$

where z_{ct} is the common shock, z_{it} is the idiosyncratic shock, and σ_{cit} and σ_{it}

determine the impact of the structural shocks on the asset returns. The variance of z_{ct} and z_{it} are normalised to unity, thus meaning that the absolute values of σ_{cit} and σ_{it} are interpreted as the standard deviation of the shocks. The value of σ_{cit} and σ_{it} are allowed to be negative so the relationship between the forecast errors of different time periods can also be negative.

The forming of the equations is mainly based on the covariance matrix as we know it:

$$\sum_t = \begin{pmatrix} \sigma_{c1t}^2 + \sigma_{1t}^2 & \sigma_{c1t} * \sigma_{c2t} \\ \sigma_{c1t} * \sigma_{c2t} & \sigma_{c2t}^2 + \sigma_{2t}^2 \end{pmatrix}$$

However, this matrix only provided us with 3 equations, which is not sufficient to solve the system. Thus, a state variable for both common shock and idiosyncratic shock is introduced:

$$\sigma_{cit} = \sigma_{ci}(1 - S_{ct}) + \sigma_{ci}^* S_{ct}$$
$$\sigma_{it} = \sigma_i (1 - S_{it}) + \sigma_i^* S_{it}$$

When the state variables are equal to 1, this means that the shock has already occurred. When the state variable equals to 0, this is prior to the shock. Thanks to the state variables, 5 more equations are formed:

$$\text{var}(u_{1t} \mid S_{ct} = 1) = \sigma_{c1}^{*2} + \sigma_1^2$$
$$\text{var}(u_{2t} \mid S_{ct} = 1) = \sigma_{c2}^{*2} + \sigma_2^2$$
$$\text{cov}(u_{1t}, u_{2t} \mid S_{ct} = 1) = \sigma_{c1}^* \sigma_{c2}^*$$
$$\text{var}(u_{1t} \mid S_{1t} = 1) = \sigma_{c1}^2 + \sigma_1^{*2}$$
$$\text{var}(u_{2t} \mid S_{2t} = 1) = \sigma_{c2}^2 + \sigma_2^{*2}$$

When combining them with the 3 equations we obtained from the covariance matrix, we can form a system to identify contagion. Gravelle, Kichian and Morley (2006) assumed that all impact coefficients to be positive except σ_{c2t}. However, we remove that restriction due to the fact that changes in the directions of the correlation may exist in both shocks and between any pairs of research targets.

Contagion is measured by $\sigma_{c1t} / \sigma_{c2t}$ and $\sigma_{1t} / \sigma_{2t}$ in this system. Indeed, the changes in the co-movement between the assets of different countries reflect the state of their linkage and equilibrium. If the linkage and equilibrium remain unchanged, then the sigma of each country shall change by approximately the same proportion while their ratio before and after the shock shall remain statistically unchanged. On the contrary, if statistically significant changes were detected in the ratio, this would suggest that the old linkage or equilibrium experienced a change after the shock, and hence contagion is identified.

Finally, the system is solved by an iterative least square method (see Section 4.3 for a more detailed explanation). It is performed by a STATA code which we wrote (available upon request). We set the maximum number of iterations to 10000 and will obtain a result for every single iteration. If the program continues to generate constant results after a few iterations, it will stop automatically. If not, the program will stop after 10,000 iterations. All estimated results are saved while the standard errors of every sigma are calculated. We will report the final iterated results, their standard errors and the t-statistics in Tables 19 to 42.

5.3.3.2.2 The Interpreting of the 4 Procedures.

We use two different forecast models (ARMA model and ARFIMA model) and two different breakpoint tests (Andrews-Ploberger test and Bai-Perron test) in order to get the information we need to build the system. As a result, we have 4 groups of information with which to form the equation set. We categorise each group of information as a procedure, while the 4 procedures we obtain are: the Andrews-Ploberger test and ARMA model based procedure, the Andrews-Ploberger test and ARFIMA model based procedure, the Bai-Perron test and the ARMA model based procedure and the Bai-Perron test and ARFIMA model based procedure. At this stage of the study, we look not only the change in the ratio, but also the change in the impact coefficients themselves. Indeed, it is possible for insignificant changes in two impact coefficients to create an amplification effect and lead to a significant change in their ratio while significant changes in two impact coefficients may offset each other and cause an insignificant change in their ratio. We would like to know as much about what is happening as we can.

We anticipate that there are 6 possible situations: 1. While the impact coefficients in both countries experienced a significant change, the ratio did not. This is because the impact coefficients changed in the same direction, and hence the change in their ratio is not as big as the coefficients. Recall we stated that the absolute value of the sigma is interpreted as the standard deviation of the shock. In this case, the variance of the shocks move proportionally in the same direction, thus suggesting that the original linkage or equilibrium between the two countries remains statistically unchanged, hence a non-significant change in the ratio.

2. The impact coefficients in both countries experienced a significant change and so did their ratio. One reason for this is that the changes in the coefficients are in different directions, thus giving rise to an even bigger size change in their ratio. Another is that the coefficients changed in the same direction. Although the changes in their ratio are not as big as the coefficients, they are still big enough to be significant. Two things can happen given this situation. Either the shocks cause the variance to move in the same direction, yet non-proportionally in the two countries, and one of them is significantly bigger than the other, or the variance in one country becomes much bigger while the other becomes much smaller. Either way, this situation suggests that the previous balance is broken and a new one is forged.

3. While none of the impact coefficients experienced significant changes, the ratio did exhibit a significant change. The coefficients changing in different directions could lead to this situation. In some way, this is similar to the last situation. The similarity is that the variance in one country continue to become bigger while the other becomes smaller. Indeed, there is no significant difference in either of the changes. However, since they move in different directions, the amplification effect they create still leads to a significant shift in the original linkages.

4. None of the impact coefficients experienced significant changes, nor did the ratio. This is because either the coefficients changed in the same direction or changed in a different direction. Regardless, the change in their ratio remains insignificant. In this case, slight changes in the variance of both countries are observed, yet their linkage remains unchanged before and after the shock.

5. Only one of the coefficients experienced significant change while their ratios also changed significantly. The significant change in one coefficient is strong enough to create a significant change in the ratio, or is enlarged by the change in the opposite direction to the other. Under this situation, although the assets of one country remain statistically stable, the variance of those in the other change dramatically, thus

eventually breaking their original linkage.

6. Only one of the coefficients experienced significant change while their ratios did not change significantly. The significant change in one coefficient is not strong enough to create a significant change in the ratio, or is partly offset by the change in the same direction as the other one. In this case, the variance in both countries behaves in a similar fashion to that of the last situation, with the only change being that the significant change in the variance of the assets in one of the countries is not big enough to shake their existing relationship. As such, we may observe some turbulence in their linkage. Nevertheless however, the original linkage is not statistically broken.

Meanwhile, we must also bear in mind that the procedures contain different features. Specifically, the feature of procedure 1 ignores long memory, short memory and heteroscedasticity; procedure 2 considers long memory and short memory features but ignores heteroscedasticity; procedure 3 ignores long memory and short memory feature, but considers heteroscedasticity, while procedure 4 considers everything. Theoretically speaking, procedure 4 is the most appropriate. Indeed, the results of each procedure are compared in order to gauge the effect of each feature. Procedures 1, 2, and 3 are compared so that we can tell how long memory, short memory, and heteroscedasticity affect the identification of contagion separately. Following this, procedure 4, deemed to be the most appropriate procedure, is studied in detail, not only with regard to the statistical effects of different features, but also the practical meaning of contagion.

5.4 ARMA and ARFIMA Forecasting

Here we must recall the procedure of 'Identification through Heteroscedasticity'. The first step is to decompose the residuals: $u_{it} = \sigma_{cit} z_{ct} + \sigma_{it} z_{it}$, where $i = 1,2$, while we use σ_{cit} to represent the interdependence and σ_{it} to represent pure contagion. In order to obtain the residuals, we must build forecasting models through which to generate the estimated values. Two kinds of models are employed in our study, namely the ARMA and ARFIMA models. ARMA models represent the short memory process whose autocorrelations decay at a fast exponential rate. ARFIMA models represent both short and long memory processes. The short memory processes which they represent are those whose autocorrelations decay at a slower hyperbolic rate. With these processes, the limit of the sum of the autocorrelations is also less than infinite. The autocorrelations decay hyperbolically to zero. The long memory processes they represent are those whose autocorrelations decay at hyperbolic rate and whose limit of the sum of autocorrelations is infinite. This suggests that the autocorrelations never reaches 0. There are two purposes here: the first is to obtain forecasting errors and the residuals, so we have the data to build equations for the contagion test. The second is to find the long memory and short memory features of the data and examine the effect of said long/short memory features. We would also like to establish whether or not data with long-term dependence and short-term dependence react differently in financial contagion.

Here we must recall the estimation process in Chapter 4.1. The first step is to estimate the ARMA models. Indeed, Table 8 summarises the information of the best-fitting lag specifications for ARMA (p, q). The length of lag terms is determined by AIC (Akaike info criterion). The length we tried for both AR and MA terms is from 0 to 3. The one with the lowest AIC is the best fitting model. Table 9 presents the final estimation of ARFIMA (p, d, q) models.

Table 8: ARMA Models

	p_1	p_2	p_3	q_1	q_2	q_3
Latvia	0.867 (0.055)	-0.766 (0.069)	0.116 (0.042)	-0.526 (0.044)	0.791 (0.044)	
Greece	-1.502 (0.008)	-0.996 (0.009)		0.527 (0.011)	-0.458 (0.013)	-0.965 (0.012)
Iceland	0.880 (0.066)			-0.825 (0.079)		
Bulgaria	0.823 (0.054)			-0.692 (0.069)		
Romania			0.910 (0.042)			-0.841 (0.055)
Lithuania	-0.146 (0.080)	0.739 (0.074)		0.266 (0.092)	-0.608 (0.086)	

The statistics inside the ( ) are Std.Error and all coefficients are significant at 1% level.

Table 9: ARFIMA Models

	p_1	p_2	p_3	q_1	q_2	q_3	d
Latvia	0.937 (0.080)	-0.799 (0.078)	0.192 (0.057)	-0.492 (0.061)	0.787 (0.037)		-0.111 (0.054)
Greece	-0. 921 (0.008)	-0.994 (0.009)		-1. 887 (0.011)	1.889 (0.013)	-0.966 (0.012)	-0.015 (0.000)
Iceland	-0. 529 (0. 239)	-0. 113 (0. 060)	-0.087 (0.037)	0. 382 (0. 250)			0.182 (0.050)
Bulgaria	-0.683 (0.146)			0.633 (0.157)			0.189 (0.028)
Romania			-0.969 (0.037)			0.961 (0.041)	0.117 (0.020)
Lithuania	1.830	-0.986		-1.821	0.985		0.119

	(0.013)	(0.014)		(0.015)	(0.014)		(0.026)
The statistics inside the ( ) are Std.Error and all coefficients are significant at 1% level.							

The AR and MA lag specifications of the best fitting ARMA model are identical to those of the final estimation of the ARFIMA model in most of our cases with the exception of Iceland, which is an ARMA (1, 1) but ARFIMA (3, 0.182, 1). The reason we changed the value of p and q is that the value of d which we estimated for the Iceland ARFIMA (1, d , 1) is not significant. The value of d is very sensitive to the value of p and q, meaning that we sometimes need to try different lag specifications to obtain a statistically significant result. We know that the ARFIMA model allows the property of long memory in the region $0 < d < 0.5$ and short memory in the region $-0.5 < d < 0$. Indeed, we can see from Table 9 that the two series in group 1, Latvia and Greece, possess short memory properties while the other four series in groups 2 and 3, Iceland, Bulgaria, Romania and Lithuania, possess long memory properties. Hence, we expect the prediction of group 2 and 3 to be better than that of group 1 and shocks to have a more persistent effect on group 2 and 3 than group 1, which is confirmed by breakpoint tests for having less structural changes.

We use Mean Error (ME), Mean Absolute Error (MAE), Mean Squared Error (MSE), Mean Percentage Error (MPE) and Mean Absolute Percentage Error (MAPE) to measure the forecasting accuracy, where:

$$ME = \frac{1}{n}\sum_{t=1}^{n} e_t$$

$$MAE = \frac{1}{n}\sum_{t=1}^{n} |e_t|$$

$$MSE = \frac{1}{n}\sum_{t=1}^{n} e_t^2$$

$$MPE = \frac{1}{n}\sum_{t=1}^{n} PE_t = \frac{1}{n}\sum_{t=1}^{n} \frac{f_t - x_t}{x_t}$$

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} |PE_t| = \frac{1}{n}\sum_{t=1}^{n} \left|\frac{f_t - x_t}{x_t}\right|$$

The advantage of ME is that it is easy to compute, but it is likely to be small since positive and negative errors tend to offset one another. MAE and MSE are more interpretable and are easier to explain, although they can only be used to compare the accuracy of methods applied to the same data length. MPE shares the same weakness with ME, with the positive and negative errors tending to offset one another. Figure 3 and 4 provide the plots of the forecasted data and table 10 and 11 report the calculated value for these criterions:

Figure 3: Forecasted Result of the ARMA Model

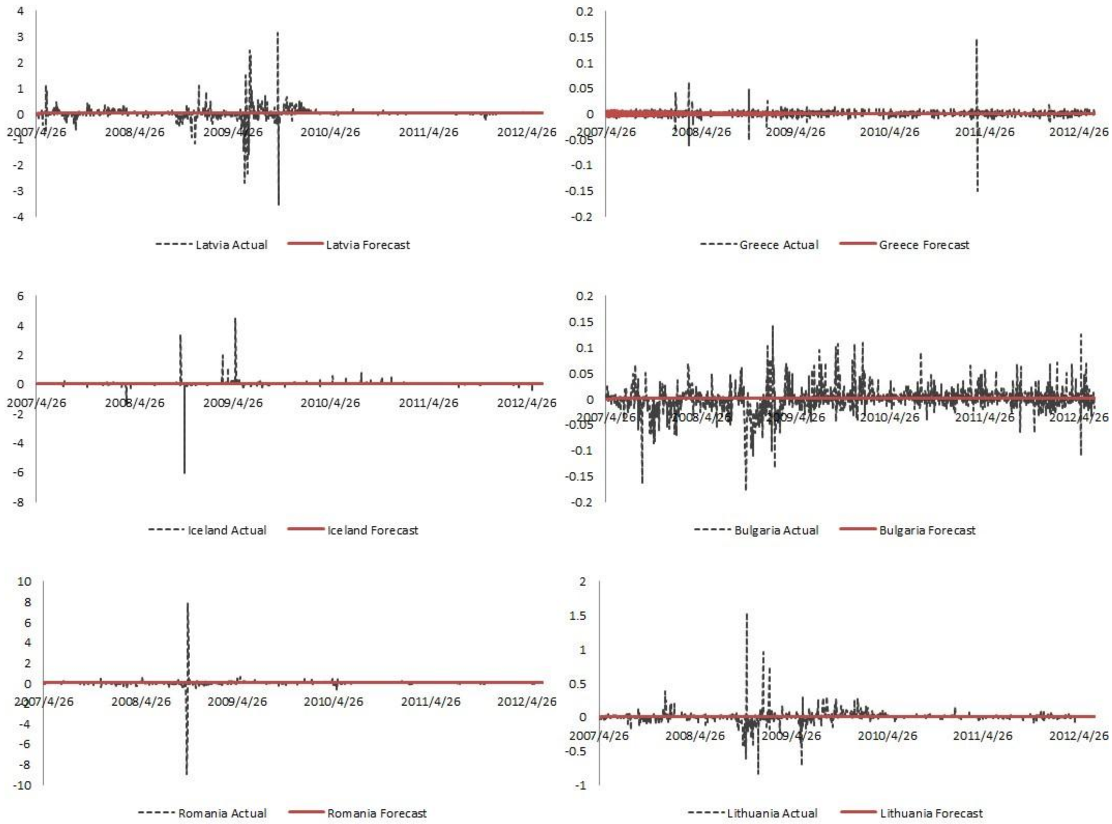
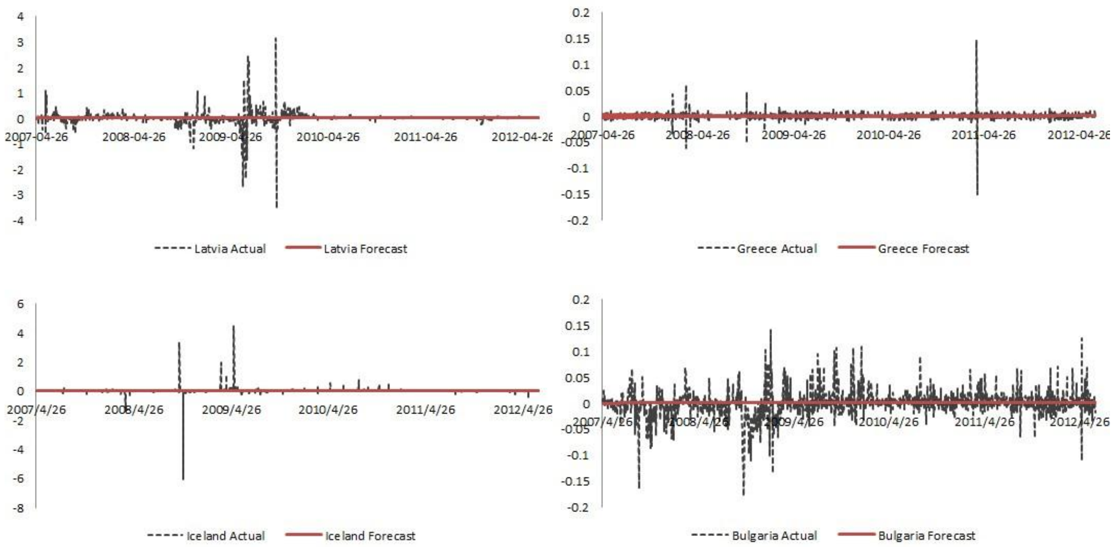
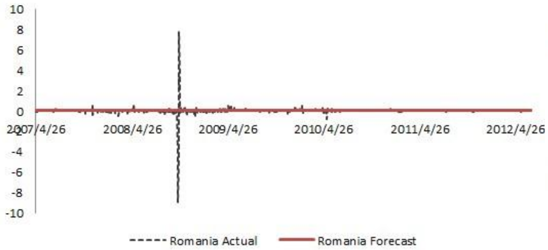


Figure 4: Forecasted Result of the ARFIMA Model





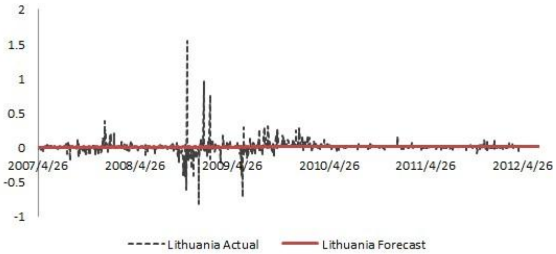


Figure 3 and 4 suggest that the predictions are all very bad, although these models fit the period from February 17, 2003 to April 25, 2007 fairly well. Their forecast accuracy is very low after the shock in 2008. However, this does not interfere with our study in a bad way. The reason for this drop in accuracy is the shock, while the reason for shock relates to the emergence into the economy of new information of which the market and investors were not previously aware, thus giving rise to significant changes. Previous statistical and fundamental linkages investors which used to forecast the market were broken or switched to new ones. Moreover, in terms of our research target, the residuals contain this information, and could well be the reason for contagion, or the route through which contagion spreads.

Table 10: ME, MAE, MSE, MPE and MAPE for ARMA Model

	ME	MAE	MSE	MPE	MAPE
Forward premium return					
Latvia	0.0033	0.0782	0.0616	0.94	0.96
Greece	4.06e-6	6.39e-5	6.51e-5	0.85	0.95
Iceland	0.0038	0.0592	0.0591	0.90	0.90
Bulgaria	-0.0007	0.0006	0.0006	0.87	0.87
Romania	-0.0008	0.1618	0.1618	0.95	0.95
Lithuania	0.0001	0.0071	0.0071	0.93	0.93

Table 11: ME, MAE, MSE, MPE and MAPE for ARFIMA Model

	ME	MAE	MSE	MPE	MAPE
Latvia	0.0023	0.0782	0.0616	0.89	0.96
Greece	4.31e-6	3.68e-3	3.78e-3	0.84	0.87
Iceland	0.0052	0.0325	0.0324	0.87	0.94
Bulgaria	-0.0006	0.0153	0.0153	0.86	0.86
Romania	-0.0023	0.0690	0.0690	0.92	0.96
Lithuania	0.0003	0.0302	0.0302	0.95	0.95

We then move on to the formal tests of accuracy. These criteria confirmed what we observed in the plots. The forecasts are very bad. This may not be very clear with ME, MAE and MSE since they only measure the scale of the error. Moreover, because the value of our observation is small, the errors are not much bigger either. But if we look at the MPE and MAPE, it becomes quite clear that the percentage error is very big.

5.5 Breakpoint Test

The second step of 'Identification through Heteroscedasticity' is to detect breakpoints. We now have the residuals for the contagion period (April 26, 2007 to June 25, 2012). It is now necessary to establish whether there are any breakpoints during this period, so that we can further test whether there are any contagion effects before and after these breakpoints. Indeed, we also make the identification process more appropriate by estimating the structural breaks before the final contagion tests. We employ two breakpoint tests in this section with a view to achieving another of our research objectives: to examine the effect of heteroscedasticity. Indeed, one of the tests (the Bai-Perron test) deals with heteroscedasticity while the other one (the Andrews-Ploberger test) does not.

The mechanism of using the Andrews-Ploberger for multi-breakpoint detection is: 1. Test a single break using the Andrews-Ploberger test for the full sample, separate the full sample into two sub-samples if the result shows that there is a structure change. 2. Carry out an Andrews-Ploberger test for each of the sub-samples; separate the respective sub-samples into two individual segments if a new break point is found. 3. Repeat the same procedure for each of the new segments until no break points are found. The plots of the breakpoints found are in Figure 5 while the summarised result is presented in Table 12. A Bai-Perron test is performed on each series individually. The plots of the breakpoints found are in Figure 6 while the summarised results of the Bai-Perron test are reported in Table 13 (please see Appendix 4 for the detailed results).

Figure 5: Plots of the Breakpoints Found Based on Andrews-Ploberger Test

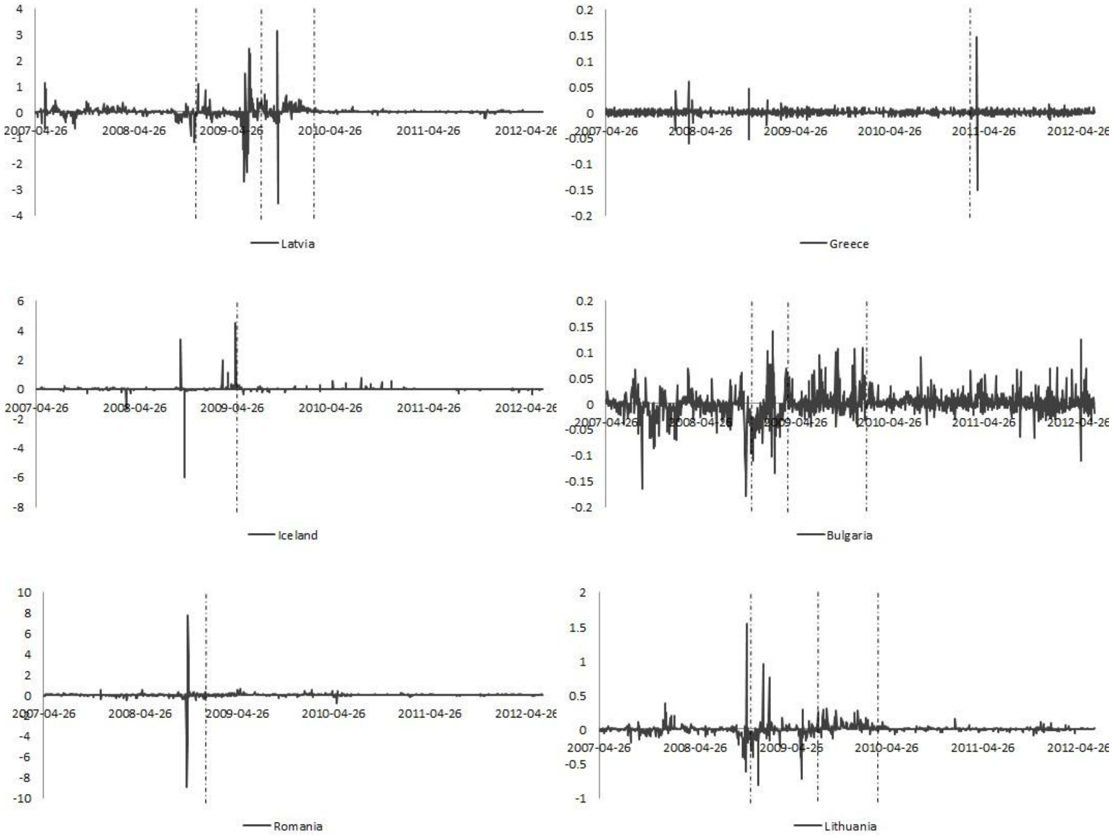


Figure 6: Plots of the Breakpoints Found Based on Bai-Perron Test

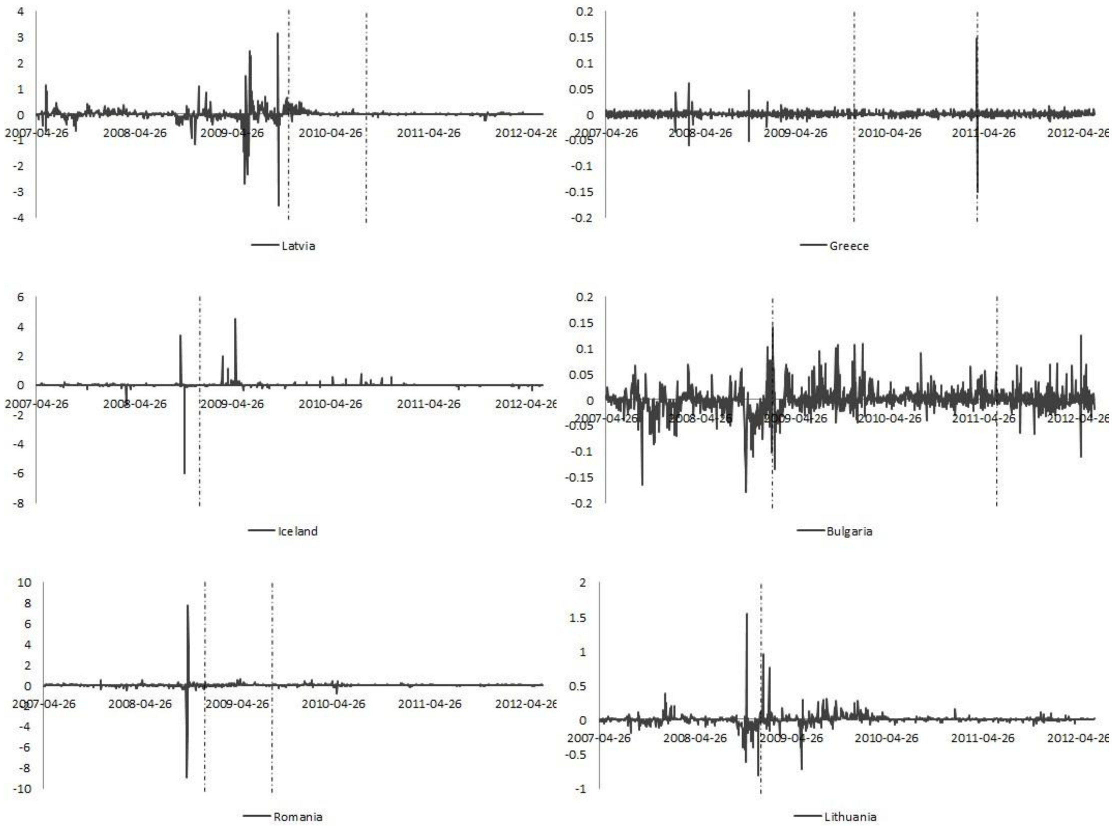


Table 12: Andrews-Ploberger Test Results

	Possible Breakpoint	P-value	AP Statistics	Is it a break at 5%? (1 yes, 0 no)
Latvia	372 (2008/09/29)	0.0056	3.7034	1
	568 (2009/06/30)	5.55e-8	7.4035	1
	722 (2010/02/01)	5.65e-38	13.288	1
Greece	1024 (2011/03/30)	1.0000	0.0018	0
Iceland	493 (2009/03/17)	0.4750	0.4585	0
Bulgaria	382 (2008/10/13)	2.15e-128	19.670	1
	492 (2009/03/16)	0.0000	33.733	1
	714 (2010/01/20)	0.0079	7.4035	1
Romania	389 (2008/10/22)	0.8858	0.2335	0
Lithuania	374 (2008/10/01)	0.0182	2.8629	1
	578 (2009/07/14)	1.67e-7	7.1906	1
	733 (2010/02/16)	0.0000	64.921	1

Table 13: Bai-Perron Test Results

	Possible Breakpoint	$\mathbf{SupF_T}(\mathbf{n}+1\vert\mathbf{n})$	$\mathbf{UD}\max$	$\mathbf{WD}\max$
Latvia	642 (2009/10/12)	35.36*	31.85*	39.97*
	844 (2010/07/21)	(n=1)		
Greece	658 (2009/11/03)	62.62*	209.4*	282.7*
	1022 (2011/03/28)	(n=1)		
Iceland	385 (2008/10/16)	1.09	10.08*	10.26*
		(n=1)		
Bulgaria	430 (2008/12/18)	9.51*	30.34*	31.23*
	1119 (2011/8/10)	(n=1)		
Romania	390 (2008/10/23)	109.8*	75.29*	98.90*
	592 (2009/08/03)	(n=1)		
Lithuania	402 (2008/11/10)	8.46	11.43*	19.84*

***: significant at 5% level**

In group 1, the Andrews-Ploberger test reports 4 breakpoints (372, 568, 722, and 1024) although one of them is not statistically significant. The Bai-Perron test reports 4 breakpoints (642, 658, 844, and 1022). The two tests reported no similar breakpoint for Latvia, thus suggesting that the change we observe in this country's premium is mainly change in variance. With regard to Greece, on the other hand, the tests reported one similar breakpoint, thus suggesting a change in variance followed by a change in mean. In group 2, the Andrews-Ploberger test reports 4 possible breakpoint (382, 492, 493, and 714), one of which is again not statistically significant (493). The Bai-Perron test reports 3 breakpoints (385, 430, and 1119). The two tests detected different breakpoints for both Iceland and Bulgaria, a sign of change in mean. In group 3, the Andrews-Ploberger test reports 4 breakpoints (374, 389, 578, and 733) with one insignificant breakpoint yet again. The Bai-Perron tests reports 3 breakpoints (390, 420, and 592). We obtained a similar breakpoint in both Romania and Lithuania, thus suggesting a change in mean followed by some changes in variance. It is very clear that these tests mostly generate very different breakpoints, especially in groups 1 and 2. However, we occasionally observe one similar breakpoint. The accuracy test we performed suggests that they tend to disagree on change in variance and the Bai-Perron test performs better in this regard. Thus, it is reasonable for us to conclude that group 1 experienced a longer initial period of change in variance, followed by a shorter period of change in mean, while groups 2 and 3 experienced a shorter initial period of change in mean followed by a longer period of change in variance. Another of our ideas related to breakpoints is that breakpoints are the tracks left behind by contagion when it passes through. Indeed, whenever contagion comes to a market or a country, it leads to a structural change, and hence contagion, before it then moves on to another market or country. Thus, the sample where the first breakpoint was detected may be the place where contagion came to this group and the sample where the last breakpoint was detected may be the place where contagion left this group. If we take all 6 countries as a group, the result from the Andrews-Ploberger test suggests that contagion came to this group on 2008/09/29 in Latvia and left on 2011/03/30 in Greece. We can see that the first breakpoints detected in Latvia, Bulgaria, Romania and Lithuania are quite similar, perhaps because the contagion we may observe in this group did not originate within this group, and actually came from another country before simultaneously spreading to these four countries. In the same manner, the result from the Bai-Perron test suggests that contagion came to this group on 2008/10/16 in Iceland and left on 2011/03/28 in Greece.

If n breakpoints were found, we should split the whole sample into n+1 subsample before moving on to the contagion test. However, all three groups have some breakpoints which are very close to each other (642, 658 in group 1; 492, 493 and 385, 430 in group 2; 374, 389 and 390, 420 in group 3). Their intervals are less than 30 while we have approximately 1400 observations; we take them as one breakpoint for modelling convenience. Thus, now group 1 has 4 breakpoints detected by the Andrews-Ploberger test and 3 breakpoints detected by the Bai-Perron test; group 2 has 3 breakpoints detected by the Andrews-Ploberger test and 2 breakpoints detected by the Bai-Perron test; group 3 has3 breakpoints detected by the Andrews-Ploberger test and 2 breakpoints detected by the Bai-Perron test.

Most of the breakpoints detected correspond to important events in the countries. The breakpoints in group 1 are discrete throughout the whole sample. 7 breakpoints are detected by the two tests, 3 of which are found in Greece and Germany's risk premium while 4 are found in Latvia and Germany's risk premium. This may be because contagion transfers from Latvia to Greece after 568 (2009/06/30) and the two countries begin to share the same contagion shock later on. The first breakpoint is found on 2008/09/29. Indeed, the reason for this seems to be the Latvian parliament's approval of the European Union's Lisbon Treaty and the financial crisis. This may be when the contagion initiates in group 1. 2009/06/30 is the second breakpoint, and is probably due to the Latvian Central Bank's expenditure of almost a billion Euros in 2009 to support the lat currency. This expenditure caused a shift in currency risk premium. The third and fourth breakpoints are detected at the end of 2009 and beginning of 2010. Many important things happened in Germany, Latvia and Greece at that time. The new elections in Germany and Greece, the major tax cut in Germany and the increase of unemployment in Latvia. However, it is our contention that the most likely reasons are related to the slump in exports and investment in Germany as well as the Latvian Government's agreement to slash the budget deficit in 2010 in order to meet targets imposed by the EU in exchange for a 7.5bn rescue loan. The fifth breakpoint is on 2010/07/21, and while many things could have led to this, the main culprit seems to debt-ridden Greece. For example, fears of a possible default on Greece's debts prompted euro zone countries to approve a $145bn (110bn Euros; £91bn) rescue package for the country. The last two breakpoints in group 1 are found at the beginning of 2011, with certain international leaders making it clear that Greece must reform its finance system. The breakpoints in group 2 and group 3 are quite similar, especially with regards to their starting point. They each have two breakpoints very near to each other (with an interval of less than 30 days). This could be a clear signal that contagion has been transferred from one country to another, i.e. the Bai-Perron test suggests that contagion is transferred from Iceland to Bulgaria in group 2 and from Romania to Lithuania in group 3, although the Andrews-Ploberger test states the opposite. We have to say that breakpoints detected in group 2 and group 3 are more mysterious than group 1. Although it is not hard to find the corresponding economic event for them, it is hard to see where contagion initiates and how it is transferred among these countries, or at least it is hard to see based on breakpoint tests. Just like group 1, besides the common major events in Germany which every groups share, the nature of the other events occurring in each country are quite similar. First are the events directly linked with the fundamental elements: Iceland's government took over control of all three of the major banks in the October of 2008 in order to stabilise the financial system. Then in the following month, IMF approved a 2.1 billion dollar loan to help Iceland. At the same time, the European Commission permanently stripped Bulgaria of half of its aid. In January 2009, Russia cut gas supplies to Bulgaria, resulting in a severe energy shortage. Second are the events that indirectly influence the economy, mostly elections. For instance, Homeland Union, a conservative party, became the largest party after parliamentary elections in Lithuania on 2008/10/15.

To sum up, based on the timing of the breakpoints and the chronology, we can split the corresponding major events into two categories. The first category is the events which are directly linked with the fundamental elements, most of which are financial account elements. In our case, we only observed 3 events related to current account elements, one of which pertains to energy supply. The other two are the changes in export in Germany and Latvia. The second category comprises events that are not directly associated with fundamental elements, although indirect influence may imply. Most of the events are elections, while the others usually suggest new political orders as well. For instance, the Latvian parliament approved the European Union's Lisbon Treaty in 2008 May. In conclusion, this provides a good reference for what kind of events may cause structural breaks. If a similar incident were to occur in a country, the market would suffer a shock and the corresponding time series data may exhibit a structural change.

5.6 Detecting Contagion

Since we used 2 forecasting models to obtain the expected return and 2 breakpoint tests to detect structural breaks, we now have 4 procedures with which to identify contagion. The Andrews-Ploberger test and ARMA model based procedure (procedure 1 henceforth), the Andrews-Ploberger test and ARFIMA model based procedure (procedure 2 henceforth), the Bai-Perron test and ARMA model based procedure (procedure 3 henceforth) and the Bai-Perron test and ARFIMA model based procedure (procedure 4 henceforth).

5.6.1 Co-Integration and Granger Causality Tests

Before we go through these 4 procedures one by one, let us examine the results of the co-integration and Granger causality tests and establish if the data are statistically linked.

The Johansen test which is a multivariate extension and allows for more than one cointegrating vector. Although the unit root tests often suffer from poor size and power properties (i.e. Type I and Type II errors), the stationary pre-tests are usually required before the cointegration test. The Engle-Granger and Johansen cointegration testing procedures are typically used under the condition that all variables are I(1), however having stationary variables in the system is theoretically acceptable as well, because I(0) data are already stationary, and when the regression includes both I(1) and I(0), the stationary variable is more important than the non-stationary one in establishing a sensitive long-run relationship. Due to the above reasons, Johansen (1995, pp. 149-153) stated that there is little need to pre-test the variables in the cointegration system for the order of integration. However, we still employ the ADF unit root test for a more comprehensive estimation. Because the data used are flat with close to zero means, intercept and trend variables are not included in the regression.

The Johansen test is the maximum likelihood estimator of the reduced rank model which can be affected by the lag order where the lag order is determined by using the information criteria in VAR (Worthington and Higgs, 2007). In order to carry out a Johansen test, we are asked to construct a VAR/VEC model with proper lag specification. The AIC criteria is used in this study to determine the best lag terms from lag 1 to 8.

According to Granger, Huang and Yang's (2000) study, the Linear Granger Causality test in this study are considered in two conditions, cointegrated or not cointegrated. The VEC models are employed to test Granger Causality for the cointegrated cases, while the 1st difference VAR models are employed to test Granger Causality for the not cointegrated cases. The general regression for VEC and VAR model are as follow:

VEC Model (Vector Error Correction):

$$\Delta y_{1t} = \alpha_0 + \lambda_1.e_{1t-1} + \sum_{i=1}^{k}\alpha_{1i}.\Delta y_{1t-i} + \sum_{i=1}^{k}\alpha_{2i}.\Delta y_{2t-i} + \varepsilon_{1t}$$

$$\Delta y_{2t} = \beta_0 + \lambda_2.e_{2t-1} + \sum_{i=1}^{k}\beta_{1i}.\Delta y_{1t-i} + \sum_{i=1}^{k}\beta_{2i}.\Delta y_{2t-i} + \varepsilon_{2t}$$

VAR Model (Vector Autoregression):

$$\Delta y_{1t} = \alpha_0 + \sum_{i=1}^{k}\alpha_{1i}.\Delta y_{1t-i} + \sum_{i=1}^{k}\alpha_{2i}.\Delta y_{2t-i} + \varepsilon_{1t}$$

$$\Delta y_{2t} = \beta_0 + \sum_{i=1}^{k}\beta_{1i}.\Delta y_{1t-i} + \sum_{i=1}^{k}\beta_{2i}.\Delta y_{2t-i} + \varepsilon_{2t}$$

Table 14 to 19 report the results of the stationary pre-test, the lag determination, the co-integration and the causality tests. The data are flat and have close to zero mean in all cases, therefore no intercepts and trend variables are included in the test regressions.

Table 14: The rank of integration and the best fitting lag terms for the VAR/VEC models based on Andrews-Ploberger Test

	Period 1		**Period 2**		**Period 3**		**Period 4**		**Period 5**	
	Rank	Lag	Rank	Lag	Rank	Lag	Rank	Lag	Rank	Lag
Latvia	I (0) [8]	8 {-8.89}	I (0) [11]	6 {-6.41}	I (0) [1]	7 {-7.00}	I (0) [10]	2 {-10.69}	I (0) [3]	8 {-12.84}
Greece	I (0) [10]		I (0) [8]		I (0) [12]		I (0) [13]		I (0) [14]	
Iceland	I (0) [11]	3 {-7.06}	I (0) [8]	2 {-1.39}	I (0) [0]	1 {-3.68}	I (0) [1]	1 {-8.08}		
Bulgaria	I (0) [5]		I (0) [1]		I (0) [1]		I (0) [1]			
Romania	I (0) [10]	2 {-5.55}	I (0) [14]	8 {0.82}	I (0) [1]	1 {-4.79}	I (0) [12]	1 {-8.19}		
Lithuania	I (0) [2]		I (0) [1]		I (0) [1]		I (0) [10]			

The number in [] and {} are the best fitting lag terms for the ADF test and AIC criteria for the best fitting VAR/VEC respectively.

Table 15: Co-Integration Test Based on Andrews-Ploberger Test

	Period 1	**Period 2**	**Period 3**	**Period 4**	**Period 5**
Group 1	282.74**	101.67**	100.12**	88.50**	210.02**
Group 2	98.89**	47.97**	75.03**	223.45**	
Group 3	91.67**	101.87**	37.38**	173.39**	

The statistics in this table are trace statistics. ** indicates significant at 1% level.

Table 16: Granger Causality Test Based on Andrews-Ploberger Test

	Group 1	Group 2	Group3
Period 1	Greece does not granger cause Latvia	Iceland does not granger cause Bulgaria	Romania does not granger cause Lithuania
	Latvia does not granger cause Greece	Bulgaria does not granger cause Iceland	Lithuania does not granger cause Romania
Period 2	Greece does not granger cause Latvia	Iceland does not granger cause Bulgaria	Romania does not granger cause Lithuania
	Latvia does not granger cause Greece	Bulgaria does not granger cause Iceland	Lithuania does not granger cause Romania
Period 3	Greece does not granger cause Latvia	Iceland does not granger cause Bulgaria	Romania does not granger cause Lithuania
	Latvia does not granger cause Greece	Bulgaria does not granger cause Iceland	Lithuania does not granger cause Romania
Period 4	Greece does not granger cause Latvia	Iceland does not granger cause Bulgaria	Romania does not granger cause Lithuania
	Latvia does not granger cause Greece	Bulgaria does not granger cause Iceland	Lithuania does not granger cause Romania
Period 5	Greece does not granger cause Latvia		
	Latvia does not granger cause Greece		

Table 17: The rank of integration and the best fitting lag terms for the VAR/VEC models based on Bai-Perron Test

	Period 1		Period 2		Period 3		Period 4	
	Rank	Lag	Rank	Lag	Rank	Lag	Rank	Lag
Latvia	I (0) [15]	8 {-7.41}	I (1) [14]	8 {-10.27}	I (0) [4]	2 {-10.69}	I (0) [3]	5 {-10.99}
Greece	I (0) [10]		I (0) [12]		I (0) [7]		I (0) [13]	
Iceland	I (0) [1]	3 {-5.25}	I (1) [8]	2 {-5.07}	I (0) [1]	1 {-8.50}		
Bulgaria	I (0) [2]		I (0) [7]		I (0) [1]			
Romania	I (0) [11]	8 {-0.41}	I (0) [14]	1 {-2.44}	I (0) [12]	5 {-6.58}		
Lithuania	I (0) [9]		I (0) [2]		I (0) [12]			

The number in [] and {} are the best fitting lag terms for the ADF test and AIC criteria for the best fitting VAR/VEC respectively.

Table 18: Co-Integration Test Based on Bai-Perron Test

	Period 1	Period 2	Period 3	Period 4
Group 1	341.32**	79.09**	100.06**	236.72**
Group 2	45.40**	211.19**	75.03**	
Group 3	42.74**	62.23**	154.37**	

The statistics in this table are trace statistics. ** indicates significant at 1% level.

Table 19: Granger Causality Test Based on Bai-Perron Test

	Group 1	Group 2	Group3
Period 1	Greece does not granger cause Latvia	Iceland does not granger cause Bulgaria	Romania does not granger cause Lithuania
	Latvia does not granger cause Greece	Bulgaria does granger cause Iceland	Lithuania does not granger cause Romania
Period 2	Greece does not granger cause Latvia	Iceland does not granger cause Bulgaria	Romania does not granger cause Lithuania
	Latvia does not granger cause Greece	Bulgaria does not granger cause Iceland	Lithuania does not granger cause Romania
Period 3	Greece does not granger cause Latvia	Iceland does not granger cause Bulgaria	Romania does not granger cause Lithuania
	Latvia does not granger cause Greece	Bulgaria does not granger cause Iceland	Lithuania does not granger cause Romania
Period 4	Greece does not granger cause Latvia	Iceland does not granger cause Bulgaria	Romania does not granger cause Lithuania
	Latvia does not granger cause Greece	Bulgaria does not granger cause Iceland	Lithuania does not granger cause Romania

The results in Table 15 and 18 show that the time series are all co-integrated at every sub-period, thus meaning that there are statistically significant long-run connections between the series. Since the data are all co-integrated, it is not likely that they will accidentally jump and have a structural change. If a significant co-movement is detected, coincidence is not the reason for it. However, we did not observe any Granger causality relationship among them, with the exception of period 1 in group 2, Granger Causality Test based on Bai-Perron Test, where Bulgaria granger cause Iceland. The reason for the lack of Granger causality may be related to the fact that the shock at the root of the structural changes in these countries did not originate within them, but was transferred to them from somewhere else. If the shock were a tornado, these countries are just cities which it passed by. However, we should bear in mind that the lack of a causal relationship does not mean no correlation at all. Markets have no causal relationship but could still have a significant correlation between their co-movements.

5.6.2 The 4 Contagion Test Procedures

We now move on to the results of contagion tests. Indeed, following the previous study, we split the shock into two segments, namely common shock and idiosyncratic shock. Common shock is a change in the interdependence of fundamentals, represented by σ_{cit}. Idiosyncratic shock is a change which cannot be directly explained, the pure contagion, represented by σ_{it}. The ratio of the σ of the two countries is used to represent the equilibrium of the corresponding time period between them. After the ratios are calculated, a t-test is performed. If there is a significant change before and after a structural break, then the old equilibrium experienced a ‘shift’, hence contagion is detected.

4 testing procedures are formed based on the 2 forecasting models and 2 breakpoint tests. They each have different roles to play. Procedure 1, as the least appropriate one of the 4 procedures, is designed to provide a base line in terms of how the results look when heteroscedasticity is not adjusted and the long memory and short memory feature is ignored. Based on the base line provided by procedure 1, procedure 2's role is to reveal the effect of the long memory and short memory features only. Correspondingly, procedure 3 is designed to show how the results behave when only heteroscedasticity is adjusted. Procedure 4, as the most appropriate one, provides a better identification of contagion because both heteroscedasticity and long memory and short memory features are considered. As it turns out, the estimation of sigma and the identification of contagion are highly sensitive to the models used. Although the absolute values of sigma are interpreted as the standard error of shock and their ratios are interpreted as the linkages between countries, we will not explore in detail their practical meaning in the first 3 procedures as they are relatively poorly estimated. Instead, we will mainly focus on the effects of the statistical features (long and short memory, and heteroscedasticity) and will not discuss the practical meaning at length until we reach the most appropriate procedure (procedure 4). The final iterated results of sigma, their standard errors and the t-statistics are reported in Tables 20 to 43.

5.6.2.1 Procedure 1: Andrews-Ploberger and ARMA Based Identification

The base line results are as follow:

Table 20: Latvia, Greece and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	0.1326569	0.007409	17.9048	0.4226829	0.0071059	59.4833
	(0.022438)	(0.196307)	(0.365319)	(0.016827)	(0.204105)	(1.254317)
Period 2/ Period 3	0.4226829	0.0071059	59.4833	0.2818184	0.0040057	70.3543
	(0.016827)	(0.204105)	(1.254317)	(0.0275)	(0.0388)	(3.6827)
Period 3/ Period 4	0.2818184	0.0040057	70.3543	0.2470999	0.0126797	19.4878
	(0.0275)	(0.0388)	(3.6827)	(0.0289)	(0.0387)	(1.0366)
Period 4/ Period 5	0.2470999	0.0126797	19.4878	0.2789751	0.0112514	24.7947
	(0.0289)	(0.0387)	(1.0366)	(0.0276)	(0.0386)	(1.6101)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-24.063499**	20.3659**	18.7821**	-18.1502**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-2.555923*	3.2519**	4.3345**	-4.8895**

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-8.605486**	-6.4844**	4.5686**	-1.5521

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 21: Latvia, Greece and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.0110517	0.0020992	5.2647	0.4014787	0.0000819	4902.0598
	(0.014456)	(0.046078)	(0.408279)	(0.012336)	(0.046677)	(130.923026)
Period 2/ Period 3	0.4014787	0.0000819	4902.0598	0.2488894	0.0003811	653.0816
	(0.012336)	(0.046677)	(130.923026)	(0.0289)	(0.0392)	(39.5551)
Period 3/ Period 4	0.2488894	0.0003811	653.0816	0.2802393	0.0120364	23.2826
	(0.0289)	(0.0392)	(39.5551)	(0.0276)	(0.0386)	(1.4647)
Period 4/ Period 5	0.2802393	0.0120364	23.2826	0.2456652	0.0119371	20.5799
	(0.0276)	(0.0386)	(1.4647)	(0.0290)	(0.0387)	(1.1021)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-21.496480**	0.2497	-18.0894**	18.6985**

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
18.816469**	2.2078*	-8.0438**	5.2201**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-9.338389**	-9.9072**	9.8915**	-0.2313

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 22: Iceland, Bulgaria and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ^*_1	σ^*_2	σ^*_1/σ^*_2
Period 1/ Period 2	0.0000337	0.1135906	0.000297	0.6401925	0.1165559	5.492579
	(0.616246)	(0.016438)	(8.110755)	(0.257152)	(0.016947)	(3.971525)
Period 2/ Period 3	0.6401925	0.1165559	5.492579	-3.43E-6	0.0266974	1.2848E-4
	(0.257152)	(0.016947)	(3.971525)	(47.0806)	(0.0102)	(845.5602)
Period 3/ Period 4	-3.43E-6	0.0266974	1.2848E-4	2.02E-6	0.0171866	1.1753E-4
	(47.0806)	(0.0102)	(845.5602)	(41.9352)	(0.0068)	(390.1542)

T-Test on σ_1 and σ^*_1

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-0.983164	0.2921	-0.5388

T-Test on σ_2 and σ^*_2

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-1.423615	21.5287**	-7.9379**

T-Test on σ_1 / σ_2 and σ^*_1/σ^*_2

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-1.150680	0.2497	-0.4684

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 23: Iceland, Bulgaria and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.1712472	0.0104907	16.323715	0.6759517	-0.0027209	-248.429453
	(0.455949)	(0.068116)	(1.192034)	(0.208469)	(0.035268)	(1.610380)
Period 2/ Period 3	0.6759517	-0.0027209	-248.429453	0.2404349	0.0014474	166.1151
	(0.208469)	(0.035268)	(1.610380)	(0.0081)	(0.0109)	(3.2931)
Period 3/ Period 4	0.2404349	0.0014474	166.1151	0.060855	1.47E-6	4.1793E4
	(0.0081)	(0.0109)	(3.2931)	(0.0066)	(0.0069)	(0.0142)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-1.320327	3.2601**	66.5195**

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
1.755255	-0.4511	-51.2038**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
0.548930	-9.4755**	9.1754**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values,**

standard errors are reported in parentheses.

Table 24: Romania, Lithuania and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	8.07E-6	0.5119757	1.57E-5	0.8951838	0.5190681	1.724597
	(1512.7212)	(0.001214)	(4418.8245)	(0.310617)	(0.001169)	(0.540555)
Period 2/ Period 3	0.8951838	0.5190681	1.724597	7.52E-6	0.0704617	1.0673E-4
	(0.310617)	(0.001169)	(0.540555)	(10.7903)	(0.0011)	(46.1335)
Period 3/ Period 4	7.52E-6	0.0704617	1.0673E-4	0.0555646	0.0177222	3.1353
	(10.7903)	(0.0011)	(46.1335)	(0.0428)	(0.0444)	(0.1297)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-4.740076**	-0.5482	-0.4351

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
59.805477**	326.1523**	11.5712**

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-1.830721	-0.1085	-1.7367*

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 25: Romania, Lithuania and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^* / \sigma_{c2}^*$
Period 1/ Period 2	0.455169	0.0082139	55.414480	0.763305	-0.0138554	-55.090794
	(0.109569)	(0.002386)	(1.483276)	(0.092406)	(0.000769)	(5.113707)
Period 2/ Period 3	0.763305	-0.0138554	-55.090794	-5.51E-06	-3.05E-06	1.8066
	(0.092406)	(0.000769)	(5.113707)	(2.1834)	(4.5281)	(55.5102)
Period 3/ Period 4	-5.51E-06	-3.05E-06	1.8066	0.0555646	0.0024008	23.1442
	(2.1834)	(4.5281)	(55.5102)	(0.0428)	(0.0452)	(1.4172)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
12.418238**	1.6536*	-0.4904

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-15.406652**	-1.7131*	3.8434**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^* / \sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
17.377366**	-0.8217	-1.6373

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

We first summarise the overall statistical result. Since this procedure used the residuals of the ARMA model which does not distinguish between long memory process and short memory process, we will not discuss this feature here. We should also bear in mind that procedure 1 is the least appropriate among all 4 procedures (see Section 5.3 for details). Tables 20 to 25 summarise the estimated results of σ_{it}, σ_{cit} and the ratios. If we call the time period from period A to period A+1 a transmission period (for instance, period 1/period 2 is a transmission period), there are 20 transmission periods in procedure 1, with both idiosyncratic shocks and common shocks included. 10 of them are significantly identified as contagion, equating to 50%. 6 of them come from group 1, between Latvia and Greece, while 2 of the remaining 4 come from group 2, between

Iceland and Bulgaria. The other two come from group 3, between Romania and Lithuania. Recall the 6 situations we mentioned in Section 5.3.3.2.2. Indeed, a significantly identified contagion suggests that the original linkage or equilibrium is broken. Since most of the contagion effects we found (60%) are in group 1, we conclude that the linkage between Latvia and Greece is much more fragile than that of Iceland and Bulgaria, and Romania and Lithuania. The linkage continued to change after each shock until the last one, which is roughly after Germany grew by 3.6%. It seems that the improvement of a major country's economy can also pacify the condition of smaller economic entities. Moreover, another fact we found in group 1 was that whenever we detect a contagion effect in the common shock, we detect a contagion effect in the same direction in the idiosyncratic shock too. Recall that we define significant change in idiosyncratic shock as pure contagion. It seems that pure contagion move in the same direction as the change in fundamentals, thus enhancing the effect of the shock. As for the remaining 2 groups, group 3 is fundamentally more stable than group 2 since it has one less contagion effect in the common shock.

One fact we observed from Table 20 is that the absolute value of the ratios from period 2 to period 4 first increased, before returning to normal. We call a phenomenon like this the counter contagion effect. It suggests that the linkage between two countries recovers after shocks. Unlike previous literature (Inci, Li and McCarthy, 2011), we observed 9 counter contagion effects in this procedure, 3 in each of the groups. A larger ratio following the shock suggests that the increase in the variance of the numerator country is bigger than that of the denominator country. This is normally reflected in the estimation of sigma, as their absolute values are interpreted as the standard error. Another fact we observed from Table 23 is that the ratios changed their sign from positive to negative in the first transmission period. We call this phenomenon a change in direction. It suggests a negative correlation between shocks in different countries. We observed 4 changes in direction among all 20 transmission periods.

5.6.2.2 Procedure 2: Andrews-Ploberger and ARFIMA Based Identification

With procedure 2 we again used the Andrews-Ploberger breakpoint test, but switched from the ARMA model to the ARFIMA model in order to examine the effect of long memory and short memory features when heteroscedasticity is not considered. Tables 26-31 present the result of procedure 2:

Table 26: Latvia, Greece and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.1281416	0.0072243	17.73758	0.412603	0.0074489	55.391133
	(0.001775)	(0.009302)	(0.102884)	(0.001122)	(0.009655)	(0.113693)
Period 2/ Period 3	0.412603	0.0074489	55.391133	0.2797229	0.0040731	68.6757
	(0.001122)	(0.009655)	(0.113693)	(0.0276)	(0.0388)	(3.5986)
Period 3/ Period 4	0.2797229	0.0040731	68.6757	1.31E-08	0.0126812	1.0331E-6
	(0.0276)	(0.0388)	(3.5986)	(16.5754)	(0.0051)	(8.4321)
Period 4/ Period 5	1.31E-08	0.0126812	1.0331E-6	0.026588	2.25E-08	1.1817E6
	(16.5754)	(0.0051)	(8.4321)	(0.0122)	(4.8904)	(2201.5417)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-396.7425**	20.3731**	2.4965**	-0.7267

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-3.339098**	3.2519**	-8.2406**	-1.6939*

T-Test on σ_1 / σ_2 and σ_1^*/σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-282.0614**	-6.4874**	3.9001**	-3.8041**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 27: Latvia, Greece and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^*/\sigma_{c2}^*$
Period 1/ Period 2	-0.0363144	0.0001151	-315.5030	0.4029376	0.000073	5519.693151
	(0.003166)	(0.002149)	(58.094727)	(0.000629)	(0.002163)	(16.546496)
Period 2/ Period 3	0.4029376	0.000073	5519.693151	0.2652591	0.000301	881.2595
	(0.000629)	(0.002163)	(16.546496)	(0.0282)	(0.0392)	(53.1839)
Period 3/ Period 4	0.2652591	0.000301	881.2595	-5.06E-06	0.012013	-4.2121E-4
	(0.0282)	(0.0392)	(53.1839)	(1.9706)	(0.0051)	(3.9993)
Period 4/ Period 5	-5.06E-06	0.012013	-4.2121E-4	0.026588	0.0002277	116.7677
	(1.9706)	(0.0051)	(3.9993)	(0.0122)	(0.0126)	(1.9531)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-150.8165**	-0.2497	3.1074**	-1.2465

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
17.424723**	2.2191*	-15.4795**	36.3778**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^*/\sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-90.9479**	-9.9938**	9.9608**	-2.2601*

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 28: Iceland, Bulgaria and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.0000337	0.1135906	0.000297	0.6401925	0.1165559	5.492579
	(0.616246)	(0.016438)	(8.110755)	(0.257152)	(0.016947)	(3.971525)
Period 2/ Period 3	0.6401925	0.1165559	5.492579	2.47E-6	0.0264187	9.3494E-5
	(0.257152)	(0.016947)	(3.971525)	(17.7778)	(0.0025)	(177.9548)
Period 3/ Period 4	2.47E-6	0.0264187	9.3494E-5	-5.39E-6	0.0170312	3.1648E-4
	(17.7778)	(0.0025)	(177.9548)	(37.6921)	(0.0036)	(251.1498)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-0.983164	0.4589	-0.5481

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-1.423615	13.6092**	-44.4658**

T-Test on σ_1 / σ_2 and σ_1^*/σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**

-1.150680	0.3946	-0.5179

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 29: Iceland, Bulgaria and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.1712472	0.0104907	16.323715	0.6759517	-0.0027209	-248.429453
	(0.455949)	(0.068116)	(1.192034)	(0.208469)	(0.035268)	(1.610380)
Period 2/ Period 3	0.6759517	-0.0027209	-248.429453	-9.47E-06	9.12E-07	-10.3838
	(0.208469)	(0.035268)	(1.610380)	(8.3855)	(7.9712)	(224.0417)
Period 3/ Period 4	-9.47E-06	9.12E-07	-10.3838	-5.87E-06	1.08E-06	5.4352
	(8.3855)	(7.9712)	(224.0417)	(11.7253)	(8.5304)	(92.7093)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-1.320327	1.4455	0.6756

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
1.755255	-0.7264	1.0886

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
0.548930	0.1922	-0.4204

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 30: Romania, Lithuania and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ^*_1	σ^*_2	σ^*_1/σ^*_2
Period 1/ Period 2	8.07E-6	0.5119757	1.57E-5	0.8951838	0.5190681	1.724597
	(1512.7212)	(0.001214)	(4418.8245)	(0.310617)	(0.001169)	(0.540555)
Period 2/ Period 3	0.8951838	0.5190681	1.724597	2.31E-06	0.0704569	3.2786E-5
	(0.310617)	(0.001169)	(0.540555)	(19.5039)	(0.0041)	(75.6477)
Period 3/ Period 4	2.31E-06	0.0704569	3.2786E-5	0.0555612	0.0177243	3.1348
	(19.5039)	(0.0041)	(75.6477)	(0.0428)	(0.0444)	(0.1296)

T-Test on σ_1 and σ^*_1

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-4.740076**	-2.4527**	-0.4345

T-Test on σ_2 and σ^*_2

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
59.805477**	114.3301**	11.5712**

T-Test on σ_1 / σ_2 and σ^*_1/σ^*_2

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-1.830721	-1.9143*	-1.7361*

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 31: Romania, Lithuania and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.455169	0.0082139	55.414480	0.763305	-0.0138554	-55.090794
	(0.109569)	(0.002386)	(1.483276)	(0.092406)	(0.000769)	(5.113707)
Period 2/ Period 3	0.763305	-0.0138554	-55.090794	-8.63E-06	6.75E-06	-1.2785
	(0.092406)	(0.000769)	(5.113707)	(28.9201)	(15.8412)	(673.9034)
Period 3/ Period 4	-8.63E-06	6.75E-06	-1.2785	0.0555612	0.002397	23.1795
	(28.9201)	(15.8412)	(673.9034)	(0.0428)	(0.0452)	(1.4194)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
12.418238**	0.6316	-0.4892

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-15.406652**	-1.5468	3.8434**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**

17.377366**	-0.3068	-1.6375

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

These results are obtained based on the same breakpoint test, although different forecasting models are used. Compared to the ARMA model, the ARFIMA model has the ability to capture the long memory and short memory characteristics of the data. From the ARFIMA models obtained in Section 5.3, we know that group 1 is the short memory group while the others are long memory groups. Procedure 2 has the same amount of transmission periods to that of procedure 1, although one more contagion was detected, equating to 11, or 55%. There remain 9 counter contagion effects, although they are in a slightly different location. Compared to procedure 1, there is one more counter contagion effect in group 1 and one less in group 2. There are 7 changes in direction (3 more than that of procedure 1), which is a relatively bigger change compared to the change in contagion and counter contagion effect. It is very clear that since we brought in the feature of long memory and short memory, the results relating to the short memory process had some observable changes in common shock. It became more volatile, with more counter contagion effects and more changes in direction, thus suggesting that given the same major economic or political events, the scale of the changes in the short memory process were more severe than we observed in procedure 1. On the contrary, long memory processes behaved almost the same. In actual fact, they are more stable since their long memory feature is considered. One less contagion and one less counter contagion effect were detected in total.

5.6.2.3 Procedure 3: Bai-Perron and ARMA Based Identification

Since procedure 3 used the Bai-Perron test instead of the Andrews-Ploberger test, we would like to compare procedure 3 with procedure 1, so as to examine the effect of heteroscedasticity on contagion identification. Table 32-37 reports the results of procedure 3:

Table 32: Latvia, Greece and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	1.03428	-0.006618	-156.28286	0.9999999	-0.0000512	-19531.233
	(0.001388)	(30.287649)	(14.968849)	(0.001444)	(1280.9556)	(1081.1559)
Period 2/ Period 3	0.9999999	-0.0000512	-19531.233	-4.53E-08	6.95E-06	-0.0065
	(0.001444)	(1280.9556)	(1081.1559)	(0.7608)	(45.9282)	(373.0602)
Period 3/ Period 4	-4.53E-08	6.95E-06	-0.0065	0.0106403	-0.0000106	-1003.8019
	(0.7608)	(45.9282)	(373.0602)	(0.0063)	(4.6498)	(82.9038)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	Period 2/ Period 3	Period 3/ Period 4
551.080853**	2.1821*	-478.49851**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	Period 2/ Period 3	Period 3/ Period 4
-9.807547**	7.9981**	-27.686526**

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	Period 2/ Period 3	Period 3/ Period 4
2.056289*	1.2733	1.147790

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 33: Latvia, Greece and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^* / \sigma_{c2}^*$
Period 1/ Period 2	0.0068916	1.005624	0.006853	-0.0242706	1.011841	-0.023986
	(0.001704)	(0.206041)	(0.000907)	(0.005055)	(0.204757)	(0.000959)
Period 2/ Period 3	-0.0242706	1.011841	-0.023986	-7.99E-06	0.0038821	-0.0021
	(0.005055)	(0.204757)	(0.000959)	(58.9937)	(0.0086)	(18.0011)
Period 3/ Period 4	-7.99E-06	0.0038821	-0.0021	0.0000107	0.0124017	8.6278E-4
	(58.9937)	(0.0086)	(18.0011)	(10.0944)	(0.0063)	(72.8518)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	Period 2/ Period 3	Period 3/ Period 4
-11.743593**	0.7163	-3.9005**

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	Period 2/ Period 3	Period 3/ Period 4
11.760293**	10.0157**	-0.7442

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^* / \sigma_{c2}^*$

Period 1/ Period 2	Period 2/ Period 3	Period 3/ Period 4
61.792914**	0.6218	16.6908**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 34: Iceland, Bulgaria and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	0.1348977	0.0232281	5.807521	0.1534613	0.021784	7.044679
	(0.117636)	(0.016647)	(0.866889)	(0.039171)	(0.016660)	(0.306357)
Period 2/ Period 3	0.1534613	0.021784	7.044679	1.51E-06	0.0222212	6.7952E-5
	(0.039171)	(0.016660)	(0.306357)	(1.9753)	(0.0076)	(23.3378)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	Period 2/ Period 3
2.861083**	-1.6751*

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	Period 2/ Period 3
10.059604**	12.9786**

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	Period 2/ Period 3
2.33855*	-1.6095

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 35: Iceland, Bulgaria and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.1337072	-0.0081521	-16.401565	0.1524159	0.0012072	126.25572
	(0.021882)	(0.013959)	(50.187636)	(0.021440)	(0.013879)	(1334.2185)
Period 2/ Period 3	0.1524159	0.0012072	126.25572	-5.37E-06	0.0045495	-0.0012
	(0.021440)	(0.013879)	(1334.2185)	(2.0306)	(0.0077)	(15.8479)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**
-22.421721**	2.2778*

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**
-20.630597**	-10.9629**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**
-3.443440**	3.3959**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 36: Romania, Lithuania and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ^*_1	σ^*_2	σ^*_1/σ^*_2
Period 1/ Period 2	0.6614737	0.3584320	1.864129	0.5070249	-7.14E-6	-7.10E4
	(0.007525)	(1.729040)	(1.732606)	(0.007735)	(2.233539)	(1533.5950)
Period 2/ Period 3	0.5070249	-7.14E-6	-7.10E4	0.058025	-6.84E-06	-8483.1871
	(0.007735)	(2.233539)	(1533.5950)	(0.0041)	(21.6211)	(306.0912)

T-Test on σ_1 and σ^*_1

Period 1/ Period 2	**Period 2/ Period 3**
140.279314**	87.7504**

T-Test on σ_2 and σ^*_2

Period 1/ Period 2	**Period 2/ Period 3**
-1.962211*	1.9646*

T-Test on σ_1 / σ_2 and σ^*_1/σ^*_2

Period 1/ Period 2	**Period 2/ Period 3**
4.547528**	-2.9821**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 37: Romania, Lithuania and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.0077968	0.5408644	0.014415	-0.025847	0.5777088	-0.044741
	(0.008046)	(0.382692)	(0.005829)	(0.019711)	(0.358477)	(0.006956)
Period 2/ Period 3	-0.025847	0.5777088	-0.044741	8.28E-06	0.0388989	2.1286E-4
	(0.019711)	(0.358477)	(0.006956)	(21.3445)	(0.0041)	(274.5958)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**
1.018478	1.0945

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**
0.863598	5.3817**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**
32.231541**	0.9673

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

First of all, it is clear that there are fewer breakpoints in all groups. There are 14 transmission periods altogether, 9 of which are detected as contagion (3 in each group). The total number of contagion increased a little in percentile, namely 64.3%. Indeed, there are 7 counter contagion effects and 7 changes in direction, with less transmission periods, and higher percentage of contagion. It seems that a different breakpoint test brings about many differences. However, if we look closer, there are actually some similarities.

In group 1, the ratios of idiosyncratic shock went up and down and up again in both procedure 1 and 3. The difference is that the first 2 up periods in procedure 1 were combined as 1 up period in procedure 3. The same thing happened in common shock as well, with the ratios all going up and then down in both procedures. Apparently, a new breakpoint test did not change the underlying contagion identification or transmission in group 1. However, after adjusting for heteroscedasticity, some major events could no longer cause breakpoints in this group, in this case, Germany's $68 billion plan to save the country's largest bank.

Group 2 had almost the same experience, except that the ratio of common shock went up again at the end, thus suggesting a big change in Iceland but a relatively much more trivial one in Bulgaria. It seems as though the effect of the rise in unemployment at the end of 2009 in Iceland is eases away when heteroscedasticity is accounted for.

Group 3 had nearly a completely opposite experience. Not only did the uptrend at the ending period in idiosyncratic shock disappear, the common shock also displayed a completely opposite result. It is worth mentioning that the ratio only represents a state of equilibrium. A very large ratio does not suggest a strong relationship. On the contrary, a very large ratio together with a very small ratio suggest that one country experienced a significant change while the other remained almost the same. Thus, based on the numbers we obtained, it is our contention that the overall economic environment of Europe and the stimulation package in Germany had more effect on Romania's idiosyncratic shock and Lithuania's common shock.

5.6.2.4 Procedure 4: Bai-Perron and ARFIMA Based Identification

We examined how different forecasting models perform with the Andrews-Ploberger test. The result reveals that short memory processes are more easily affected. We now plan to establish whether the Bai-Perron test changes anything or simply further confirms this result.

Table 38: Latvia, Greece and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	0.1846988	-0.0069832	-26.449020	-2.5E-7	0.0036324	-6.88E-5
	(0.000709)	(0.000861)	(0.194030)	(11.093263)	(0.000606)	(393.8667)
Period 2/ Period 3	-2.5E-7	0.0036324	-6.88E-5	0.0192963	-1.37E-08	-1.4085E6
	(11.093263)	(0.000606)	(393.8667)	(0.0063)	(5.7213)	(9445.3611)
Period 3/ Period 4	0.0192963	-1.37E-08	-1.4085E6	0.0264993	-8.64E-09	3.0671E6
	(0.0063)	(5.7213)	(9445.3611)	(0.0086)	(7.7306)	(9797.6588)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-0.647537	0.5604	-60.1851**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-13.793113**	0.1333	-0.1909

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-0.758126	6.2166**	4.0742**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 39: Latvia, Greece and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^* / \sigma_{c2}^*$
Period 1/ Period 2	0.1846863	-0.0165844	-2274.4285	9.34E-7	-0.0187755	-2.96E-5
	(0.0778339)	(0.000316)	(496.3095)	(0.001385)	(0.000363)	(121.9118)
Period 2/ Period 3	9.34E-7	-0.0187755	-2.96E-5	0.0192963	0.0013342	14.4628
	(0.001385)	(0.000363)	(121.9118)	(0.0063)	(0.0064)	(0.1286)
Period 3/ Period 4	0.0192963	0.0013342	14.4628	0.0264993	0.0118648	2.2334
	(0.0063)	(0.0064)	(0.1286)	(0.0086)	(0.0087)	(0.0186)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
107.953564**	-5.6118**	-60.1851**

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-42.267246**	-2.9505**	-39.2512**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^* / \sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
3.935044**	0.8423	9.4666**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 40: Iceland, Bulgaria and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.1348977	0.0232281	5.807521	0.1534613	0.021784	7.044679
	(0.117636)	(0.016647)	(0.866889)	(0.039171)	(0.016660)	(0.306357)
Period 2/ Period 3	0.1534613	0.021784	7.044679	-8.78E-07	0.0222213	-3.9512E-5
	(0.039171)	(0.016660)	(0.306357)	(15.8901)	(0.0045)	(12.0533)
			T-Test on σ_1 and σ_1^*			
	Period 1/ Period 2				**Period 2/ Period 3**	
	2.861083**				-0.1346	
			T-Test on σ_2 and σ_2^*			
	Period 1/ Period 2				**Period 2/ Period 3**	
	10.059604**				13.0324**	
			T-Test on σ_1 / σ_2 and σ_1^*/σ_2^*			
	Period 1/ Period 2				**Period 2/ Period 3**	
	2.33855*				-0.4304	

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 41: Iceland, Bulgaria and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^*/\sigma_{c2}^*$
Period 1/ Period 2	0.1337072	-0.0081521	-16.401565	0.1524159	0.0012072	126.25572
	(0.021882)	(0.013959)	(50.187636)	(0.021440)	(0.013879)	(1334.2185)
Period 2/ Period 3	0.1524159	0.0012072	126.25572	-5.39E-06	0.0045496	-0.0012
	(0.021440)	(0.013879)	(1334.2185)	(1.5249)	(0.0045)	(27.3644)
			T-Test on σ_{c1} and σ_{c1}^*			
	Period 1/ Period 2				**Period 2/ Period 3**	
	-22.421721**				1.9779*	
			T-Test on σ_{c2} and σ_{c2}^*			
	Period 1/ Period 2				**Period 2/ Period 3**	
	-20.630597**				-10.8989**	
			T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^*/\sigma_{c2}^*$			
	Period 1/ Period 2				**Period 2/ Period 3**	
	-3.443440**				3.4085**	

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 42: Romania, Lithuania and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.6614737	0.3584320	1.864129	0.5070249	-7.14E-6	-7.10E4
	(0.007525)	(1.729040)	(1.732606)	(0.007735)	(2.233539)	(1533.5950)
Period 2/ Period 3	0.5070249	-7.14E-6	-7.10E4	0.0580189	1.58E-06	3.6721E4
	(0.007735)	(2.233539)	(1533.5950)	(0.0039)	(4.9673)	(999.4411)
			T-Test on σ_1 and σ_1^*			
	Period 1/ Period 2				**Period 2/ Period 3**	
	140.279314**				87.8364**	
			T-Test on σ_2 and σ_2^*			
	Period 1/ Period 2				**Period 2/ Period 3**	
	-1.962211*				1.9626*	
			T-Test on σ_1 / σ_2 and σ_1^*/σ_2^*			
	Period 1/ Period 2				**Period 2/ Period 3**	
	4.547528**				-6.6803**	

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 43: Romania, Lithuania and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.0077968	0.5408644	0.014415	-0.025847	0.5777088	-0.044741
	(0.008046)	(0.382692)	(0.005829)	(0.019711)	(0.358477)	(0.006956)
Period 2/ Period 3	-0.025847	0.5777088	-0.044741	0.0000161	0.0389052	4.1383E-4
	(0.019711)	(0.358477)	(0.006956)	(20.6111)	(0.0039)	(71.7814)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**
1.018478	-1.8016*

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**
0.863598	5.3756**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**
32.231541**	-1.6028

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

The result is identical to the comparison of procedure1 and 2, with only short memory processes affected. The number of identified contagion, counter contagion effects and change in direction of long memory processes did not change at all. As discussed in Section 4.1, the autocorrelation of long memory process decays slower than that of the short memory process, and theoretically never reaches 0. In other words, a long memory process is more stable and predictable when compared to a short memory process. As a result, the combination of two long memory processes will have a more persistent relationship than the combination of two short memory processes. Indeed, this is why we tend to see more identified contagion in short memory processes. It is also why, when their short memory feature is not properly accounted for, they tend to generate very different results. The lack of persistency makes them more vulnerable to uncertainty. We now have the results of the most appropriate procedure, and we would like to look at each group separately before assessing their practical meanings.

It seems that common shock and idiosyncratic shock react in the same way in group 1 judging by the absolute value of the ratios (Table 38 to 39). They both initially decreased before then returning after the second shock. This suggests that the variance of Latvia (the numerator) drops first and then rises again; a notion which is confirmed by the estimated value of sigma. The reason for the drop in market variance is that Latvia agreed to slash its budget deficit in exchange for a €7.5 billion rescue loan. Apparently, this alleviated the market's anxiety. However, the depression across all of

Europe's economy slowly drove it up again in the next transmission period. Interestingly, the first event was identified as contagion in common shock and the second event was identified as contagion in idiosyncratic shock. It seems that although the reasons for pure contagion may have a certain influence over the local fundamental elements, it originated outside of the affected country. However, this does not mean that influence coming from outside of the country only has an effect on pure contagion. Indeed, it also affects the common shock. As suggested by the result of the third transmission period, when Germany's economy grew by 3.6%, both common shock and idiosyncratic shock are identified as contagion.

Just like in group 1, common shock and idiosyncratic shock in group 2 (Table 40 to 41) also share many similarities. First, their movement throughout the sample is almost identical, with the absolute values of both ratios increasing before returning to almost zero. Second, they both had a counter contagion effect in the second transmission period. Finally, the first transmission period was detected as contagion in both shocks. However, despite these similarities, they have two differences as well. The first difference is that common shock experienced a change in direction in the first transmission period while idiosyncratic shock did not. Recall that we allow sigma to have a negative value, thus meaning that the shocks may have a negative correlation. This suggests that the common shocks in Iceland and Bulgaria acted reversely. This is quite reasonable when considering that around October 2008 October, Iceland was given a $2.1 billion loan from IMF while Bulgaria had half of its aid permanently stripped away by the European Commission. Then came the second transmission period, where the variance of Iceland's shocks steadily approached zero after it obtained the rescue loan and the government stepped in to stabilise the financial system.

Common shock and idiosyncratic shock react almost identically in group 3 (Table 42 to 43) with the exception that idiosyncratic shock identified the second transmission period as contagion while common shock did not. It seems that the elections occurring in Lithuania did not affect the fundamental linkage between Romania and Lithuania as we expected. However, from another perspective, those elections did create a contagion effect in the idiosyncratic shock. Although they may not have a direct effect on the fundamentals, the implied influence is reflected in the pure contagion.

5.7 Conclusion

In this chapter, we have examined contagion under a more comprehensive definition. We used a different method to perform the contagion test. The process of 'Identification through Heteroscedasticity' was combined with different forecasting models, breakpoint tests and the iterative nonlinear least square method. By exogenously estimating the breakpoints before the contagion test, we improved the power of the tests compared to Gravelle, Kichian and Morley (2006). We introduced 4 procedures with which to examine the effect of short/long memory properties and heteroscedasticity. We concluded that short memory processes are more easily affected by different forecasting models while long memory processes seem to be immune to them. Since our definition was more comprehensive than those provided by previous studies, we were essentially testing for different things as well as examining the existing definitions. The contagion examined in most studies actually relates only to the change in interdependence (the common shock), while in our study, pure contagion is ignored. In this regard, we reached almost the same conclusion to those of previous studies, with many contagion effects detected. Only in our case, the movements were more active. As for the pure contagion, we observed that idiosyncratic shock is as volatile as common shock. Although not always identified as contagion at the same time, we normally expect a change in idiosyncratic shock in the same direction when the common shock has experienced a change. Meanwhile, we also concluded that coincidence is never the reason for significant co-movement because all data are statistically related. For the period under study, governments' macroeconomic regulations, such as cutting tax, slashing budget deficit and international capital assistance could easily cause breakpoints. On the other hand, governments' personnel adjustments and elections also showed some influence, but more with regard to idiosyncratic shock than common shock. We also illustrated the importance of breakpoints in the study of contagion. Our results suggest that contagion exists and that an appropriate length of time should be allocated to detect it. Indeed, there exist not only contagion effects but also counter-contagion effects. The counter-contagion period usually offset the previous contagion effect. However, on occasions it bent back so hard, that it eventually caused contagion in another direction. The breakpoint test in our study also helps us to track the transmission of contagion. Unlike most studies, we did not need to know where contagion originated from before the test, meanwhile, based on the results, we could see how contagion is transferred between countries.

Chapter 6 Contagion in Risk Premium - High Trade Links

6.1 Introduction

In this chapter, we employ the same framework for research targets with a different feature: higher trade links (top 6 among European countries). Trade links and financial linkages are highly correlated based on the equation of the balance of payments. They have both been proven to be the reason for contagion.

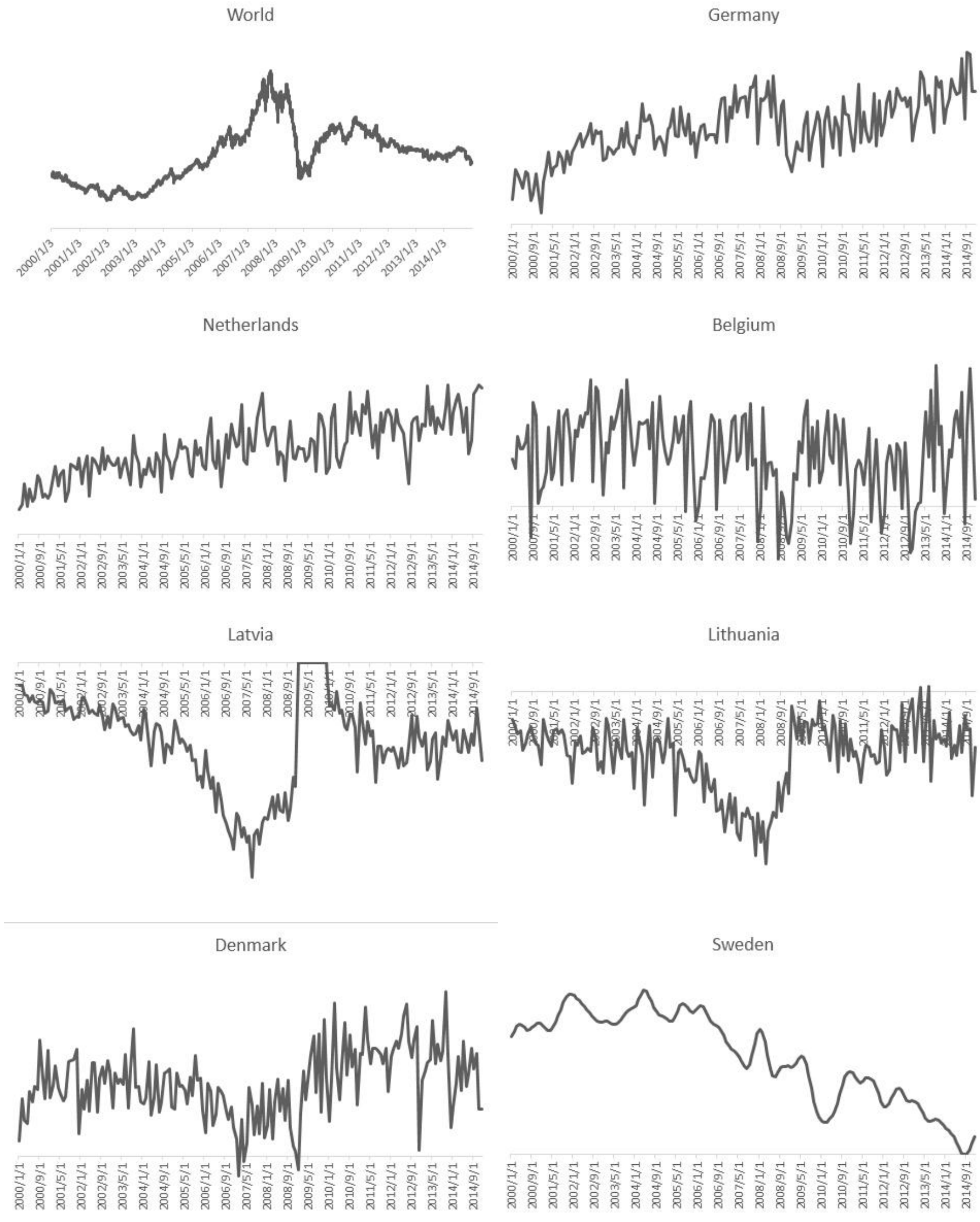
In the last chapter we illustrated that financial activities, such as cutting tax, slashing budgets and international capital assistance, would cause contagion. In this chapter, our attention falls on trade linkages. Rijckeghem and Weder (2001) use a binary variable based on newspaper reports about Mexico and Asia to test the importance of financial contagion relative to trade and bank lending. They concluded that trade linkages and country characteristics can help explain contagion.

Gravelle, Kichian and Morley (2006) have examined why the interdependence between assets in different Latin American countries often increased during the financial market crises between 1991 and 2001. They find that shocks are generally transmitted via long-term linkages between these countries; for instance, trade linkages. As a result, any attempts to reduce Latin American countries' vulnerability to contagion by employing short-term strategies may be ineffective.

Glick and Rose (1999) argue that countries who trade and compete with the targets of speculative attacks are more likely to be attacked. They point out that countries may be attacked because of the actions (or inaction) of their neighbours, who tend to be trading partners merely because of geographic proximity. Allen and Gale (1998) show that even a small liquidity preference shock in one region can spread by contagion throughout the economy. The possibility of contagion depends strongly on the completeness of the structure of interregional claims, with fluid international capital and trade as the main channels.

Indeed, the role of trade has grown significantly in the last two decades, especially since the establishment of the WTO in 1995. Figure 7 presents the international trade balance and the research targets of this chapter between 2000 and 2014.

Figure 7: International Trade Balance



(Source: Data are collected with DataStream in Newcastle University. World Trade from Thomson Reuters, Germany from Deutsche Bundesbank, Latvia from Bank of Latvia, Lithuania from Statistics Lithuania, Netherlands from Statistics Netherlands, Belgium from National Bank of Belgium, Denmark from Statistics Denmark, Sweden from Statistics Sweden.)

The world trade balance reached a peak around 2008 and then declined due to the financial crisis. For the countries with a trade surplus, there was an obvious decline in trade around 2008, just as with the world trade balance. For the countries with a trade deficit, the trade balance almost reached 0 during the crisis, which also indicates a very weak trade link. We observe a similar, yet not so obvious situation during the European debt crisis, with the exception of Germany and the Netherlands.

The above observation suggests that trade has a certain relationship with financial crisis. Since the relationship between trade and financial crisis is most significant during the 2008 crisis, we would like to choose this period as the focus for our research in this chapter.

In the last chapter, we chose countries with extremely low trade links in order to detect (successfully) pure contagion. However, we only did so when focusing on countries with low trade links. What would happen if we switched to those with higher links? Would it diminish our ability to identify contagion, especially pure contagion?

In this chapter, our attention falls upon the effect of trade. We would also like to establish whether there meaningful changes are identifiable when the same framework is employed on targets with higher trade links. Do the long memory, short memory and heteroscedasticity features still work in the same way? If differences are observed, what does trade bring?

The remainder of this chapter is organised as follows: Section 2 describes the data and how we process it; Sections 3-5 present and discuss the empirical findings; and Section 6 draws conclusions.

6.2 Data

The currency risk premium of the 7 countries we studied is also divided into 3 groups. Group 1 contains the Netherlands, Belgium and Germany; group 2 contains Latvia, Lithuania and Germany, and group 3 comprises Denmark, Sweden and Germany. As before, we arrange the groups based on their degrees of dependence on foreign trade. The similarity between this chapter and the last chapter is that they are still European countries and use Germany as a benchmark, while the dependence of the other two countries remains very high with Germany while Germany's dependence on each of them is very low. Moreover, judging by the plots, all countries involved still respond to shocks in a very similar way. However, the difference with the last chapter is that in this chapter each of the other two countries' degree of dependence on foreign trade are relatively higher with each other. The degrees of dependence on foreign trade of the selected countries and their GDP (by the percentage of Germany's GDP) are presented in Table 44:

Table 44: GDP% and DoD

Chapter 5	**Group 1**		**Group 2**		**Group 3**	
	Latvia	**Greece**	**Iceland**	**Bulgaria**	**Lithuania**	**Romania**
GDP%	0.91%	9.24%	1.40%	1.22%	1.25%	4.68%
DoD	0.001051	0.000075	0.000044	0.000052	0.001448	0.000355
Chapter 6	**Group 1**		**Group 2**		**Group 3**	
	Netherlands	**Belgium**	**Latvia**	**Lithuania**	**Denmark**	**Sweden**
GDP%	23.32%	13.81%	0.91%	1.25%	9.36%	13.99%
DoD	0.147642	0.250134	0.106474	0.070523	0.080634	0.055421

GDP%: Percentage of Germany's GDP; DOD: Degree of Dependence on Foreign Trade.

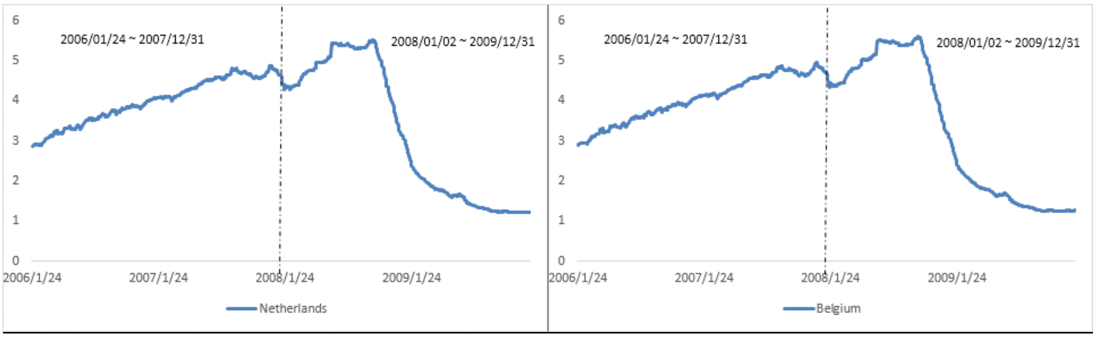
(Source: Data are collected with DataStream in Newcastle University. GDP are collected from Oxford Economics. Export and Import are collected from IMF - Direction of Trade Statistics.)

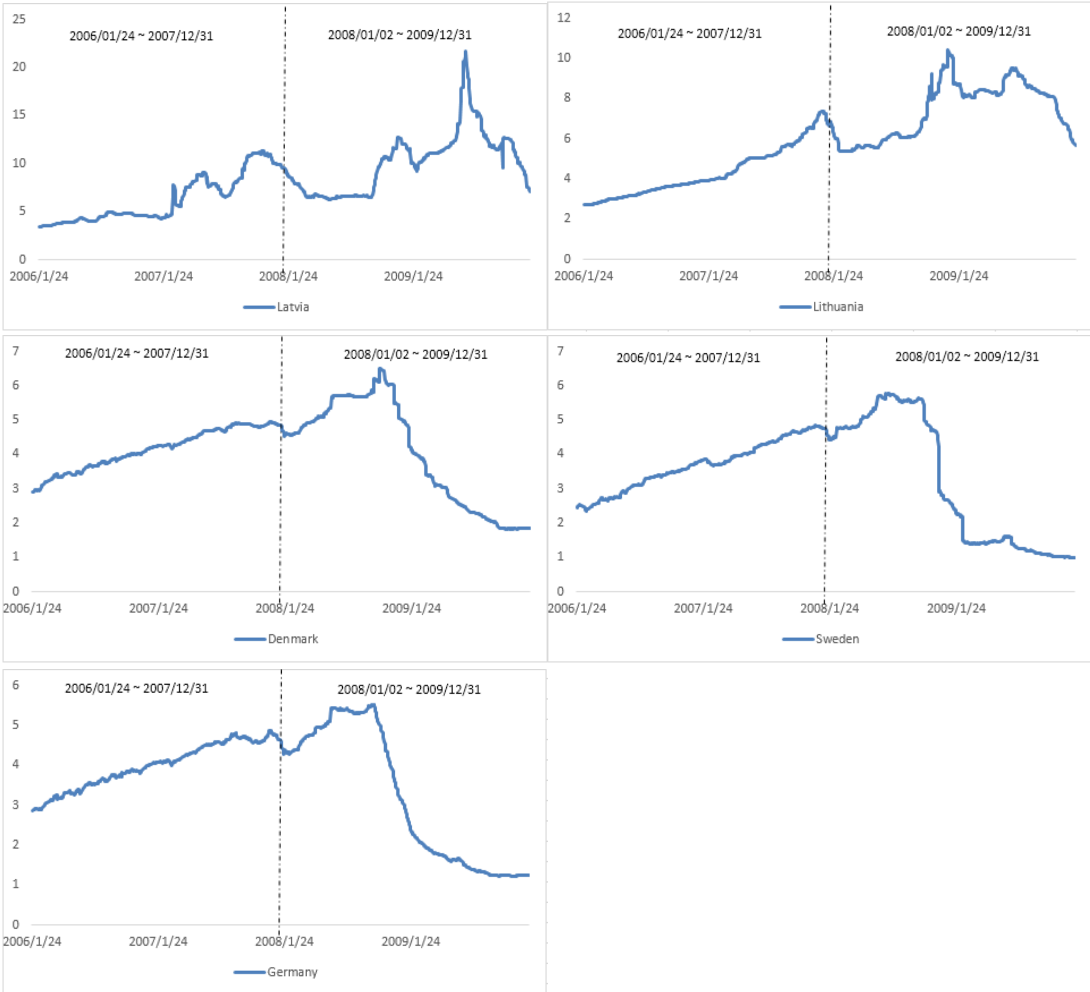
The focus of this chapter is on what trade can do in our framework. However, are there any other differences between the targets we chose? First of all, they all come from the same region, Europe. However, none of the groups in Chapter 5 are neighbours, while all groups in Chapter 6 are neighbours. Research studies (Glick and Rose, 1999) have pointed out that countries which are neighbours tend to have more frequent trading activities because of the geographical convenience. This conclusion is confirmed by our findings. Second, we can see that the countries included in Chapter 6 have relatively higher GDP with the exception of group 2. However, the increase in GDP is much less significant than the increase in the degree of dependence on each other. Although trade is not the only difference among them, it is our contention that the other differences are not sufficiently significant to conceal the effect of trade.

Since the effect of trade has been emphasised so often in previous studies, we wish to determine whether a higher trade link will bring about any differences when compared to our findings from the last chapter. Thus, in this chapter we choose countries with a high degree of dependence on foreign trade. Moreover, because the other two countries in each of the groups still have relatively lower GDP than Germany, we can assume that it is almost impossible for changes in one country to spread through Germany to the other. With this said however, they can still be affected by changes in Germany. However, the higher trade links many cause some transmission among themselves.

The time period examined spans from January 24, 2006 to December 31, 2009. We cannot choose the same data length as the last chapter due to data availability, although we try to use data which falls within the same time period. The simple is split into two periods: a stable period to build forecasting models and a turbulent period to observe and identify contagion. We process the data in the same as we did in the last chapter. Data from January 24, 2006 to December 31, 2007 is the stable period and used to build the forecasting model while data from January 02, 2008 to December 31, 2009 is the turbulent period and the target for contagion identification. Figure 8 presents the plots of the data in level:

Figure 8: Plots of the Data in Level





(Source: Data are collected with DataStream in Newcastle University. Germany from Thomson Reuters, Netherlands from Wallich & Matthes B.V., Belgium from National Bank of Belgium, Latvia from Bank of Latvia, Lithuania from Bank of Lithuania, Denmark from Danmarks Nationalbank, Sweden from Stockholm Chamber of Commerce.)

The plots are very similar to the last chapter in this time period and the situation is also very similar. All countries' interbank rates showed an upward trend until the crisis. Indeed, this trend changed from upward to downward after the middle of 2008. Judging from the plots, we expect the forecasting to have large errors, as suggested by the significant drop seen.

Table 45: Descriptive Statistics (January 14, 2006 to December 31, 2007)

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	ADF
Netherlands	2.57e-7	0.0051	-0.0205	53.0333	52674.27**	-14.69**[10]
Belgium	5.25e-5	0.0003	-0.3385	5.9991	198.9123**	-21.37**[2]
Latvia	0.0091	0.1502	2.4787	50.2938	47581.11**	-11.32**[8]
Lithuania	0.0053	0.0298	1.4837	10.0374	1227.356**	-10.48**[16]
Denmark	0.0002	0.0121	0.2425	8.9506	750.0395**	-26.05**[3]
Sweden	0.0008	0.0194	0.5217	7.4693	443.2121**	-21.35**[1]

****denotes significance at 1%. The number in [] are the best fitting lag terms for the ADF test.**

Table 45 summarises the statistics for the time period prior to January 2, 2008. The unit root tests (ADF, PP, and KPSS) reach a unique conclusion that all data are stationary. The Jarque-Bera test strongly rejects the hypothesis of normality in all cases, but we still assume normality. Although normality the hypothesis is strongly rejected, stationary data represents a strong support base from which to forecast the expected return. All data are proved to be stationary by all three unit root tests, with the exception of Lithuania. The SPSS test concludes that Lithuania has a unit root. However, since the other two tests agree that it is stationary, we view Lithuania's data as stationary despite the result of the SPSS test.

Table 46: Descriptive Statistics (January 02, 2008 to December 31, 2009)

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	ADF
Netherlands	-6.20e-5	0.0044	0.5683	7.1683	405.9951**	-15.61**[11]
Belgium	-9.31e-5	0.0003	2.9942	45.2003	39513.81**	-4.83**[16]
Latvia	0.0013	0.3044	2.6308	52.9793	54932.23**	-5.52**[12]
Lithuania	0.0036	0.1184	-2.5898	55.2986	60073.12**	-10.57**[15]
Denmark	0.0008	0.0474	-2.5322	64.0951	81742.15**	-22.89**[1]
Sweden	-0.0005	0.0682	-12.4116	204.0231	892325.9**	-20.29**[1]

****denotes significance at 1%. The number in [] are the best fitting lag terms for the ADF test.**

Table 46 summarises the statistics for the time period following January 2, 2008. The Jarque-Bera test still strongly rejects the hypothesis of normality in all cases and all data series are stationary. But again, we assume normality. All data are proved to be stationary by all the unit root tests.

6.3 ARMA and ARFIMA forecasting

Table 47 and Table 48 summarise the information related to the best-fitting lag specifications for ARMA (p, q) and ARFIMA (p, d, q) models.

Table 47: ARMA Models

	p_1	p_2	p_3	q_1	q_2	q_3
Netherlands	0.139			-0.939		
	(0.048)			(0.017)		
Belgium	0.844			-0.774		
	(0.111)			(0.132)		
Latvia			-0.341	0.265	0.123	0.519
			(0.114)	(0.041)	(0.041)	(0.098)
Lithuania	0.277		-0.607	-0.243		0.773
	(0.077)		(0.071)	(0.056)		(0.053)
Denmark	-0.148					
	(0.044)					
Sweden			-0.794			0.835
			(0.176)			(0.161)

The statistics inside the ( ) are Std.Error and all coefficients are significant at 1% level.

Table 48: ARFIMA Models

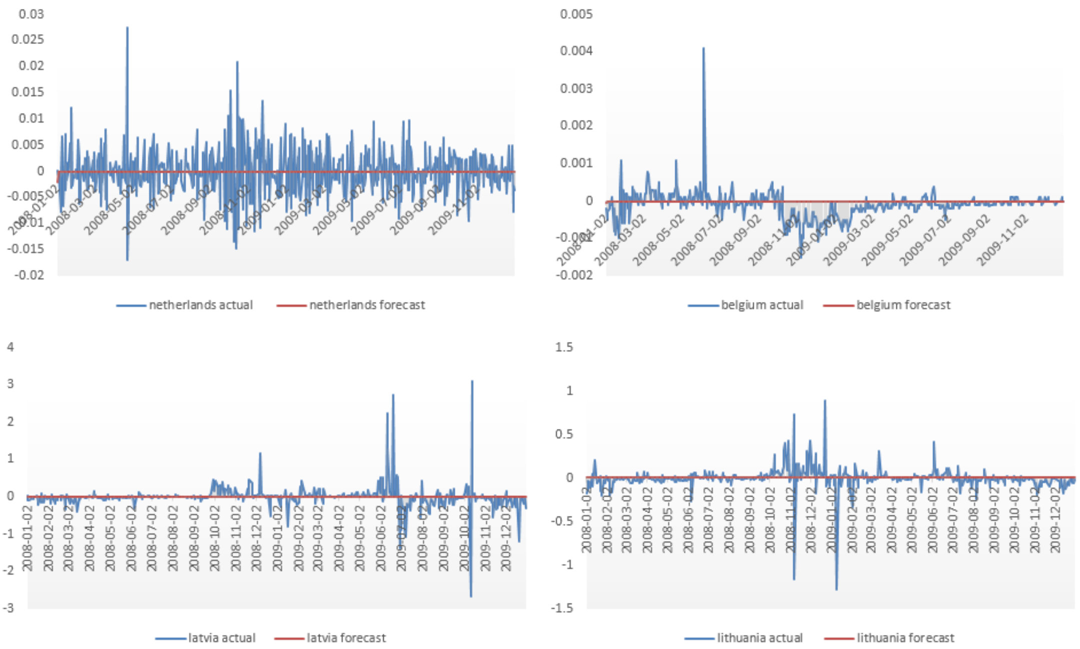
	p_1	p_2	p_3	q_1	q_2	q_3	d
Netherlands	0.137			-0.936			
	(0.051)			(0.023)			
Belgium	0.722			-0.417			-0.265
	(0.115)			(0.108)			(0.155)
Latvia			0.931	-0.065	-0.913		0.254
			(0.038)	(0.026)	(0.034)		(0.048)
Lithuania	-0.171						0.176
	(0.057)						(0.041)
Denmark	1.105		-0.175	-0.804			0.461
	(0.175)		(0.094)	(0.256)			(0.136)
Sweden			-0.919			0.946	0.045
			(0.081)			(0.067)	(0.036)

The statistics inside the ( ) are Std.Error and all coefficients are significant at 1% level.

We can see from table 48 that the two series in group 1, Netherlands and Belgium, possess short memory properties, while the other four series in group 2 and 3, Latvia, Lithuania, Denmark and Sweden, possess long memory properties. Hence, we expect the prediction of group 2 and 3 to be better than that of group 1 and shocks to have a more persistent effect on group 2 and 3 than group 1, which is again confirmed by breakpoint tests for having less structural changes.

Figure 9 and 10 provide the plots of the forecasted data while Table 49 and Table 50 report the calculated value for these criteria:

Figure 9: Forecasted Result of the ARMA Model



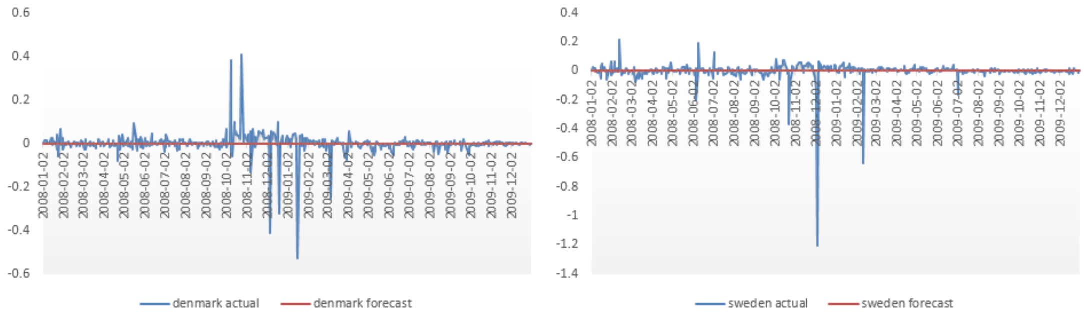
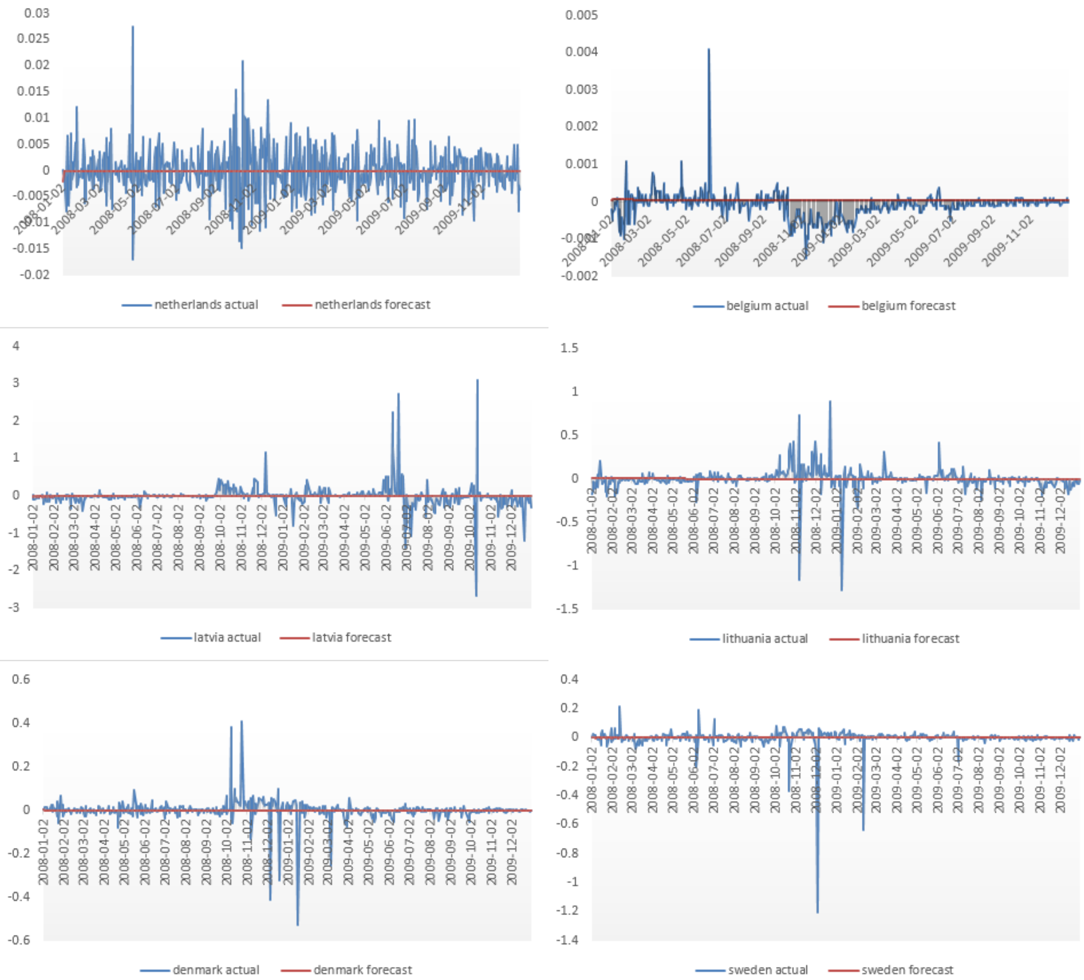


Figure 10: Forecasted Result of the ARFIMA Model



As we can see from the figures above, the forecasting is very bad for both models, just as we anticipated when we presented the plot for the data in level. Despite the higher trade links, the shock still gave rise to many changes.

Table 49: ME, MAE, MSE, MPE and MAPE for ARMA Model

	ME	MAE	MSE	MPE	MAPE
Netherlands	-5.73e-5	0.0031	1.97e-5	0.9951	0.9951
Belgium	-9.27e-5	0.0002	1.27e-7	0.7914	0.7959
Latvia	0.0012	0.1144	0.0925	0.9738	0.9738
Lithuania	-0.0053	0.0515	0.0141	0.7026	1.4954
Denmark	0.0008	0.0184	0.0022	0.9717	0.9717
Sweden	-0.0005	0.0206	0.0046	0.9611	0.9808

Table 50: ME, MAE, MSE, MPE and MAPE for ARFIMA Model

	ME	MAE	MSE	MPE	MAPE
Netherlands	-5.73e-5	0.0031	1.97e-5	0.9951	0.9951
Belgium	-0.0001	0.0002	1.41e-7	0.8625	0.8625
Latvia	-0.0014	0.1145	0.0924	0.9452	1.0376
Lithuania	0.0012	0.0504	0.0141	0.8981	0.9993
Denmark	0.0009	0.0184	0.0023	0.9697	0.9697
Sweden	-0.0006	0.0206	0.0046	0.9588	0.9744

The formal tests of accuracy confirmed what we observed in the plots again. The forecasts are still very bad. The value of ME, MAE and MSE remain too small for us to see how big the error is. However, the percentage error presented by the MPE and MAPE gives us a much clearer picture. Judging by the forecasting results, we see that the nature of countries' trade links is irrelevant. When shock occurs, it can bring the same changes to all kinds of countries.

6.4 Breakpoint tests

The plots of the breakpoints found by the Andrews-Ploberger test can be seen in Figure 11, while the summarised result is presented in Table 51. The Bai-Perron test is performed on each series individually. The plots of the breakpoints found are in Figure 12 while the summarised results of the Bai-Perron test are reported in Table 52 (please see Appendix 4 for detailed results).

Figure 11: Plots of the Breakpoints Found Based on Andrews-Ploberger Test

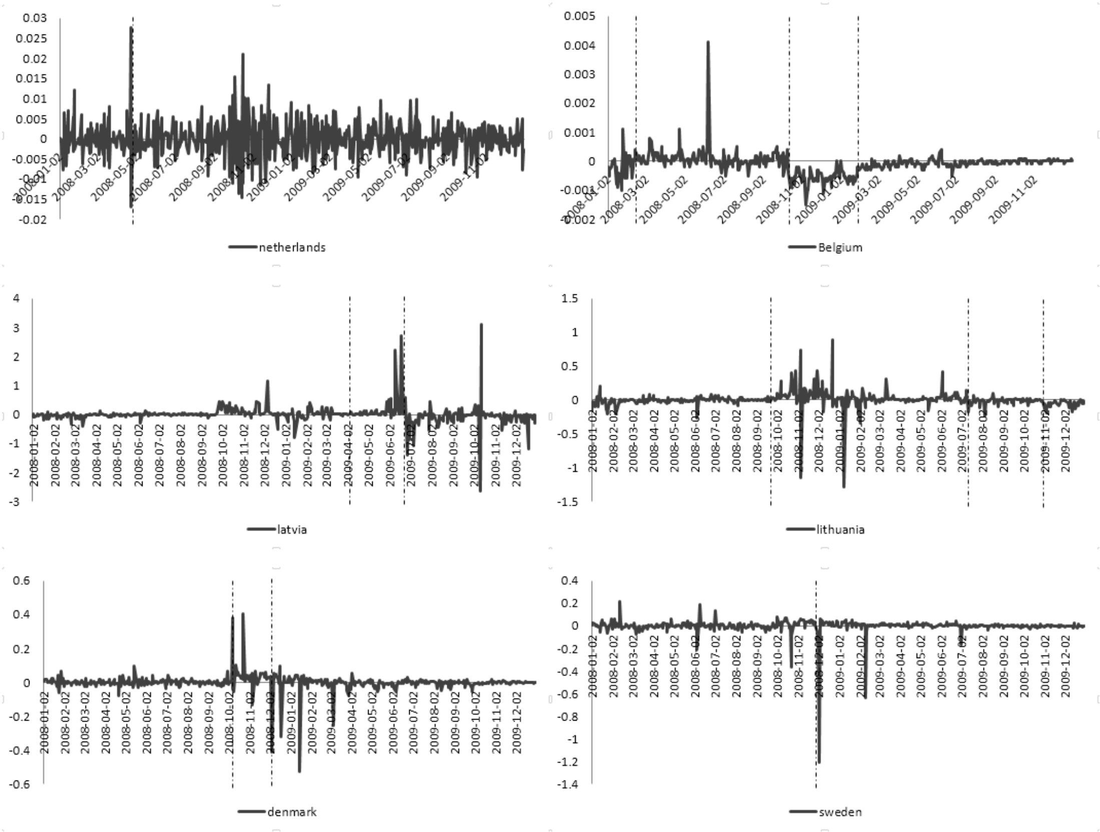


Table 51: Andrews-Ploberger Test Results

	Possible Breakpoint	P-value	AP Statistics	Is it a break at 5%? (1 yes, 0 no)
Netherlands	81 (2008/04/21)	1.0000	0.0711	0
Belgium	31 (2008/02/12)	0.0028	4.1206	1
	203 (2008/10/09)	0.0000	28.8501	1
	280 (2009/01/26)	0.0000	313.9001	1
Latvia	330 (2009/04/06)	8.44e-21	10.8210	1
	389 (2009/06/26)	8.95e-7	6.8382	1
Lithuania	191 (2008/09/23)	0.0021	4.2782	1
	399 (2009/07/10)	0.0042	3.8879	1
	480 (2009/11/02)	2.85e-9	7.9176	1
Denmark	201 (2008/10/07)	8.28e-7	16.1991	1
	243 (2008/12/04)	0.0181	2.8647	1
Sweden	239 (2008/11/28)	1.0000	0.0845	0

Figure 12: Plots of the Breakpoints Found Based on Bai-Perron Test

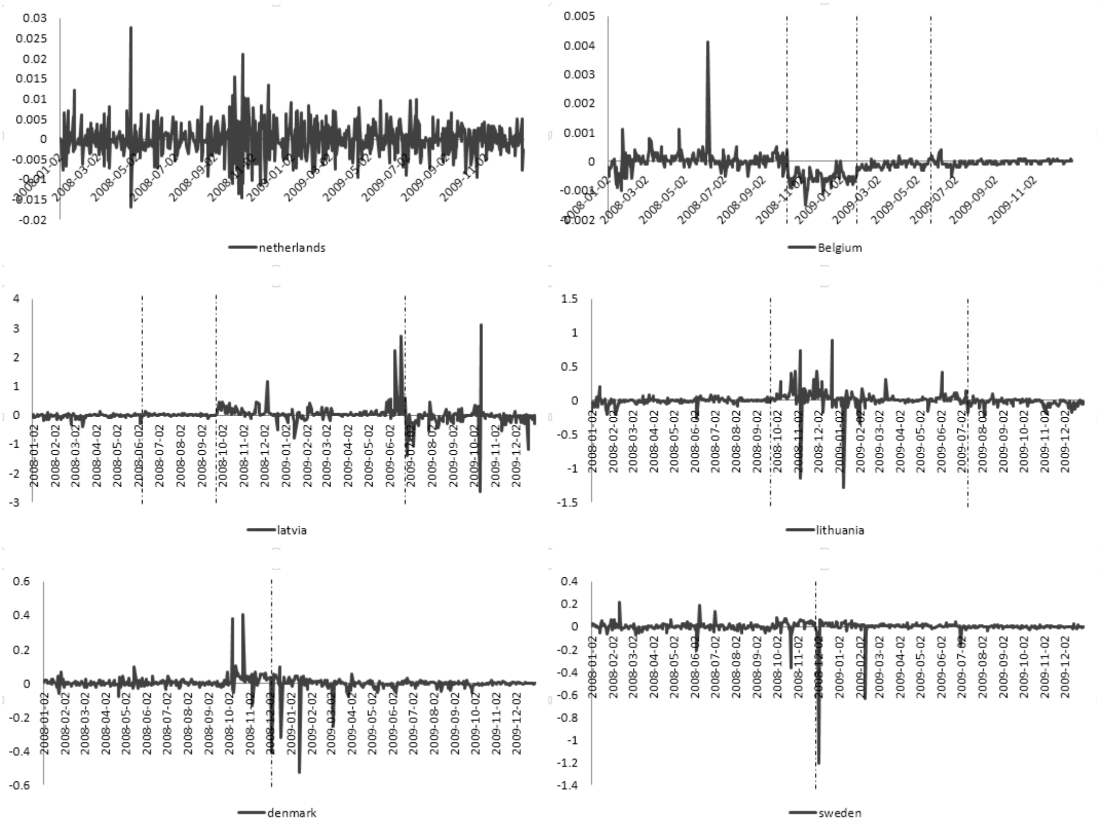


Table 52: Bai-Perron Test Results

	Possible Breakpoint	$\mathbf{SupF_T(n+1\mid n)}$	$\mathbf{UD}\max$	$\mathbf{WD}\max$
Netherlands	0	1.78 (n=1)	1.76	2.53
Belgium	202 (2008/10/08) 280 (2009/01/26) 360 (2009/05/18)	22.89* (n=2)	61.01*	85.12*
Latvia	113 (2008/06/05) 191 (2008/09/23) 388 (2009/06/25)	20.02* (n=2)	22.94*	22.94*
Lithuania	190 (2008/09/22) 398 (2009/07/09)	14.42* (n=1)	25.92*	25.92*
Denmark	242 (2008/12/03)	8.17 (n=1)	13.76*	13.76*
Sweden	238 (2008/11/27)	0.67 (n=1)	10.78*	15.52*

***: significant at 5% level**

To sum up, in group 1, the Andrews-Ploberger test reports 4 breakpoints (31, 81, 203, and 280) although one of these is not statistically significant (the Netherlands). The Bai-Perron test reports 3 breakpoints (202, 280, and 360), with 2 of them identical to the findings of the Andrews-Ploberger, and the one in the Netherlands ignored. Because of the different breakpoint found in Belgium, we conclude that the Andrews-Ploberger test neglected a change in variance. Since the breakpoint found in the Netherlands by the Andrews-Ploberger test is not significant, we do not consider it in the contagion test.

The first 2 breakpoints are exactly the same, thus suggesting a significant change in mean. In group 2, the Andrews-Ploberger test reports 5 possible breakpoints (191, 330, 389, 399 and 480), which are all significant. The Bai-Perron test reports 5 breakpoints (113, 190, 191, 388 and 398). The two tests detected 2 different breakpoints and 1 identical breakpoint in Latvia. In contrast, the Bai-Perron test reported one less breakpoint in Lithuania. This result means there are more changes in variance in Latvia and almost no change in mean in Lithuania. Indeed, because certain breakpoints detected are very close to each other (190 and 191, 388 and 398, 389 and 399), we consider them as 1 breakpoint. Thus, the Andrews-Ploberger test has 4 breakpoints and the Bai-Perron test has 3 breakpoints. In group 3, the Andrews-Ploberger test reports 3 breakpoints (201, 239, and 243) with 1 insignificant breakpoint. Bai-Perron tests reports 2 breakpoints (238, and 242). We obtained one similar breakpoint in both Denmark and Sweden, thus suggesting a change in variance first and then some changes in mean in Denmark, followed by a change in mean in Sweden. If we take all 6 countries as a group, the result from the Andrews-Ploberger test suggests that contagion came to this group on 2008/02/12 in Belgium and left on 2009/11/02 in Lithuania. In the same manner, the result from the Bai-Perron test suggests that contagion came to this group on 2008/06/05 in Latvia and left on 2009/07/09 in Lithuania.

Again, most of the breakpoints detected correspond to the important events in the countries. 4 breakpoints are detected by the two tests in group 1, and are all found in Belgium. The Netherlands is quite steady, and it seems as though nothing has caused any significant structural changes. The first breakpoint is found on 2008/02/12, with the reason relating to the transmission of minor power from main parties to regions in Belgium. A switching in power usually implies a switching in policies. And indeed, this may be when the contagion initiates in group 1. 2008/10/09 is the second breakpoint, and most likely results from the worsening global financial crisis. The third breakpoint is detected at the beginning of 2009, which corresponds to the appointment of Belgium’s new prime minister.

5 breakpoints are detected by the two tests in group 2. Many breakpoints were found around two events: the 2008 financial crisis and the countries’ approval of the European Union’s Lisbon treaty. The first breakpoint is found on 2008/06/05 by the Bai-Perron test, when Latvia approved the Lisbon Treaty. However, the crisis occurred at the same

time, thus meaning it is difficult to tell which one caused the contagion in this group. Judging by the results in group 1, both global economy event and country specific issue have impact on structural changes. Indeed, it could well be both. The other breakpoints are all detected when there are major banking or government issues, such as the lat currency supporting plan and the slash of the budget deficit. 2 breakpoints are found by the two tests in group 3, and all occurred around the time when Sweden became the 24th member to ratify the Lisbon Treaty. Compared to Chapter 5, we start to see a lower number of fundamental related events. Perhaps the higher trade links have made those countries more vulnerable to events that imply political changes.

6.5 Detecting contagion

The research procedures are identical to those employed in the last chapter, although they are applied to countries with more significant trade links. The Andrews-Ploberger test and ARMA model based procedure (procedure 1 henceforth), the Andrews-Ploberger test and ARFIMA model based procedure (procedure 2 henceforth), the Bai-Perron test and ARMA model based procedure (procedure 3 henceforth) and the Bai-Perron test and ARFIMA model based procedure (procedure 4 henceforth). Their roles are exactly the same as in the last chapter. Procedure 1 provides a base line, while procedures 2 and 3 examine the effect of long and short memory and heteroscedasticity separately, and procedure 4 considers both features.

6.5.1 Co-Integration and Granger Causality Tests

Tables 53 to 58 report the results of the co-integration test and the Granger causality test.

Table 53: The rank of integration and the best fitting lag terms for the VAR/VEC models based on Andrews-Ploberger Test

	Period 1		Period 2		Period 3		Period 4		Period 5	
	Rank	Lag	Rank	Lag	Rank	Lag	Rank	Lag	Rank	Lag
Netherlands	I (0) [1]	1 {-20.31}	I (0) [1]	5 {-21.18}	I (0) [1]	2 {-21.33}	I (0) [1]	6 {-24.29}		
Belgium	I (0) [1]		I (0) [1]		I (0) [1]		I (0) [1]			
Latvia	I (0) [3]	2 {-6.08}	I (0) [1]	1 {-0.93}	I (0) [1]	1 {-0.87}	I (0) [1]	1 {-2.24}	I (0) [1]	1 {-3.46}
Lithuania	I (0) [1]		I (0) [1]		I (0) [1]		I (0) [1]		I (1) [2]	
Denmark	I (0) [1]	2 {-7.85}	I (0) [1]	1 {-2.25}	I (0) [1]	1 {-6.90}				
Sweden	I (0) [1]		I (0) [1]		I (0) [1]					

The number in [] and {} are the best fitting lag terms for the ADF test and AIC criteria for the best fitting VAR/VEC respectively.

Table 54: Co-Integration Test Based on Andrews-Ploberger Test

	Period 1	Period 2	Period 3	Period 4	Period 5
Group 1	28.54**	145.47**	66.61**	168.22**	
Group 2	119.63**	94.72**	41.27**	93.61**	30.81**
Group 3	148.58**	26.69**	289.01**		

The statistics in this table are trace statistics. ** indicates significant at 1% level.

Table 55: Granger Causality Test Based on Andrews-Ploberger Test

	Group 1	Group 2	Group3
Period 1	Netherlands does not Granger Cause Belgium	Lithuania does Granger Cause Latvia	Sweden does not Granger Cause Denmark
	Belgium does not Granger Cause Netherlands	Latvia does not Granger Cause Lithuania	Denmark does not Granger Cause Sweden
Period 2	Netherlands does not Granger Cause Belgium	Lithuania does not Granger Cause Latvia	Sweden does Granger Cause Denmark
	Belgium does not Granger Cause Netherlands	Latvia does not Granger Cause Lithuania	Denmark does not Granger Cause Sweden
Period 3	Netherlands does not Granger Cause Belgium	Lithuania does not Granger Cause Latvia	Sweden does not Granger Cause Denmark
	Belgium does not Granger Cause Netherlands	Latvia does not Granger Cause Lithuania	Denmark does not Granger Cause Sweden
Period 4	Netherlands does Granger Cause Belgium	Lithuania does not Granger Cause Latvia	
	Belgium does not Granger Cause Netherlands	Latvia does not Granger Cause Lithuania	
Period 5		Lithuania does not Granger Cause Latvia	
		Latvia does not Granger Cause Lithuania	

Table 56: The rank of integration and the best fitting lag terms for the VAR/VEC models based on Bai-Perron Test

	Period 1		Period 2		Period 3		Period 4	
	Rank	Lag	Rank	Lag	Rank	Lag	Rank	Lag
Netherlands	I (0) [1]	7 {-21.05}	I (1) [1]	1 {-21.34}	I (0) [1]	1 {-24.16}	I (0) [1]	1 {-24.48}
Belgium	I (0) [1]		I (0) [1]		I (0) [1]		I (0) [1]	
Latvia	I (0) [1]	1 {-5.29}	I (1) [1]	1 {-8.40}	I (0) [4]	5 {0.02}	I (0) [1]	1 {-2.28}
Lithuania	I (0) [2]		I (0) [1]		I (0) [1]		I (0) [2]	
Denmark	I (0) [11]	5 {-5.54}	I (0) [1]	1 {-5.45}				
Sweden	I (0) [1]		I (0) [1]					

The number in [] and {} are the best fitting lag terms for the ADF test and AIC criteria for the best fitting VAR/VEC respectively.

Table 57: Co-Integration Test Based on Bai-Perron Test

	Period 1	Period 2	Period 3	Period 4
Group 1	151.99**	73.39**	69.43**	114.26**
Group 2	66.23**	111.19**	145.80**	121.45**
Group 3	98.60**	470.81**		

The statistics in this table are trace statistics. ** indicates significant at 1% level.

Table 58: Granger Causality Test Based on Bai-Perron Test

	Group 1	Group 2	Group3
Period 1	Netherlands does not Granger Cause Belgium	Lithuania does not Granger Cause Latvia	Sweden does Granger Cause Denmark
	Belgium does Granger Cause Netherlands	Latvia does not Granger Cause Lithuania	Denmark does not Granger Cause Sweder
Period 2	Netherlands does not Granger Cause Belgium	Lithuania does not Granger Cause Latvia	Sweden does Granger Cause Denmark
	Belgium does not Granger Cause Netherlands	Latvia does not Granger Cause Lithuania	Denmark does not Granger Cause Swedei
Period 3	Netherlands does not Granger Cause Belgium	Lithuania does not Granger Cause Latvia	
	Belgium does not Granger Cause Netherlands	Latvia does not Granger Cause Lithuania	
Period 4	Netherlands does Granger Cause Belgium	Lithuania does not Granger Cause Latvia	
	Belgium does not Granger Cause Netherlands	Latvia does not Granger Cause Lithuania	

The results in Table 54 and Table 57 show that the time series are all co-integrated at every sub-period, thus meaning there are statistically significant long-run connections between the series. As a result, there are no accidental jumps. If a significant co-movement is detected, coincidence is not the reason for it. The difference here compared to the last chapter is that we observe more causal relationships; 3 in the Andrews-Ploberger based causality test (1 in each group) and 4 in the Bai-Perron based causality test (2 in group 1, 2 in group 3). Recall how we argued that no causal relationship implies that the shock transfers through fundamentals from a mutual third party, in our case, Germany. Conversely, if causal relationships were detected, this might imply that besides originating from a mutual third party, shocks are likely to be transferred through fundamentals between the two countries studied. Evidently the increase in trade has made the transfer through fundamentals more possible, as there is one more transmission channel available. This makes us more curious as to whether the increase in trade will affect our ability to detect pure contagion.

6.5.2 The 4 Contagion Test Procedures

6.5.2.1 Procedure 1: Andrews-Ploberger and ARMA Based Identification

The estimated value of impact coefficients and the results of their hypothesis tests are as follow:

Table 59: Netherlands, Belgium and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	0.8165	0.0043	189.8837	-7.45E-6	0.0049	0.0015
	(0.5773)	(13.3351)	(0.3148)	(22.1391)	(11.8201)	(93.2984)
Period 2/ Period 3	-7.45E-6	0.0049	0.0015	2.44E-4	0.0044	0.0555
	(22.1391)	(11.8201)	(93.2984)	(0.0305)	(0.0304)	(0.0463)
Period 3/ Period 4	2.44E-4	0.0044	0.0555	-3.04E-9	0.0036	-8.44E-7
	(0.0305)	(0.0304)	(0.0463)	(6.9667)	(6.71E-6)	(0.0485)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
0.8680	1.2514	4.9081**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-48.3391**	27.0451**	10.2820**

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
1.0302	0.7101	0.0748

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 60: Netherlands, Belgium and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^* / \sigma_{c2}^*$
Period 1/ Period 2	0.8165	-2.72E-7	-3.0018E6	-3.90E-6	0.0043	-9.07E-4
	(0.5774)	(1.4142)	(53.9974)	(26.8779)	(19.0055)	(0.0134)
Period 2/ Period 3	-3.90E-6	0.0043	-9.07E-4	2.44E-4	2.96E-4	0.8243
	(26.8779)	(19.0055)	(0.0134)	(0.0305)	(0.0305)	(0.7473)
Period 3/ Period 4	2.44E-4	2.96E-4	0.8243	1.21E-5	0.0034	0.0036
	(0.0305)	(0.0305)	(0.7473)	(0.0142)	(0.4088)	(0.0435)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
366.7848**	24.4168**	5.0062**

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-79.5721**	7.6079**	-2.0317*

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^* / \sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-34.7228**	24.0351**	5.8765**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values,**

standard errors are reported in parentheses.

Table 61: Latvia, Lithuania and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	0.1722	1.38E-6	1.25E5	0.2071	0.1994	1.0386
	(0.7846)	(72.9439)	(94.1479)	(0.6662)	(0.0464)	(1.2119)
Period 2/ Period 3	0.2071	0.1994	1.0386	0.4817	-2.17E-6	-2.22E5
	(0.6662)	(0.0464)	(1.2119)	(0.0021)	(9.5734)	(471.7723)
Period 3/ Period 4	0.4817	-2.17E-6	-2.22E5	0.4806	-6.13E-7	-7.84E5
	(0.0021)	(9.5734)	(471.7723)	(0.0025)	(18.3686)	(1013.3811)
Period 4/ Period 5	0.4806	-6.13E-7	-7.84E5	3.49E-6	0.0485	7.19E-5
	(0.0025)	(18.3686)	(1013.3811)	(8.6457)	(1.7095)	(62.2356)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
5.9799**	8.2080**	165.9029**	1.2425

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
0.1712	1.0363	1.4427*	-1.7131*

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
6.9544**	6.6386**	-7.0934**	7.1961**

*denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.

Table 62: Latvia, Lithuania and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^* / \sigma_{c2}^*$
Period 1/ Period 2	0.0045	0.1236	0.0364	0.0272	0.2161	0.01258
	(0.0618)	(0.0174)	(0.4246)	(0.0612)	(0.0151)	(0.2528)
Period 2/ Period 3	0.0272	0.2161	0.01258	0.4358	-2.53E-7	-1.72E6
	(0.0612)	(0.0151)	(0.2528)	(0.0023)	(12.6309)	(1091.6067)
Period 3/ Period 4	0.4358	-2.53E-7	-1.72E6	0.4345	-4.51E-7	-9.63E5
	(0.0023)	(12.6309)	(1091.6067)	(0.0028)	(22.4519)	(6380.9712)
Period 4/ Period 5	0.4345	-4.51E-7	-9.63E5	-1.71E-6	0.0485	3.53E-5
	(0.0028)	(22.4519)	(6380.9712)	(3.0241)	(1.7095)	(21.7622)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-11.1268**	-6.4093**	129.7705**	0.0662

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-5.9716**	0.8432	-0.0706	-0.2161

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^* / \sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
22.4569**	2.2607*	-1.0981	-3.3168**

*denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.

Table 63: Denmark, Sweden and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	0.3239	7.83E-6	4.14E4	0.3343	0.1564	2.1375
	(0.3434)	(806.5552)	(1020.1812)	(0.3322)	(0.1135)	(0.8016)
Period 2/ Period 3	0.3343	0.1564	2.1375	0.0366	2.19E-6	1.67E4
	(0.3322)	(0.1135)	(0.8016)	(1.0104)	(14.7085)	(196.3013)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**
5.0725**	9.6924**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**
-6.1436**	-0.7204

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**

1.9041*	-13.8101**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 64: Denmark, Sweden and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^*/\sigma_{c2}^*$
Period 1/ Period 2	-0.0154	0.1581	-0.0974	-0.0241	0.2531	-0.0952
	(0.0264)	(0.1119)	(0.1935)	(0.0248)	(0.0704)	(0.1101)
Period 2/ Period 3	-0.0241	0.2531	-0.0952	-2.45E-6	-1.04E-6	2.3557
	(0.0248)	(0.0704)	(0.1101)	(0.2294)	(2.4870)	(5.9925)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**
22.0219**	-2.7090**

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**
18.3105**	1.5562

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^*/\sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**
22.4344**	1.5310

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Tables 59 to 64 summarise the estimated results of σ_{it}, σ_{cit} as well as the ratios. We cannot see that procedure 1 performed differently in this and the last chapter. There are 18 transmission periods in procedure 1, with both idiosyncratic shocks and common shocks included. 13 of them are significantly identified as contagion, equating to 72.2%. In Table 59, we detect no significant changes throughout the whole sample. The ratio continues to become smaller and smaller, thus suggesting a continuous contagion effect moving in the same direction and a weakened correlation. Moreover, no counter-contagion effect was detected here. The figures in Table 60 report a completely different situation. There are contagion effects throughout the sample. We observe one counter-contagion effect in this table, in period 2/period 3. All contagion effects in group 1 concentrate on common shocks; pure contagion is not a key player here. The absolute value of the ratio continues to go down in common shocks, with the same holding true for idiosyncratic shock, although on a smaller scale. Based on the chronology, we can see that the financial sector salvation plan of European governments in October 2008 still plays a role in this and serves as the reason for the counter contagion we detect in common shock.

Among all 3 groups, group 2 reports the most contagion. Like Table 60, Table 61 reports contagion throughout the whole sample but with one more transmission period. We again observe a counter-contagion effect in idiosyncratic shock, with the ratio becoming smaller (although bigger in the absolute value) in period 3/period 4 and going up in the following period. The direction of the change is altered once. Table 62 reports a slightly different situation, and this time only 3 contagion are detected out of 4 transmission periods. Although the ratios change from positive to negative, as long as the value continues to rise, we do not view it as a counter contagion effect. Thus, compared to idiosyncratic shock, common shock is less dynamic and active and has one less significant change.

There are fewer transmission periods in group 3, with Table 63 reporting 2 contagion out of 2 transmission periods. The direction of the ratio changes and the absolute value is bigger. Table 64 reports 1 significant change out of 2 transmission periods. The direction of the ratio does not change but the absolute value is much smaller, thus suggesting a much weaker interdependence level. Given that Denmark and Sweden's dependence on foreign trade with Germany is fairly high, Germany's recession in November 2008 must have hit them hard. Indeed, Sweden becoming the 24th member to ratify the EU's Lisbon Treaty has surely had a certain level of influence.

6.3.3.2 Procedure 2: Andrews-Ploberger and ARFIMA Based Identification

Given that we have nothing to show that procedure 1 performed differently in this and the last chapter, we will now establish whether procedure 2 reports differently in terms of long and short memory features.

Table 65: Netherlands, Belgium and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	4.03E-4	-3.17E-6	-127.1293	3.70E-4	0.0019	0.1947
	(3.24E-5)	(0.0139)	(34.5214)	(4.99E-5)	(1.37E-5)	(77.2966)
Period 2/ Period 3	3.70E-4	0.0019	0.1947	2.37E-4	0.0039	0.0607
	(4.99E-5)	(1.37E-5)	(77.2966)	(1.63E-4)	(9.78E-6)	(0.0237)
Period 3/ Period 4	2.37E-4	0.0039	0.0607	3.73E-4	-2.20E-9	-1.69E5
	(1.63E-4)	(9.78E-6)	(0.0237)	(0.0312)	(3.0819)	(367.7164)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
15.1512**	20.3659**	-27.0904**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-6.2906**	3.2519**	0.8557

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-4.4945**	-6.4844**	-1.1043

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 66: Netherlands, Belgium and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	5.18E-5	0.0043	0.0121	-5.76E-5	0.0047	-0.0123
	(8.68E-6)	(4.34E-6)	(0.0137)	(7.92E-6)	(3.96E-6)	(0.0138)
Period 2/ Period 3	-5.76E-5	0.0047	-0.0123	1.21E-5	0.0060	2.02E-3
	(7.92E-6)	(3.96E-6)	(0.0138)	(1.29E-5)	(0.0074)	(0.0284)
Period 3/ Period 4	1.21E-5	0.0060	2.02E-3	3.03E-4	-1.28E-9	-2.36E5
	(1.29E-5)	(0.0074)	(0.0284)	(0.0384)	(24.5012)	(38.2084)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
24.7253**	0.2497	-24.6104**

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-22.2971**	2.2078*	5.2473**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
18.3076**	-9.9072**	-13.3204**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 67: Latvia, Lithuania and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ^*_1	σ^*_2	σ^*_1/σ^*_2
Period 1/ Period 2	0.1906	-0.0884	-2.1561	0.2554	-0.1522	-1.6781
	(0.0029)	(0.5181)	(0.1227)	(0.0027)	(0.3942)	(0.1169)
Period 2/ Period 3	0.2554	-0.1522	-1.6781	0.4825	2.68E-6	1.80E5
	(0.0027)	(0.3942)	(0.1169)	(0.0769)	(20.3890)	(950.4964)
Period 3/ Period 4	0.4825	2.68E-6	1.80E5	0.2532	0.0455	5.5648
	(0.0769)	(20.3890)	(950.4964)	(0.0022)	(0.0120)	(0.1206)
Period 4/ Period 5	0.2532	0.0455	5.5648	0.2127	0.0165	12.8909
	(0.0022)	(0.0120)	(0.1206)	(0.0443)	(0.5684)	(0.2326)

T-Test on σ_1 and σ^*_1

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-57.4957**	54.4601**	50.9807**	46.1514**

T-Test on σ_2 and σ^*_2

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
5.0092**	-0.3511	-1.6797*	26.6817**

T-Test on σ_1 / σ_2 and σ^*_1/σ^*_2

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
11.2078**	-6.6787**	4.0203**	-12.2778**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 68: Latvia, Lithuania and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	-0.0074	-0.2644	0.0279	0.0047	0.3283	0.0143
	(0.0053)	(0.1138)	(0.0042)	(0.0024)	(0.0922)	(0.0045)
Period 2/ Period 3	0.0047	0.3283	0.0143	0.4093	3.98E-7	1.03E6
	(0.0024)	(0.0922)	(0.0045)	(0.0906)	(9.7842)	(551.0849)
Period 3/ Period 4	0.4093	3.98E-7	1.03E6	-0.0012	0.0455	-0.0264
	(0.0906)	(9.7842)	(551.0849)	(0.2192)	(0.0120)	(4.7858)
Period 4/ Period 5	-0.0012	0.0455	-0.0264	5.84E-7	0.0165	3.54E-5
	(0.2192)	(0.0120)	(4.7858)	(3.8677)	(0.5684)	(84.4552)

T-Test on σ_{c1} and σ^*_{c1}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-7.1909**	-19.9169**	2.5491**	-1.4087

T-Test on σ_{c2} and σ^*_{c2}

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**
-6.9986**	-3.3537**	-0.6052	26.6816**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**	**Period 4/ Period 5**

0.2093**	-3.2807**	3.9143**	-1.2649

*denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.

Table 69: Denmark, Sweden and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.1001	2.27E-6	4.09E4	0.1178	0.1924	0.6123
	(0.2349)	(36.2723)	(281.7692)	(0.2273)	(0.0838)	(0.4555)
Period 2/ Period 3	0.1178	0.1924	0.6123	0.0428	2.50E-6	1.71E4
	(0.2273)	(0.0838)	(0.4555)	(1.0104)	(6.4801)	(79.0754)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**
4.5512**	9.9895**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**
-10.0254**	-0.1786

T-Test on σ_1 / σ_2 and σ_1^*/σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**
2.4445**	0.1813

*denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.

Table 70: Denmark, Sweden and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^*/\sigma_{c2}^*$
Period 1/ Period 2	0.0068	0.0616	0.1104	-0.0095	0.2052	-0.0463
	(0.0242)	(0.2352)	(0.1336)	(0.0172)	(0.0636)	(0.0779)
Period 2/ Period 3	-0.0095	0.2052	-0.0463	-6.89E-6	1.77E-6	-3.8927
	(0.0172)	(0.0636)	(0.0779)	(0.0003)	(0.6028)	(67.7307)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**
1.0484	-7.3665**

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**
-1.6966*	2.7701**

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^*/\sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**
21.9208**	-26.2489**

*denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.

The contagion test performed here is still based on the AP test, although with the ARFIMA model instead used. Procedure 2 detects 2 more contagion effects than procedure 1, which is 15 in total, equating to 83.3%. In addition, 2 more contagion effects are detected in group 1's idiosyncratic shock where procedure 1 detects nothing. Which indicates that when the long memory and short memory feature is properly considered, the implied changes in policies and global crisis affects the idiosyncratic shock as well. Among all 3 groups, group 1 contains exclusively short memory processes while group 2 and group 3 contain only long memory processes. We reach the same conclusion as that reached in Chapter 5. The short memory processes are significantly affected while long memory processes behave almost exactly the same.

Although additional contagion are detected in group 1, the counter contagion effect disappears. Which suggests that the structural changes have more persistent effects on the short memory processes, and they do not tend to self-recover.

6.3.3.3 Procedure 3: Bai-Perron and ARMA Based Identification

Having established that the first 2 procedures react similarly to an increase in trade, we now move on to procedure 3 in order to establish if we have a similar result again.

Table 71: Netherlands, Belgium and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	2.46E-4	0.0045	0.0547	1.37E-9	0.0061	2.25E-7
	(0.0019)	(0.0333)	(97.7264)	(0.0026)	(0.0014)	(55.7901)
Period 2/ Period 3	1.37E-9	0.0061	2.25E-7	7.24E-4	-2.49E-9	-2.91E5
	(0.0026)	(0.0014)	(55.7901)	(0.0059)	(0.9141)	(887.3681)
Period 3/ Period 4	7.24E-4	-2.49E-9	-2.91E5	-2.01E-9	0.0032	-6.28E-7
	(0.0059)	(0.9141)	(887.3681)	(37.7241)	(8.02E-5)	(57.9568)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-1.6136	6.1245**	0.2558

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
8.6614**	0.9897	-0.4183

T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
6.1785**	1.0368	-1.2991

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 72: Netherlands, Belgium and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^* / \sigma_{c2}^*$
Period 1/ Period 2	-3.13E-4	8.46E-4	-0.3699	2.64E-5	0.0042	0.0063
	(0.0013)	(0.0019)	(0.0036)	(0.0013)	(0.0019)	(0.0013)
Period 2/ Period 3	2.64E-5	0.0042	0.0063	7.24E-4	-0.0012	-0.6033
	(0.0013)	(0.0019)	(0.0013)	(0.0059)	(0.0059)	(0.0352)
Period 3/ Period 4	7.24E-4	-0.0012	-0.6033	4.58E-7	0.0109	4.20E-5
	(0.0059)	(0.0059)	(0.0352)	(4.75E-5)	(0.0218)	(0.0213)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-39.5051**	-0.9807	13.3652**

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-38.9611**	6.5143**	-2.3223*

T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^* / \sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-15.5486**	14.2641**	-12.8783**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 73: Latvia, Lithuania and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1/σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.0561	-0.0462	-1.2143	1.08E-7	0.0114	9.47E-6
	(0.0165)	(0.0372)	(3.7134)	(0.4614)	(0.1503)	(17.7442)
Period 2/ Period 3	1.08E-7	0.0114	9.47E-6	0.3325	0.1747	1.9033
	(0.4614)	(0.1503)	(17.7442)	(0.0402)	(0.0496)	(0.0628)
Period 3/ Period 4	0.3325	0.1747	1.9033	0.2456	0.0466	5.2704
	(0.0402)	(0.0496)	(0.0628)	(0.0454)	(0.0564)	(0.2821)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-3.0444**	3.9222**	10.6339**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-12.6188**	3.2474**	8.0998**

T-Test on σ_1/σ_2 and σ_1^*/σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-7.6586**	-3.4168**	-5.0197**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 74: Latvia, Lithuania and Germany (Common Shock)

	σ_{c1}	σ_{c2}	σ_{c1}/σ_{c2}	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^*/\sigma_{c2}^*$
Period 1/ Period 2	0.0479	0.0264	1.8144	5.65E-7	-4.87E-7	-1.1602
	(0.0194)	(0.0487)	(0.0154)	(68.9228)	(67.5087)	(0.0861)
Period 2/ Period 3	5.65E-7	-4.87E-7	-1.1602	0.3325	-0.0119	24.9412
	(68.9228)	(67.5087)	(0.0861)	(0.0402)	(0.0613)	(5.6121)
Period 3/ Period 4	0.3325	-0.0119	24.9412	0.2456	-0.0010	-242.1374
	(0.0402)	(0.0613)	(5.6121)	(0.0454)	(0.0604)	(49.6962)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-2.1907*	-4.7321**	10.6339**

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-0.9952	8.1997**	-7.5802**

T-Test on σ_{c1}/σ_{c2} and $\sigma_{c1}^*/\sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
2.9441**	0.1971	-0.5788

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 75: Denmark, Sweden and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1/σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.0467	0.0128	4.09E4	0.0499	0.0726	0.6123
	(0.0033)	(0.1855)	(0.1091)	(0.0044)	(0.0043)	(0.0525)

T-Test on σ_1 and σ_1^*

-24.3338**

T-Test on σ_2 and σ_2^*

23.2606**

T-Test on σ_1/σ_2 and σ_1^*/σ_2^*

38.2081**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 76: Denmark, Sweden and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.0018 (0.0107)	0.0407 (.0054)	0.1104 (0.0052)	-0.0036 (0.0053)	0.0823 (0.0027)	-0.0463 (0.0025)
			T-Test on σ_{c1} and σ^*_{c1} 23.3847**			
			T-Test on σ_{c2} and σ^*_{c2} -23.7317**			
			T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$ 2.5811**			

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Again, just as in Chapter 5, procedure 3 reduces the number of transmission periods. While there are still 3 transmission periods in each shock in group 1, the numbers in group 2 and group 3 are each reduced by 1. 10 out of 14 transmission periods are identified as contagion, equating to 71.4%. Another obvious difference compared to procedure 1 is that we observe more changes in direction in all groups.

Table 71 shows that only the 1st transmission period is significantly identified as contagion. The value of the ratio lowers to unity in the next transmission period, and changes direction in the period after that. In the meantime, Table 72 reports a 100% contagion, with one counter contagion effect. Common shock prevails in group 1. The bank saving project in Germany and Belgium must have played a role in this, and could well have created significant changes in interdependence.

Table 73 and Table 74 report a reversed situation. Only one contagion is detected in common shocks while idiosyncratic shock reports a 100% contagion. We see one counter contagion effect in idiosyncratic shock and one change in direction in common shocks. In our opinion, this suggests a change in transmission channels. Moreover, we feel that the Lisbon Treaty is still the reason.

Table 75 and Table 76 suggest a one off contagion in group 3, which is most likely caused by the Lisbon Treaty as well. However, the results are still quite different to those obtained from the last two procedures. Based on the superiority of the BP test over the AP test, although a similar proportion of transmission periods are significantly detected as contagion, we think the details of the results based on the BP test are more trustable.

6.3.3.4 Procedure 8: Bai-Perron and ARFIMA Based Identification

Given what we find in the first 3 procedures, we see no reason to assume that procedure 4 will not be affected by an increase in trade either. Let us now see if the results confirm our hypothesis.

Table 77: Netherlands, Belgium and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1 / σ_2	σ_1^*	σ_2^*	σ_1^* / σ_2^*
Period 1/ Period 2	2.29E-5	0.0062	0.0037	-1.84E-4	0.0067	-0.0275
	(0.0004)	(0.1855)	(0.1092)	(0.0004)	(0.0276)	(0.0525)
Period 2/ Period 3	-1.84E-4	0.0067	-0.0275	-2.59E-9	0.0038	-6.82E-7
	(0.0004)	(0.0276)	(0.0525)	(2.8771)	(0.0088)	(68.1079)
Period 3/ Period 4	-2.59E-9	0.0038	-6.82E-7	-6.18E-10	0.0032	-1.93E-7
	(2.8771)	(0.0088)	(68.1079)	(0.5849)	(0.0046)	(9.8427)
			T-Test on σ_1 and σ_1^*			
Period 1/ Period 2			**Period 2/ Period 3**			**Period 3/ Period 4**
-24.3338**			1.3547			-1.3083
			T-Test on σ_2 and σ_2^*			
Period 1/ Period 2			**Period 2/ Period 3**			**Period 3/ Period 4**
23.2606**			5.9994**			45.8972**
			T-Test on σ_1 / σ_2 and σ_1^* / σ_2^*			
Period 1/ Period 2			**Period 2/ Period 3**			**Period 3/ Period 4**
38.2081**			1.3178			-1.3027

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 78: Netherlands, Belgium and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^* / \sigma_{c2}^*$
Period 1/ Period 2	0.0039	-3.89E-5	-100.2571	0.0039	2.17E-5	179.7235
	(0.0016)	(0.0507)	(0.0052)	(0.0011)	(0.0313)	(0.0025)
Period 2/ Period 3	0.0039	2.17E-5	179.7235	0.0013	0.0012	1.0833
	(0.0011)	(0.0313)	(0.0025)	(0.0088)	(0.0088)	(0.0021)
Period 3/ Period 4	0.0013	0.0012	1.0833	6.46E-4	5.92E-4	1.0912
	(0.0088)	(0.0088)	(0.0021)	(0.0046)	(0.0046)	(0.0041)
			T-Test on σ_{c1} and σ_{c1}^*			
Period 1/ Period 2			**Period 2/ Period 3**			**Period 3/ Period 4**
23.3847**			-3.6899**			31.4184**
			T-Test on σ_{c2} and σ_{c2}^*			
Period 1/ Period 2			**Period 2/ Period 3**			**Period 3/ Period 4**
-23.7317**			-3.6088**			30.2571**
			T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma_{c1}^* / \sigma_{c2}^*$			
Period 1/ Period 2			**Period 2/ Period 3**			**Period 3/ Period 4**
2.5811**			-89.9424**			-10.3631**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 79: Latvia, Lithuania and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1/σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.0176	0.0720	0.2444	2.87E-6	0.0577	4.97E-5
	(0.0801)	(0.0011)	(0.6813)	(17.2649)	(0.0011)	(50.3561)
Period 2/ Period 3	2.87E-6	0.0577	4.97E-5	0.3202	0.1747	1.8329
	(17.2649)	(0.0011)	(50.3561)	(0.0409)	(0.0496)	(0.0581)
Period 3/ Period 4	0.3202	0.1747	1.8329	0.2456	0.0467	5.2591
	(0.0409)	(0.0496)	(0.0581)	(0.0454)	(0.0564)	(0.2814)

T-Test on σ_1 and σ_1^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
8.7761**	-4.5931**	10.5724**

T-Test on σ_2 and σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
81.2612**	10.3225**	8.0996**

T-Test on σ_1/σ_2 and σ_1^*/σ_2^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
6.3612**	-9.7169**	-5.1271**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 80: Latvia, Lithuania and Germany (Common Shock)

	σ_{c1}	σ_{c2}	σ_{c1}/σ_{c2}	σ_{c1}^*	σ_{c2}^*	$\sigma_{c1}^*/\sigma_{c2}^*$
Period 1/ Period 2	0.1261	4.72E-4	267.1610	0.0901	0.0088	10.2386
	(0.0556)	(0.0009)	(2.0118)	(0.0578)	(0.0007)	(32.8591)
Period 2/ Period 3	0.0901	0.0088	10.2386	0.3326	0.0119	27.9495
	(0.0578)	(0.0007)	(32.8591)	(0.0402)	(0.0598)	(2.0346)
Period 3/ Period 4	0.3326	0.0119	27.9495	0.2616	-9.37E-4	-279.1889
	(0.0402)	(0.0598)	(2.0346)	(0.0444)	(0.0605)	(341.4351)

T-Test on σ_{c1} and σ_{c1}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
21.7592**	8.8959**	10.7130**

T-Test on σ_{c2} and σ_{c2}^*

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
21.6034**	0.5325	-0.3972

T-Test on σ_{c1}/σ_{c2} and $\sigma_{c1}^*/\sigma_{c2}^*$

Period 1/ Period 2	**Period 2/ Period 3**	**Period 3/ Period 4**
-9.7298**	2.1480*	2.6768**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 81: Denmark, Sweden and Germany (Idiosyncratic Shock)

	σ_1	σ_2	σ_1/σ_2	σ_1^*	σ_2^*	σ_1^*/σ_2^*
Period 1/ Period 2	0.0467	0.0128	4.09E4	0.0499	0.0726	0.6123
	(0.0033)	(0.1867)	(0.1092)	(0.0044)	(0.0043)	(0.0525)

T-Test on σ_1 and σ_1^*

-244.8592**

T-Test on σ_2 and σ_2^*

23.2325**

T-Test on σ_1/σ_2 and σ_1^*/σ_2^*

38.3959**

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 82: Denmark, Sweden and Germany (Common Shock)

	σ_{c1}	σ_{c2}	$\sigma_{c1} / \sigma_{c2}$	σ^*_{c1}	σ^*_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$
Period 1/ Period 2	0.0018 (0.0107)	0.0407 (.0054)	0.1104 (0.0061)	-0.0036 (0.0053)	0.0823 (0.0027)	-0.0463 (0.0016)
			T-Test on σ_{c1} and σ^*_{c1} 23.4863**			
			T-Test on σ_{c2} and σ^*_{c2} -23.8311**			
			T-Test on $\sigma_{c1} / \sigma_{c2}$ and $\sigma^*_{c1}/\sigma^*_{c2}$ 3.6591**			

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Procedure 4 reports a very similar result again, with the results of the short memory processes changing significantly. However, there are some slight changes in the long memory processes as well. We observe fewer changes in direction now. However, compared to the changes in the short memory process, they are still very stable. We wonder whether a stronger trade link is the reason for the reduced changes in direction. 12 among 14 transmission periods are identified as contagion (85.7%), which is the highest proportion. Higher trade links may represent more transmission channels and a higher probability of contagion.

Although the number of contagion effects detected in Table 77 and Table 78 are still the same, the counter contagion effects have completely changed. Both common and idiosyncratic shocks identified the bank saving action of French bank BNP Paribas as contagion, which is quite reasonable because this deal is significant enough to create one of the continent's biggest savings banks. 4 month later, a government personnel adjustment concerning the prime minister led to a contagion effect in common shock.

In group 2, Latvia and Lithuania's parliament approved the European Union's Lisbon Treaty, which of course caused the first contagion effect. Then came the financial crisis, and the second contagion effect. As for the third effect, we believe both Latvia's currency saving plan and Lithuania's presidential election were responsible for this. Group 3's only transmission period is identified as contagion, which in our opinion is the result of European's coordinated plans to shore up the financial sectors.

6.6 Conclusion:

This chapter employed the same framework as that used in the previous one. At the same time, we have switched targets here to countries with higher trade links (the top 6 amongst European countries). We first noticed the involvement of more events with indirect links with fundamentals. We therefore feel that stronger trade links might make countries more vulnerable to events which imply political changes. Moreover, stronger trade links open more transmission channels, and hence more causal relationships are identified.

However, all these differences seem trivial when identifying contagion being that we continue to obtain results similar to those of the last chapter under each procedure deployed. This indicates that, unlike that demonstrated in previous studies, trade doesn't help to explain much about contagion. On the contrary, country characteristics like adjustment of government personnel and changes in budget deficits continue to have an explanatory power.

Unlike previous research, less fundamental related events have been identified in our study. Therefore, our results do not support the idea that macroeconomic fundamentals have significant explanatory power in regard to the contagion effects during the financial crisis. Adjusting for heteroscedasticity will still cause a decrease in the number of transmission periods.

Moreover, although long memory processes are slightly more sensitive, we nevertheless conclude that long and short memory features matter and short memory processes are still very sensitive to the models used. This feature should be properly accounted for when quantifying shocks. Furthermore, the extra sensitivity of long memory processes might stem from the additional transmission channels which come with the higher trade links. This result is consist with the empirical work suggesting that shocks are generally transmitted via long-term linkages between infected countries. Last but not least, although the increase in trade brings about some observable differences in the causal relationship, it does not diminish our ability to identify contagion. On the contrary, because higher trade links leads to more indirect links with fundamentals, it enhances our power to identify pure contagion.

Chapter 7 Contagion in Market Returns

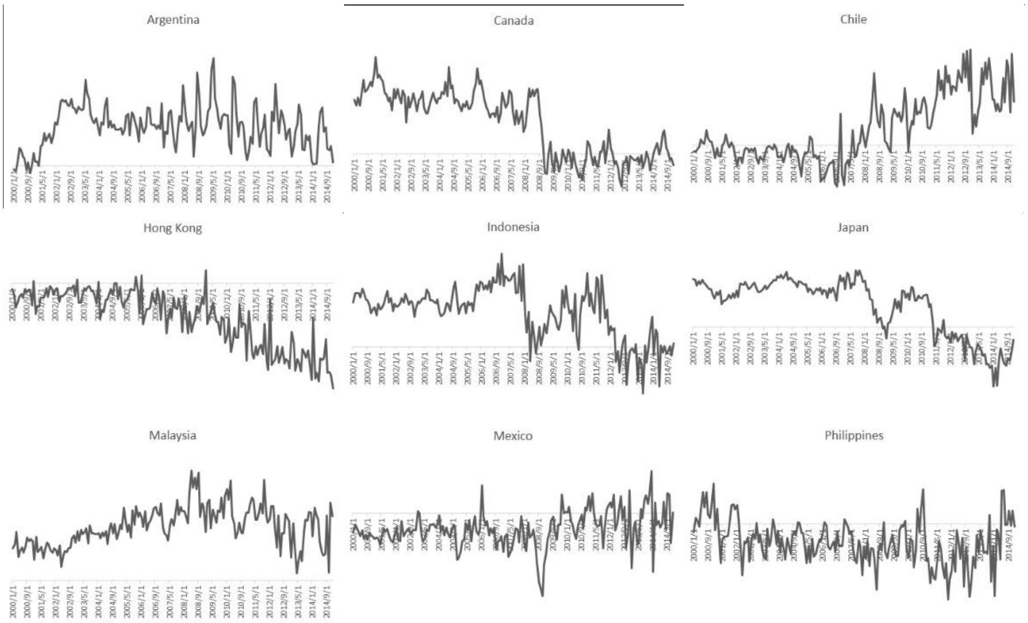
7.1 Introduction

In the last two chapters, we illustrated that the estimations of sigma are very sensitive to the long, short memory and heteroscedasticity features. As a result, these features should be properly accounted for when identifying contagion. We will split the shocks into two elements: the common shock and the idiosyncratic shock, thus distinguishing the pure contagion from the conventional definition of contagion which only focusses on the fundamental related transmission. We have also illustrated that, regardless of the kinds of trade links enjoyed by countries, the ability of our framework to identify contagion will not be diminished.

However, there are still a few issues which must be addressed. First, if our research targets are not exclusively European countries and come from another two continents, will the switch to the region examined bring any changes? Second, we may be able to see the reaction of common shock and idiosyncratic shock separately, but what about the overall effect? Third, when contagion is detected, how long will it last?

The importance of region has been highlighted by many empirical studies (see Gregorio and Valdés, 2001; Hernandez and Valdes, 2001; Kaminsky and Reinhart, 2000; Rigobon, 2002). However, nearly all of the conclusions suggest that the effects of a change in region mainly come with the trade linkages because neighbours tend to have higher trade volume. Figure 13 presents the trade balance of our nine research targets, from which we can see that, unlike the empirical work suggests (Glick and Rose, 1999), trade and region are not necessarily directly related. For instance, Canada and Indonesia have very similar patterns of trade balance, yet they are located on two different continents. The same goes for Canada and Indonesia. Argentina and Chile are neighbours, but they have reacted very differently to the European debt crisis.

Figure 13: International Trade Balance



(Source: Data are collected with DataStream in Newcastle University. Argentina from National Institute of Statistics and Censuses, Canada from Statistics Canada, Chile from U.S. Census Bureau, Hong Kong from Census and Statistics Department, Indonesia from Statistics Indonesia, Japan from Bank of Japan, Malaysia from MATRADE, Mexico from INEGI, Philippines from Philippines National Statistics Office.)

As we reviewed in Chapter 3, correlation methods are very convenient when it comes to examining overall effects. By employing various kinds of correlation techniques, Chiang, Jeon and Li (2007) found a large proportion of contagion amongst Asian countries during the Asian financial crisis. Meanwhile, Syllignakis and Kouretas (2011) demonstrate a statistically significant increase in the correlation between the US and the Germany stock market between 2007 and 2009. In addition, Missio and Watzka (2011) have illustrated how contagion spread from Greece to other European countries during the European debt crisis. However, no existing research is able to provide a comprehensive analysis to examine both the split effects and the overall effects.

In this chapter, we aim to answer the above questions by employing three contagion detecting methods in regard to nine economic entities from multiple regions and markets, those with different degrees of dependence on foreign trade. The rest of the study is organized as follow: section 2 describes the data; section 3 reviews the methodology; section 4 tests the overall correlation; section 5 analyses the split effect while trying to interpret the relationship between overall and split effects; section 6 examines the causal relationship and sheds light on how long the contagion effects last; section 7 provides a conclusion.

7.2Data

Instead of 1 market (interest rate market) from 1 region (European), we study 9 entities and 3 markets: the 9 entities are Argentina, Canada, Chile, Hong Kong, Indonesia, Japan, Malaysia, Mexico and Philippines, while the 3 markets are exchange rate market, interest rate market and stock market. A paired study is employed. Each area is paired with all the other 8 to test for possible contagion. We do not choose countries based on low or high degree of dependence. In fact, we use mixed degrees this time. The degrees of dependence between some countries are high and some are low. Moreover, based on our conclusion in the last chapter, we do not think this will lower the power of our test. The degrees of dependence on foreign trade of the selected countries are presented in Table 83:

Table 83: Degree of Dependence

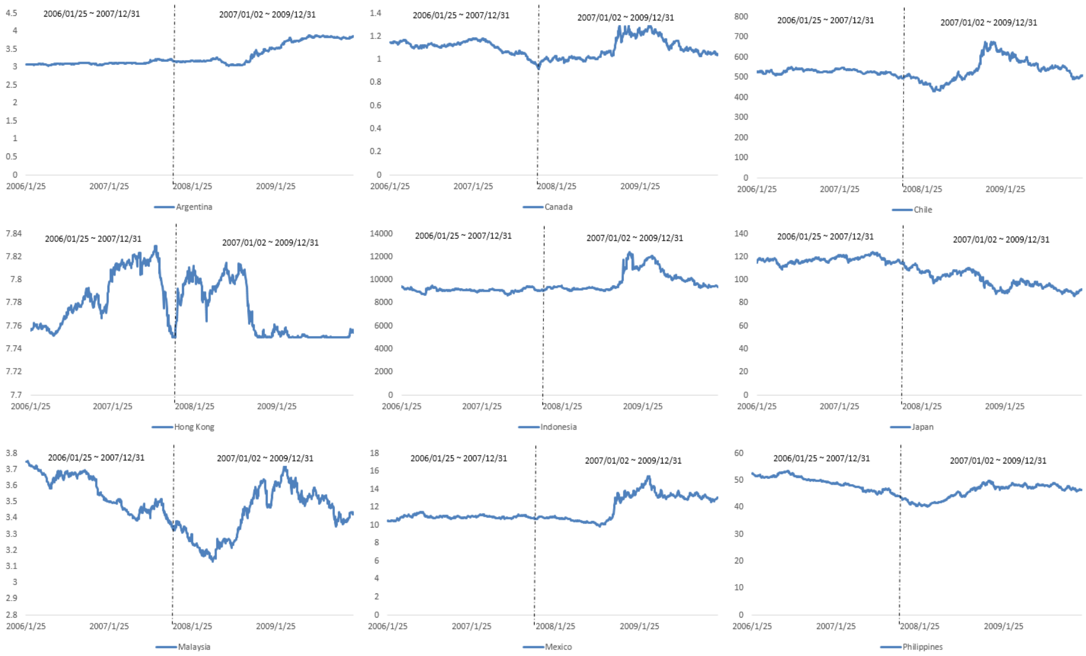
	Argentina	Canada	Chile	Hong Kong	Indonesia	Japan	Malaysia	Mexico	Philippines
Argentina	1	0.000622	0.029793	0.002814	0.001319	0.000267	0.003709	0.001802	0.001899
Canada	0.002488	1	0.009768	0.023723	0.004022	0.003263	0.008764	0.008982	0.005571
Chile	0.021089	0.001244	1	0.002828	0.000776	0.001591	0.001243	0.003038	0.001236
Hong Kong	0.001926	0.004583	0.003427	1	0.011239	0.009548	0.062731	0.00196	0.04537
Indonesia	0.001864	0.001181	0.001968	0.017195	1	0.005823	0.045558	0.000457	0.014638
Japan	0.004763	0.016064	0.044227	0.24372	0.094534	1	0.209127	0.01006	0.13992
Malaysia	0.002124	0.001216	0.001385	0.047176	0.020952	0.005966	1	0.001071	0.029819
Mexico	0.005881	0.006627	0.016941	0.00808	0.001167	0.001641	0.005753	1	0.001665
Philippines	0.001045	0.000633	0.001047	0.027218	0.005533	0.003246	0.024082	0.000239	1

(Source: Data are collected with DataStream in Newcastle University. GDP are collected from Oxford Economics. Export and Import are collected from IMF - Direction of Trade Statistics.)

The time period examined is identical to that explored in the last chapter, from January 25, 2006 to December 31, 2009. We also process the data in the same way. Data from January 25, 2006 to December 31, 2007 are used to build the forecasting model (if needed) while data from January 02, 2008 to December 31, 2009 are the target for contagion identification. We first have a look at the data plots:

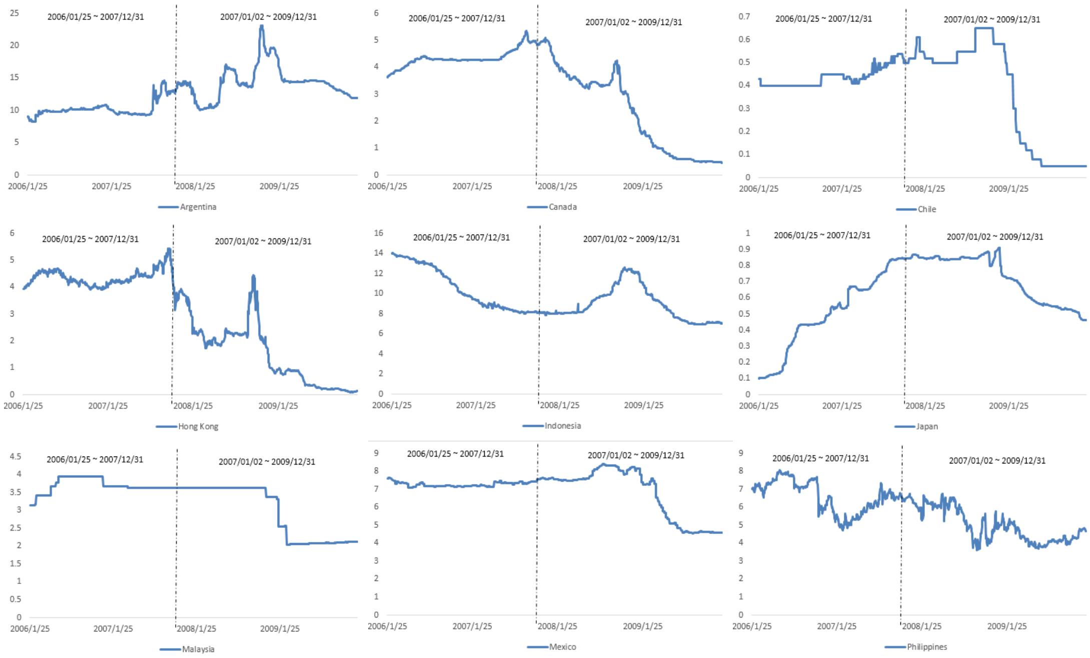
Figure 14: Plots of Data in Level

Exchange Rate Plots



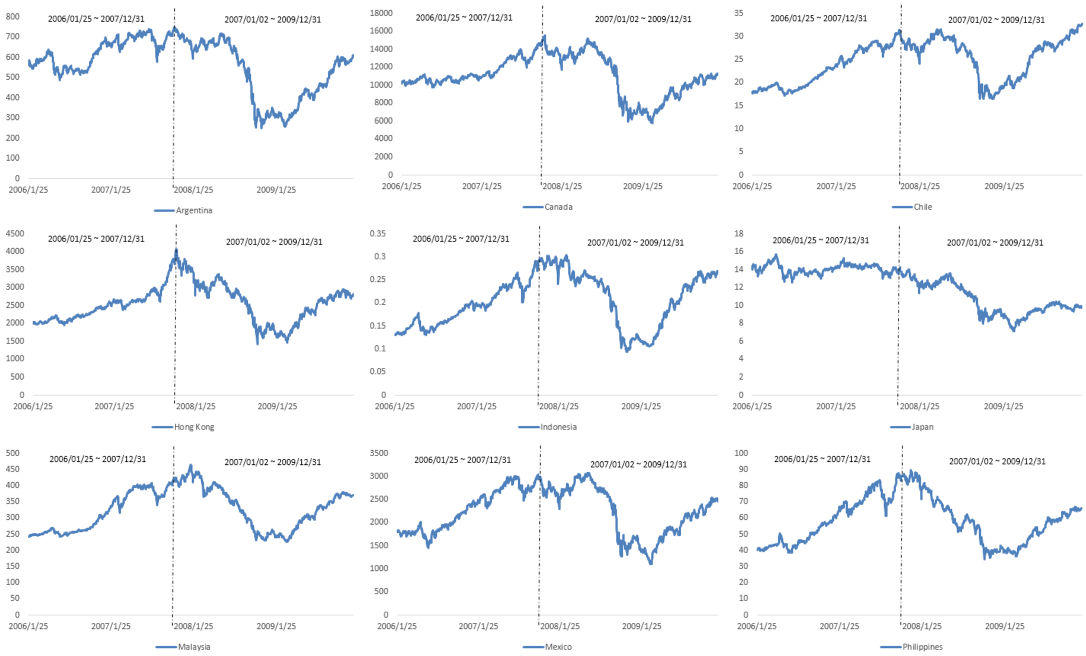
(Source: Data are collected with DataStream in Newcastle University. Argentina from Thomson Reuters, Canada from Bank of Canada, Chile from Central Bank of Chile, Hong Kong from WM/Reuters, Indonesia from Bank Indonesia, Japan from Bank of Japan, Malaysia from Central Bank of Malaysia, Mexico from BBV Probursa, Philippines from Business World Publishing Corporation.)

Interest Rate Plots



(Source: Data are collected with DataStream in Newcastle University. Argentina from Central Bank of Argentina, Canada from British Bankers' Association, Chile from ABN Tanner Corresdores, Hong Kong from Hong Kong Association of Banks, Indonesia from Thomson Reuters, Japan from Thomson Reuters, Malaysia from Maybank Group, Mexico from BBV Probursa, Philippines from Thomson Reuters.)

Stock Data Plots



(Source: Data are collected with DataStream in Newcastle University. Argentina from Buenos Aires Stock Exchange, Canada from S&P/TSX, Chile from Santiago Stock Exchange, Hong Kong from Hang Seng Bank, Indonesia from Jakarta Stock Exchange, Japan from Tokyo Stock Exchange, Malaysia from FTSE, Mexico from Mexican Stock Exchange, Philippines from Philippine Stock Exchange.)

We can see that among all 3 markets, the exchange rate market is the most stable. The interest rate market and stock market are much more volatile. Hong Kong and Malaysia are the exceptions when it comes to the exchange rate market, because they are more volatile than others. As unstable as the stock market seems, the trends of the data in the contagion detection period are very similar, namely a downward trend followed by an upward trend. The interest market mainly follows a downward trend in the contagion detection period, with the exception of Argentina and Indonesia. They first have an upward trend and then return to the original level.

We then describe the data in Table 84. We look at the mean, Standard Deviation, Skewness, Kurtosis, normality test, Augmented Dickey-Fuller (ADF)

Table 84: Descriptive Statistics

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	ADF
Exchange Rate						
Argentina	0.0013	0.0148	-0.2116	14.6134	2931.75**	-17.57**[1]
Canada	0.0001	0.0112	-0.4673	8.2007	606.11**	-21.67**[1]
Chile	0.0195	5.3667	0.5007	7.7113	503.62**	-20.34**[1]
Hong Kong	-0.0001	0.0022	-1.6924	20.7497	7087.93**	-23.55**[1]

Indonesia	0.0576	134.0005	2.3687	59.6875	70246.35**	-21.24**[1]
Japan	-0.0403	0.9183	-0.3753	4.5668	65.52**	-24.05**[1]
Malaysia	0.0002	0.0145	-0.0764	4.0886	26.23**	-22.57**[1]
Mexico	0.0042	0.1310	0.4635	10.1354	1126.41**	-22.33**[1]
Philippines	0.0095	0.1949	-0.1302	3.5105	7.12*	-20.68**[1]
Interest Rate						
Argentina	-0.0038	0.2291	0.3758	18.0808	4949.42**	-17.57**[2]
Canada	-0.0077	0.0421	-1.7302	17.4728	4870.11**	-21.67**[1]
Chile	-0.0009	0.0105	-5.3756	105.4582	230396**	-20.34**[1]
Hong Kong	-0.0061	0.0814	1.6193	36.7541	24960.54**	-23.55**[2]
Indonesia	-0.0018	0.0877	-1.2807	36.0522	24507.78**	-21.24**[1]
Japan	-0.0008	0.0064	-10.6345	154.1086	505504.1**	-24.05**[1]
Malaysia	-0.0029	0.0424	-15.2447	247.5133	1318051**	-22.57**[1]
Mexico	-0.0058	0.0572	-5.9245	66.1471	89610.79**	-22.33**[4]
Philippines	-0.0026	0.1561	-0.6655	22.7739	8526.61*	-20.68**[1]
Stock						
Argentina	-0.1411	10.9319	-0.5428	6.0285	224.68**	-22.86**[1]
Canada	-5.3422	233.7901	-0.4335	5.0517	107.69**	-21.76**[1]
Chile	0.0095	0.4059	-0.4037	7.1631	390.22**	-21.07**[1]
Hong Kong	-1.3582	60.3125	0.1054	5.7067	160.03**	-24.78**[1]
Indonesia	-4.03E-5	0.0045	-0.5986	6.9335	366.99**	-20.12**[1]
Japan	-0.0071	0.2009	-0.0515	5.1231	98.08**	-27.01**[1]
Malaysia	-0.1189	4.3818	-1.8048	20.2115	6713.63**	-21.39**[0]
Mexico	-0.3331	48.2513	-0.1161	6.0618	204.68**	-20.51**[0]
Philippines	-0.0417	1.0161	-0.7123	6.1324	257.05*	-19.48**[1]

****denotes significance at 1%. *denotes significance at 5%. The number in [] are the best fitting lag terms for the ADF test.**

The ADF test reach a conclusion that all data are stationary. The Jarque-Bera test strongly rejects the hypothesis of normality in all cases, although we assume normality. The means are all very close to zero with the exception of Canada and Hong Kong in the stock market. The volatility of the exchange rate market and the interest rate market are relatively low compared to the stock market, with the exception of Chile and Indonesia.

7.3 A Retrospect of Methodology

We would like to employ a 3-tier analysis to address two questions: First, can we detect any contagion in the overall co-movement, and if we do, what role do common shock and idiosyncratic shock play in it? Second, if contagion were identified, how long does the effect last? The three tiers are: tier 1: Correlation tests, tier 2: Identification through

Heteroscedasticity and tier 3: Causality tests and Impulse response analysis. Tiers 1 and 2 will help us to answer the first question and tier 3 will help us to answer the second question.

7.3.1 Correlation Test

We start with the correlation test to establish if we can identify contagion in the overall movement in order to address the first half of the first question. We employ Forbes and Rigobon's (2002) method of conditional and unconditional correlations (see Section 3.4 for details) although we employ a more appropriate method to detect structural breaks. Instead of branding the date of an event as a breakpoint, we combine the Bai-Perron test and chronology to identify the timing of structural changes. Thus, our results will hold practical meaning as well as statistical significance.

7.3.2 Identification through Heteroscedasticity

In order to address the second half of the first question, we employ our 'Identification through Heteroscedasticity' process. As we have illustrated the effect of long and short memory and heteroscedasticity in the previous chapters, here we will only use our most appropriate procedure, namely the 4th procedure: ARFIMA and Bai-Perron test based procedure. By comparing the contagion effects identified in the overall movement and the split elements, we can trace the role played by common shock and idiosyncratic shock.

7.3.3 Causality Test and Impulse Response Analysis

Tier 3 is used not only to answer the second question but also to reveal the statistical linkages among the countries. If the co-integration or the causal relationship changes between transmission periods, it could serve as a further confirmation of contagion.

7.4 Correlation Test

We will answer the first question and test the overall movement using an adjusted correlation technique proposed by Forbes and Rigobon (2002) (see chapter 3 for more detailed methodology). The dependent variable in their study was stock market returns. Interest rate was also considered in order to control for any aggregate shocks and monetary policy coordination. In our study, we add the exchange rate market in addition to the stock returns and interest rate. Before the correlation test, we must first detect the structural breaks. Unlike Forbes and Rigobon (2002), the structural changes in our study are identified by breakpoint test rather than assigning it based on economic information. Their conclusion: no contagion, only interdependence, was disproved by many other literatures (see Caporale, Serguieva and Wu, 2008; Kleimeier, Lehnert and Verschoor, 2008). The Bai-Perron test is employed to achieve this purpose.

7.4.1 Breakpoint Test

The breakpoints found by Bai-Perron test are summarised in table 85.

Table 85: Bai-Perron Test Results of Exchange Rate

	Possible Breakpoint	$\mathbf{SupF_T(n+1 \mid n)}$	**UD**max	**WD**max
Exchange Rate				
Argentina	173 (2008/09/01)	7.14 (n=1)	4.69	5.76
Canada	214 (2008/10/28)	4.28 (n=1)	5.04	5.04
Chile	214 (2008/10/28)	9.29* (n=1)	6.77	8.04
Hongkong	218 (2008/11/03)	2.51 (n=1)	2.23	3.27
Indonesia	233 (2008/11/24)	4.59 (n=1)	6.95	6.95
Japan	251 (2008/12/18)	3.12 (n=1)	2.47	4.77
Malaysia	214 (2008/10/28)	8.01 (n=1)	5.77	6.85
Mexico	308 (2009/03/09)	7.12 (n=1)	4.87	4.87
Philippines	232 (2008/11/21)	3.46 (n=1)	7.21	7.21
Interest Rate				
Argentina	82 (2008/04/25) 225 (2008/11/12)	8.69* (n=1)	8.09	13.91*
Canada	198 (2008/10/03) 276 (2009/01/22)	12.38* (n=1)	8.34	17.74*
Chile	229 (2008/11/18)	NA	NA	NA
Hongkong	202 (2008/10/10)	5.45 (n=1)	2.94	5.11
Indonesia	218 (2008/11/03) 372 (2009/06/05)	12.68* (n=1)	33.98*	33.98*
Japan	248 (2008/12/15)	3.96 (n=1)	10.41*	11.26*
Malaysia	298 (2009/02/23)	NA	NA	NA
Mexico	253 (2008/12/22)	7.19 (n=1)	11.69*	11.69*
Philippines	189 (2008/09/23)	2.01 (n=1)	2.62	4.57
Stock				
Argentina	213 (2008/10/27)	7.55* (n=1)	9.78*	9.78
Canada	232 (2008/11/21)	4.82	5.47	5.47

		(n=1)		
Chile	242 (2008/12/05)	4.02 (n=1)	7.25	7.25
Hongkong	213 (2008/10/27)	2.31 (n=1)	7.55	7.55
Indonesia	232 (2008/11/21)	3.47 (n=1)	9.98*	9.98*
Japan	309 (2009/03/10)	5.49 (n=1)	5.84	6.31
Malaysia	215 (2008/10/29)	2.91 (n=1)	10.32*	12.12*
Mexico	308 (2009/03/09)	5.15 (n=1)	6.47	6.47
Philippines	213 (2008/10/27)	1.15 (n=1)	9.91*	9.91*
***: significant at 5% level**				

More breakpoints are found in the interest rate market; only 1 breakpoint is found in each economic entity in the exchange rate market and stock market. In the exchange rate market, we find no significant breakpoints. Most of the breakpoints found in the interest rate market are significant with the exceptions of Chile, Malaysia and Philippines. Close to half of the breakpoints in the stock market are significant, including Argentina, Indonesia, Malaysia and Philippines.

Most of the breakpoints found are in October and November 2008, a period which corresponds to the 2008 subprime crisis. We also observe some other interesting facts in each entity. For instance, Argentina’s lower house of parliament approved the government’s controversial plan to nationalise pension funds. Hong Kong’s pro-democracy camp won more than a third of seats in legislative elections, retaining a key veto over future bills in September 2008. Japan’s Prime Minister Yasuo Fukuda resigned in September 2008. Following October and November 2008, the next period with an abundance of breakpoints is January to March 2009. Many interesting events occurred during this time period as well. Argentina declared a state of emergency in January 2009. Canada’s parliament passed a budget including a major stimulus package in February 2009. Japan’s Economics Minister Kaoru Yosano stated that Japan was facing its worst economic crisis since World War II. Mexico’s government unveiled a package of emergency measures worth nearly 100 million pounds to protect the economy. Just as we observed in the last two chapters, most of the events are related to the financial account and the government’s personnel adjustments and elections.

7.4.2 Correlation Test Results

Tables 86 to table 88 summarise the results of the correlation tests.

Table 86: Correlation Results of Exchange Rate

	Time Periods	Conditional	T-Statistics	Unconditional	T-Statistics
Exchange Rate					
Argentina/Canada	Period 1/Period 2	-0.0013/ 0.3824 (0.3707/0.3381)	-6.3211*	-0.0046/ 0.4087 (0.4132/0.3638)	-6.2756*
	Period 2/Period 3	0.3824/ 0.0317 (0.3381/0.3525)	6.1422*	0.4087/ 0.0361 (0.3638/0.3832)	6.0538*
Argentina/Chile	Period 1/Period 2	0.0117/ 0.3731 (0.3634/0.2819)	-6.8483*	0.0137/ 0.4009 (0.4047/0.3043)	-6.7305*
	Period 2/Period 3	0.3731/ -0.0391 (0.2819/0.3994)	8.2291*	0.4009/ -0.0445 (0.3043/0.4401)	8.2019*
Argentina/Hongkong	Period 1/Period 2	0.0874/ -0.1105 (0.4318/0.2584)	3.8506*	0.0988/ -0.1336 (0.4682/0.2946)	4.0461*
	Period 2/Period 3	-0.1105/ 0.0133 (0.2584/0.4014)	-2.7343*	-0.1336/ 0.0143 (0.2946/0.4484)	-2.8821*
Argentina/Indonesia	Period 1/Period 2	0.0377/ 0.3335 (0.3814/0.3866)	-5.0626*	0.0487/0.3487 (0.4239/0.4317)	-4.6031*
	Period 2/Period 3	0.3335/ 0.0135 (0.3866/0.4027)	5.7458*	0.3487/ 0.0159 (0.4317/0.4479)	5.3581*
Argentina/Japan	Period 1/Period 2	-0.1551/ -0.3274 (0.3958/0.3508)	3.4191*	-0.1652/-0.3504 (0.4343/0.3756)	3.3952*
	Period 2/Period 3	-0.3274/ -0.0112 (0.3508/0.3684)	6.8962*	-0.3504/ -0.0094 (0.3756/0.4032)	-6.9074*
Argentina/Malaysia	Period 1/Period 2	-0.0712/0.3588 (0.3731/0.2384)	-9.0462*	-0.0786/0.3927 (0.4208/0.2415)	-9.3712*
	Period 2/Period 3	0.3588/ 0.0751 (0.2384/0.3928)	6.4645*	0.3927/0.0811 (0.2415/0.4188)	6.9176*
Argentina/Mexico	Period 1/Period 2	0.0609/0.2084 (0.4002/0.3629)	-3.3419*	0.0649/0.2222 (0.4373/0.3916)	-3.2762*
	Period 2/Period 3	0.2084/ -0.1085 (0.3629/0.3724)	7.8339*	0.2222/-0.1141 (0.3916/0.4088)	7.6505*
Argentina/Philippines	Period 1/Period 2	-0.0537/0.2668 (0.3889/0.3302)	-6.0683*	-0.0565/0.2853 (0.4263/0.3606)	-5.9129*
	Period 2/Period 3	0.2668/ -0.0741 (0.3302/0.4351)	6.7689*	0.2853/-0.0759 (0.3606/0.4678)	6.6052*
Canada/Chile	Period 1/Period 2	0.0655/-0.0071 (0.3068/0.3931)	2.3403*	0.0664/ -0.0085 (0.3409/0.4335)	2.1888*
Canada/Hongkong	Period 1/Period 2	0.0388/0.2181 (0.4294/0.3884)	-4.8093*	0.0384/ 0.2369 (0.4754/0.4231)	-4.8296*
Canada/Indonesia	Period 1/Period 2	0.1385/ 0.3955 (0.3675/0.2939)	-3.4804*	0.1462/0.4148 (0.4057/0.3218)	-3.3195*
	Period 2/Period 3	0.3955/ 0.1458 (0.2939/0.4021)	3.4092*	0.4148/ 0.1573 (0.3218/0.4451)	3.2090*
Canada/Japan	Period 1/Period 2	-0.1475/-0.4359 (0.4232/0.2338)	5.9067*	-0.1514/-0.4756 (0.4506/0.2565)	6.1112*
	Period 2/Period 3	-0.4359/-0.0807 (0.2338/0.3762)	-7.8545*	-0.4756/-0.0864 (0.2565/0.4105)	-7.8544*
Canada/Malaysia	Period 1/Period 2	0.1783/0.2544	-2.0142*	0.1981/0.2723	-1.8248

		(0.4504/0.3689)		(0.4857/0.3954)	
Canada/Mexico	Period 1/Period 2	0.3328/0.4534	-2.5563*	0.3533/0.4751	-2.4371*
		(0.3461/0.3912)		(0.3716/0.4119)	
	Period 2/Period 3	0.4534/0.3052	3.1109*	0.4751/0.3323	2.8165*
		(0.3912/0.3641)		(0.4119/0.3964)	
Canada/Philippines	Period 1/Period 2	0.1011/0.1167	-0.3095	0.1112/0.1372	-0.4546
		(0.3915/0.1767)		(0.4167/0.2029)	
	Period 2/Period 3	0.1167/-0.0268	2.9191*	0.1372/-0.0271	2.9511*
		(0.1767/0.4086)		(0.2029/0.4419)	
Chile/Hongkong	Period 1/Period 2	0.0642/0.0731	-0.2428	0.0624/0.0781	-0.3889
		(0.4118/0.3967)		(0.4453/0.4442)	
Chile/Indonesia	Period 1/Period 2	0.1081/0.4429	-5.2713*	0.1119/0.4735	-5.5068*
		(0.3895/0.2505)		(0.4321/0.2542)	
	Period 2/Period 3	0.4429/0.1788	4.2879*	0.4735/0.1972	4.3687*
		(0.2505/0.3765)		(0.2542/0.4143)	
Chile/Japan	Period 1/Period 2	-0.0116/-0.0913	0.9637	-0.0124/-0.0991	0.9766
		(0.4124/0.4717)		(0.4461/0.5059)	
	Period 2/Period 3	-0.0913/-0.0861	-0.0634	-0.0991/-0.0942	-0.0557
		(0.4717/0.4264)		(0.5059/0.4601)	
Chile/Malaysia	Period 1/Period 2	0.2412/0.2412	-0.3898	0.2621/0.2704	-0.2462
		(0.3301/0.3536)		(0.3699/0.3743)	
Chile/Mexico	Period 1/Period 2	-0.0096/0.0109	-0.4402	-0.0076/0.0138	-0.4194
		(0.3741/0.3772)		(0.4137/0.4118)	
	Period 2/Period 3	0.0109/0.2024	-4.1951*	0.0138/0.2243	-4.2351*
		(0.3772/0.3475)		(0.4118/0.3756)	
Chile/Philippines	Period 1/Period 2	0.2136/0.4178	-4.6121*	0.2215/0.4553	-4.8787*
		(0.4235/0.1401)		(0.4454/0.1547)	
	Period 2/Period 3	0.4178/0.1536	6.3621*	0.4553/0.1672	6.3683*
		(0.1401/0.4276)		(0.1547/0.4546)	
Hongkong/Indonesia	Period 1/Period 2	0.0691/0.2581	-3.7942*	0.0777/0.2956	-3.7221*
		(0.3994/0.1555)		(0.4388/0.1874)	
	Period 2/Period 3	0.2581/0.1086	3.2026*	0.2956/0.1152	3.2601*
		(0.1555/0.3567)		(0.1874/0.3981)	
Hongkong/Japan	Period 1/Period 2	0.2228/0.0116	4.1856*	0.2366/0.0178	3.7605*
		(0.3825/0.2434)		(0.4042/0.2888)	
	Period 2/Period 3	0.0116/0.0624	-1.0035	0.0178/0.0599	-0.7215
		(0.2434/0.4328)		(0.2888/0.4632)	
Hongkong/Malaysia	Period 1/Period 2	0.0957/0.1795	-2.3162*	0.1067/0.1895	-2.1224*
		(0.4343/0.3523)		(0.4674/0.3812)	
Hongkong/Mexico	Period 1/Period 2	-0.0013/-0.0655	1.2619	-0.0011/-0.0741	1.3155
		(0.3824/0.4062)		(0.4184/0.4419)	
	Period 2/Period 3	-0.0655/0.0855	-2.9843*	-0.0741/0.0927	-3.0371*
		(0.4062/0.3733)		(0.4419/0.4048)	
Hongkong/Philippines	Period 1/Period 2	0.0863/-0.3249	3.9532*	0.0991/-0.3509	4.2213*
		(0.3535/0.3647)		(0.3804/0.3726)	
	Period 2/Period 3	-0.3249/0.0835	-3.9439*	-0.3509/0.0926	-4.1837*
		(0.3647/0.3747)		(0.3726/0.4012)	
Indonesia/Japan	Period 1/Period 2	-0.1567/0.0297	-1.7938	-0.1671/0.0434	-1.8061
		(0.4154/0.4133)		(0.4446/0.4652)	
	Period 2/Period 3	0.0297/-0.0562	0.8371	0.0434/-0.0581	0.8789
		(0.4133/0.3745)		(0.4652/0.4077)	
Indonesia/Malaysia	Period 1/Period 2	0.4243/0.7048	-9.0324*	0.4588/0.7381	-8.3791*
		(0.3125/0.0917)		(0.3207/0.1022)	

	Period 2/Period 3	0.7048/0.5583 (0.0917/0.3328)	4.9377*	0.7381/0.5824 (0.1022/0.3426)	4.8663*
Indonesia/Mexico	Period 1/Period 2	0.0816/0.0315 (0.3723/0.3958)	0.9587	0.0915/0.0298 (0.4105/0.4234)	1.0941
	Period 2/Period 3	0.0315/-0.0311 (0.3958/0.3538)	1.2049	0.0298/-0.0346 (0.4234/0.3954)	1.1461
Indonesia/Philippines	Period 1/Period 2	0.0784/0.1021 (0.3259/0.3703)	-0.7663	0.0893/0.1083 (0.3595/0.3983)	-0.5646
Japan/Malaysia	Period 1/Period 2	0.0647/-0.3244 (0.3723/0.3958)	4.7197*	0.0755/-0.3445 (0.4978/0.4842)	4.7288*
	Period 2/Period 3	-0.3244/-0.0686 (0.3958/0.3538)	-3.1965*	-0.3445/-0.0741 (0.4842/0.4242)	-3.1502*
Japan/Mexico	Period 1/Period 2	-0.0718/-0.0905 (0.3729/0.3783)	0.3341	-0.0753/-0.0895 (0.4136/0.4043)	0.2366
	Period 2/Period 3	-0.0905/-0.0732 (0.3783/0.3613)	-0.3067	-0.0895/-0.0777 (0.4043/0.4028)	-0.1953
Japan/Philippines	Period 1/Period 2	0.0624/0.1713 (0.3736/0.1852)	-2.1675*	0.0691/0.2011 (0.4055/0.2223)	-2.2375*
	Period 2/Period 3	0.1713/0.0227 (0.1852/0.3442)	3.0679*	0.2011/0.0276 (0.2223/0.3738)	3.0354*
Malaysia/Mexico	Period 1/Period 2	0.1132/0.3528 (0.2845/0.3106)	-6.3407*	0.1247/0.3822 (0.3227/0.3269)	-6.3339*
	Period 2/Period 3	0.3528/0.1076 (0.3106/0.3586)	6.0464*	0.3822/0.1188 (0.3269/0.3983)	6.0481*
Malaysia/Philippines	Period 1/Period 2	0.1571/-0.1101 (0.3253/0.4223)	2.5474*	0.1759/-0.1067 (0.3527/0.4632)	2.4593*
	Period 2/Period 3	-0.1101/0.0983 (0.4223/0.3728)	-1.9887	-0.1067/0.1089 (0.4632/0.4018)	-1.8794
Mexico/Philippines	Period 1/Period 2	0.0199/0.1446 (0.3352/0.3381)	-2.7701*	0.0228/0.1609 (0.3646/0.3712)	-2.8042*
	Period 2/Period 3	0.1446/0.0464 (0.3381/0.3509)	2.1406*	0.1609/0.0502 (0.3712/0.3793)	2.2083*

***: significant at 5% level**

Among the 65 transmission periods, 48 are identified as contagion by the unconditional correlation while 49 are identified as contagion by the conditional correlation. Normally, when the conditional correlation of the exchange rate is detected as contagion, the unconditional correlation is also detected as contagion. The exception in this case is between Canada and Malaysia. When their conditional correlation is significantly identified as contagion, the adjusted unconditional correlation is not. During October 2008, Canada's conservatives failed to gain an overall majority in the early general election and Malaysia's Prime Minister suffered the worst election result in decades, thus exacerbating political tensions. These two events, along with the global financial crisis, are sufficient to cause structural changes in both countries. However, when the change in volatility in exchange rate is adjusted, the correlation between these two countries seems to be rather stable compared to most of other country combinations. Despite this, the results lead us to believe that the fluctuation in market volatility caused by political instability can be adjusted. The other stable country combinations are Canada/Philippines, Chile/Hong Kong, Chile/Japan, Chile/Malaysia, Chile/Mexico, Hong Kong/Japan, Hong Kong/Mexico, Indonesia/Japan, Indonesia/Mexico, Indonesia/Philippines, Japan/Mexico and Malaysia/Philippines. Trade does not seem to be a good criterion with which to identify contagion in this case. Indeed, we can see combinations with various degrees of dependence on each other; for instance, Canada/Philippines have a low level of dependence while Hong Kong/Japan have a high level of dependence. On the other hand, region does not seem to be a strong criterion either. Among the 12 pairs of stable country combinations, 7 of them (58.3%) are from different continents. The exceptions include Hong Kong/Japan, Indonesia/Japan, Indonesia/Philippines, Chile/Mexico and Malaysia/Philippines. There are 28 counter contagion effects in all the country combinations with the exception of Chile/Mexico. It is quite clear that the correlations among countries tend to recover after shocks. In Chile/Mexico, the absolute value of their correlation maintained its growth while there was also a change in the direction of the correlation. During the first transmission period, the correlation changed from slightly negative to slightly positive. The financial crisis did nothing to affect the magnitude of the correlation but did alter its direction. The energy reforms in Mexico due to a drop in oil production lead to a stronger relation with Chile according to the significant change in the correlation. Among all the 28 counter contagion effects, 7 of them changed direction, thus suggesting that there are two ways in which the correlations can recover after shocks. The first is to gradually return to their original level, while the other is to reach a new equilibrium. It seems that most country combinations follow the first methods in the exchange rate market. Another phenomenon we observe is that whenever a counter contagion effect occurs, then changes in the correlations are almost always an increase in the absolute value followed by a decrease. This suggests that the 2008 crisis intensified the exchange rate correlations among countries and that the crisis transfers from one to another through this channel until all of the affected countries either recover to their original level or reach a new equilibrium.

Table 87: Correlation Results of Interest Rate

	Time Periods	Conditional	T-Statistics	Unconditional	T-Statistics
Interest Rate					
Argentina/Canada	Period 1/Period 2	0.1471/-0.0884 (0.3445/0.3392)	4.7358*	0.1549/ -0.0924 (0.3931/0.3757)	4.3754*
	Period 2/Period 3	-0.0884/-0.2001 (0.3392/0.2763)	1.8447	-0.0924/ 0.0788 (0.3757/0.4394)	-2.8077*
	Period 3/Period 4	-0.2001/0.2059 (0.2763/0.3845)	-5.2886*	0.0788/ 0.2271 (0.4394/0.4203)	-5.0667*
	Period 4/Period 5	0.2059/ 0.0669 (0.3845/0.3593)	2.3042*	0.2271/ 0.0621 (0.4203/0.3517)	2.5926*
Argentina/Chile	Period 1/Period 2	0.0596/ -0.0364 (0.1678/0.1346)	4.2836*	0.0725/ -0.0405 (0.2063/0.1474)	4.2141*
	Period 2/Period 3	-0.0364/ 0.0098 (0.1346/0.2505)	-2.3536*	-0.0405/ 0.0064 (0.1474/0.2458)	-2.4797*
Argentina/Hongkong	Period 1/Period 2	0.1694/ -0.0715 (0.4257/0.3973)	3.9389*	0.1801/ -0.0724 (0.4615/0.4394)	3.7792*
	Period 2/Period 3	-0.0715/ -0.3299 (0.3973/0.5139)	2.2377*	-0.0724/ -0.3524 (0.4394/0.5235)	2.3597*
	Period 3/Period 4	-0.3299/ 0.0447 (0.5139/0.4081)	-3.3273*	-0.3524/ 0.0392 (0.5235/0.4034)	-3.4331*
Argentina/Indonesia	Period 1/Period 2	0.0589/ 0.1691 (0.3804/0.3243)	-2.1789*	0.0561/ 0.1935 (0.4198/0.3594)	-2.4392*
	Period 2/Period 3	0.1691/ -0.0102 (0.3243/0.4141)	3.9321*	0.1935/ -0.0162 (0.3594/0.4366)	4.4423*
	Period 3/Period 4	-0.0102/ -0.0387 (0.4141/0.4445)	0.5147	-0.0162/ -0.0282 (0.4366/0.4301)	0.2361
Argentina/Japan	Period 1/Period 2	0.0595/ 0.1157 (0.3735/0.4287)	-1.0258	0.0457/ 0.1173 (0.4374/0.4533)	-1.1571
	Period 2/Period 3	0.1157/ -0.0296 (0.4287/0.2741)	2.1565*	0.1173/ -0.0197 (0.4533/0.3131)	1.8154
	Period 3/Period 4	-0.0296/ 0.0668 (0.2741/0.3256)	-1.5767	-0.0197/ 0.0589 (0.3131/0.3388)	-1.1495
Argentina/Malaysia	Period 1/Period 2	0/ 0 (0/0)	NA	0/ 0 (0/0)	NA
	Period 2/Period 3	0/ 0.0849 (0/0.2149)	-3.3759*	0/ 0.0905 (0/0.2305)	-3.3575*
	Period 3/Period 4	0.0849/ -0.0152 (0.2149/0.2901)	2.9794*	0.0905/ -0.0124 (0.2305/0.2687)	3.1659*
Argentina/Mexico	Period 1/Period 2	0.0858/ -0.1299 (0.3581/0.5233)	3.6492*	0.1031/ -0.1325 (0.4031/0.5523)	3.6519*
	Period 2/Period 3	-0.1299/ -0.4869 (0.5233/0.3995)	4.0911*	-0.1325/ -0.5081 (0.5523/0.4027)	4.2203*
	Period 3/Period 4	-0.4869/ 0.1375 (0.3995/0.3294)	-7.9259*	-0.5081/ 0.1199 (0.4027/0.3369)	-7.9631*
Argentina/Philippines	Period 1/Period 2	-0.0213/ 0.1416 (0.3753/0.3285)	-3.1094*	-0.0115/ 0.1533 (0.4317/0.3686)	-2.7489*
	Period 2/Period 3	0.1416/ 0.0996 (0.3285/0.3508)	0.6301	0.1533/ 0.0901 (0.3686/0.3987)	0.8397
	Period 3/Period 4	0.0996/ -0.0358 (0.3508/0.3819)	2.1378*	0.0901/ -0.0343 (0.3987/0.3826)	1.7737
Canada/Chile	Period 1/Period 2	0.0069/ 0.0081 (0.0396/0.0192)	-0.2399	0.0074/ 0.0101 (0.0422/0.0259)	-0.4933
	Period 2/Period 3	0.0081/ 0.0993	-3.2213*	0.0101/ 0.1083	-3.1728*

		(0.0192/0.1928)		(0.0259/0.2096)	
	Period 3/Period 4	0.0993/ 0.0241 (0.1928/0.2026)	2.3827*	0.1083/ 0.0208 (0.2096/0.1982)	2.6396*
Canada/Hongkong	Period 1/Period 2	0.1666/ 0.0469 (0.4371/0.3858)	2.2009*	0.1672/0.0561 (0.4738/0.4277)	1.8556
	Period 2/Period 3	0.0469/ 0.0605 (0.3858/0.4097)	-0.2573	0.0561/ 0.0573 (0.4277/0.4048)	-0.0221
Canada/Indonesia	Period 1/Period 2	-0.0361/-0.4448 (0.4418/0.1954)	7.5816*	-0.0448/ -0.4692 (0.4801/0.2086)	7.3294*
	Period 2/Period 3	-0.4448/0.0795 (0.1954/0.5711)	-6.0415*	-0.4692/ 0.0725 (0.2086/0.5947)	-5.9557*
	Period 3/Period 4	0.0795/0.1501 (0.5711/0.4791)	-0.7794	0.0725/ 0.1534 (0.5947/0.5058)	-0.8649
	Period 4/Period 5	0.1501/ 0.0031 (0.4791/0.4467)	2.2331*	0.1534/ 0.0039 (0.5058/0.4396)	2.3612*
Canada/Japan	Period 1/Period 2	0.0988/ -0.1357 (0.4059/0.4661)	3.2584*	0.1064/ -0.1553 (0.4342/0.4919)	3.4371*
	Period 2/Period 3	-0.1357/ 0.5929 (0.4661/0.3921)	-7.3481*	-0.1553/ 0.6423 (0.4919/0.3801)	-7.9768*
	Period 3/Period 4	0.5929/ 0.1334 (0.3921/0.3212)	5.9308*	0.6423/ 0.1309 (0.3801/0.3335)	6.8199*
Canada/Malaysia	Period 1/Period 2	0/ 0.1333 (0/0.3191)	-3.6921*	0/ 0.1389 (0/0.3296)	-3.7219*
	Period 2/Period 3	0.1333/ 0.1956 (0.3191/0.3281)	-0.7911	0.1389/ 0.2055 (0.3296/0.3452)	-0.8077
	Period 3/Period 4	0.1956/ -0.0082 (0.3281/0.2749)	2.7976*	0.2055/ -0.0092 (0.3452/0.2695)	2.8331*
Canada/Mexico	Period 1/Period 2	0.0065/ -0.1398 (0.3425/0.3335)	2.8582*	0.0041/ -0.1464 (0.3757/0.3477)	2.7871*
	Period 2/Period 3	-0.1398/ 0.0794 (0.3335/0.3868)	-2.3741*	-0.1464/ 0.0633 (0.3477/0.4817)	-1.8926
	Period 3/Period 4	0.0794/ 0.0696 (0.3868/0.3041)	0.1172	0.0633/ 0.0564 (0.4817/0.3096)	0.0668
Canada/Philippines	Period 1/Period 2	0.1121/ -0.1031 (0.3804/0.1601)	3.5787*	0.1223/ -0.1034 (0.4071/0.1743)	3.4572*
	Period 2/Period 3	-0.1031/ -0.1055 (0.1601/0.4108)	0.0351	-0.1034/ -0.1097 (0.1743/0.4473)	0.0822
	Period 3/Period 4	-0.1055/ 0.0071 (0.4108/0.3748)	-2.1072*	-0.1097/ 0.0049 (0.4473/0.3882)	-2.0289*
Chile/Hongkong	Period 1/Period 2	0.3219/0.6102 (0.2479/0.0737)	-5.1483*	0.0529/0.1282 (0.1468/0.2761)	-1.3852
	Period 2/Period 3	0.6102/-0.1983 (0.0737/0.4032)	13.1995*	0.1282/-0.0455 (0.2761/0.2172)	3.1805*
Chile/Indonesia	Period 1/Period 2	-0.0513/ -0.2062 (0.1761/0.0153)	4.7102*	-0.0061/ -0.1053 (0.0854/0.1229)	2.6437*
	Period 2/Period 3	-0.2062/ 0.0951 (0.0153/0.4045)	-5.4318*	-0.1053/ 0.0345 (0.1229/0.2708)	-3.2209*
	Period 3/Period 4	0.0951/ 0.1241 (0.4045/0.0191)	-0.5221	0.0345/ 0.0071 (0.2708/0.0324)	1.2071
Chile/Japan	Period 1/Period 2	-0.0813/-0.1593 (0.3481/0.0165)	1.2993	-0.0128/-0.0167 (0.1504/0.0504)	0.2569
	Period 2/Period 3	-0.1593/0.2041 (0.0165/0.1988)	-12.7986*	-0.0167/0.0541 (0.0504/0.1484)	-4.8298*
Chile/Malaysia	Period 1/Period 2	0/0 (0/0)	NA	0/0 (0/0)	NA
	Period 2/Period 3	0/0 (0/0)	NA	0/0 (0/0)	NA

Chile/Mexico	Period 1/Period 2	-0.1972/0 (0.4004/0)	-2.9146*	-0.0305/0 (0.1716/0)	-2.6812*
	Period 2/Period 3	0/0 (0/0)	NA	0/0 (0/0)	NA
Chile/Philippines	Period 1/Period 2	0.0552/0.2604 (0.3616/0.0921)	-2.6375*	0.0145/0.0367 (0.1753/0.1059)	-1.0533
	Period 2/Period 3	0.2604/0.0736 (0.0921/0.3077)	3.2777*	0.0367/0.0184 (0.1059/0.1659)	0.9475
Hongkong/Indonesia	Period 1/Period 2	0.0534/ -0.0965 (0.3752/0.3171)	1.8429	0.0465/ -0.0846 (0.4211/0.3438)	1.4422
	Period 2/Period 3	-0.0965/ 0.2021 (0.3171/0.3959)	-3.5853*	-0.0846/ 0.2316 (0.3438/0.4331)	-3.4102*
	Period 3/Period 4	0.2021/ -0.0694 (0.3959/0.3361)	6.3953*	0.2316/ -0.0849 (0.4331/0.3794)	6.7237*
Hongkong/Japan	Period 1/Period 2	0.0311/0.1373 (0.3871/0.5559)	-1.2412	0.0321/0.1461 (0.4298/0.5706)	-1.2856
	Period 2/Period 3	0.1373/0.0843 (0.5559/0.3782)	0.6283	0.1461/0.0915 (0.5706/0.4263)	0.6261
Hongkong/Malaysia	Period 1/Period 2	0/-0.0441 (0/0.1339)	3.2404*	0/-0.0474 (0/0.1481)	3.1592*
	Period 2/Period 3	-0.0441/-0.0028 (0.1339/0.1202)	-2.5993*	-0.0474/-0.0036 (0.1481/0.1395)	-2.4718*
Hongkong/Mexico	Period 1/Period 2	0.0282/0.1312 (0.3866/0.4199)	-1.6021	0.0372/0.1286 (0.4294/0.4428)	-1.3338
	Period 2/Period 3	0.1312/0.0203 (0.4199/0.3478)	1.7881	0.1286/0.0174 (0.4428/0.3852)	1.6885
Hongkong/Philippines	Period 1/Period 2	-0.0252/0.0041 (0.3431/0.2474)	-0.4013	-0.0336/0.0022 (0.3975/0.2658)	-0.4525
	Period 2/Period 3	0.0041/0.0244 (0.2474/0.4156)	-0.2814	0.0022/0.0309 (0.2658/0.4577)	-0.3682
Indonesia/Japan	Period 1/Period 2	0.0116/ -0.0844 (0.4659/0.2021)	2.0504*	0.0071/ -0.0938 (0.4698/0.2277)	1.9256
	Period 2/Period 3	-0.0844/ 0.1038 (0.2021/0.2399)	-4.4071*	-0.0938/ 0.1209 (0.2277/0.2909)	-4.3718*
	Period 3/Period 4	0.1038/ 0.1066 (0.2399/0.3402)	-0.0775	0.1209/ 0.1188 (0.2909/0.3781)	0.0502
Indonesia/Malaysia	Period 1/Period 2	0/ 0.0359 (0/0.1467)	-2.1921*	0/ 0.0456 (0/0.1792)	-2.2781*
	Period 2/Period 3	0.0359/ -0.0461 (0.1467/0.3669)	1.7974	0.0456/ -0.0396 (0.1792/0.3764)	1.7729
	Period 3/Period 4	-0.0461/ -0.0628 (0.3669/0.1889)	0.3674	-0.0396/ -0.0732 (0.3764/0.2107)	0.7124
Indonesia/Mexico	Period 1/Period 2	0.0681/ 0.0814 (0.4314/0.3425)	-0.2052	0.0711/ 0.0871 (0.4598/0.3705)	-0.2275
	Period 2/Period 3	0.0814/ 0.1781 (0.3425/0.3763)	-1.4351	0.0871/ 0.2005 (0.3705/0.4092)	-1.5533
	Period 3/Period 4	0.1781/ 0.0736 (0.3763/0.3171)	2.4049*	0.2005/ 0.0785 (0.4092/0.3435)	2.5858*
Indonesia/Philippines	Period 1/Period 2	0.0034/ -0.1993 (0.4561/0.4222)	2.3806*	-0.0018/ -0.3184 (0.4598/0.3705)	2.6601*
	Period 2/Period 3	-0.1993/ -0.1481 (0.4222/0.4089)	-0.6021	-0.3184/ -0.1593 (0.3705/0.4092)	-1.3351
	Period 3/Period 4	-0.1481/ 0.0492 (0.4089/0.4186)	-4.1124*	-0.1593/ 0.0576 (0.4092/0.3435)	-4.1185*
Japan/Malaysia	Period 1/Period 2	-0.0121/-0.0016 (0.0897/0.2689)	-0.2706	-0.0117/0.0118 (0.0866/0.3034)	-0.5448
	Period 2/Period 3	-0.0016/-0.0414	0.9654	0.0118/-0.0466	1.2668

		(0.2689/0.2344)		(0.3034/0.2511)	
Japan/Mexico	Period 1/Period 2	0.0829/0.1091 (0.4971/0.4717)	-0.5976	0.0755/0.1167 (0.4827/0.4866)	-0.9577
Japan/Philippines	Period 1/Period 2	0.1023/0.0871 (0.4288/0.3926)	0.2495	0.1035/0.0886 (0.4618/0.4296)	0.2277
	Period 2/Period 3	0.0871/-0.0375 (0.3926/0.3631)	2.1321*	0.0886/-0.0338 (0.4296/0.4905)	1.9302
Malaysia/Mexico	Period 1/Period 2	-0.6576/0.4948 (0.3426/0.4884)	-6.9953*	-0.0188/0.2553 (0.3227/0.3269)	-4.2483*
	Period 2/Period 3	0.4948/-0.0951 (0.4884/0.2826)	5.4775*	0.2553/-0.0304 (0.3269/0.3983)	4.3915*
Malaysia/Philippines	Period 1/Period 2	0.0073/-0.0952 (0.3306/0.4081)	1.3028	0.0041/-0.0306 (0.1949/0.2359)	1.4136
Mexico/Philippines	Period 1/Period 2	-0.1294/-0.0959 (04637/0.3819)	-0.5543	-0.1292/-0.0899 (0.4824/0.4059)	-0.6356
	Period 2/Period 3	-0.0959/0.1425 (0.3819/0.3875)	-4.3241*	-0.0899/0.1311 (0.4059/0.4012)	-3.9167*

***: significant at 5% level**

Factors related to interest rate are more complicated than those related to exchange rate. First of all, there are more detected breakpoints, and hence more transmission periods. There are 91 transmission periods in our interest rate case. Second, a smaller proportion of transmission periods is identified as contagion (60.4% in conditional correlation and 51.6% in unconditional correlation). The cases in which conditional correlation and unconditional correlation are not consistent with each other include Argentina/Canada, Argentina/Japan, Argentina/Philippines, Canada/Hong Kong, Canada/Mexico, Chile/Hong Kong, Chile/Philippines, Indonesia/Japan and Japan/Philippines. In the above cases, nearly all of the unconditional correlations, with the exception of Argentina/Canada, suggest no contagion effect when the two kinds of correlations are not consistent with each other. The country involved contains different features, which may come from different regions or the same region. They may have a very low degree of dependence or a high degree of dependence. This finding again suggests that region and trade are not very strong criteria for contagion. The main factor giving rise to breakpoints and thus leading to contagion is global crisis. Indeed, considering the fact that the correlations are more stable after they are adjusted for heteroscedasticity, we can conclude that although the co-movement between countries may seem much more volatile during shocks, this may simply be due to proportional changes. The underlying correlations could be quite stable and do not experience significant changes. Although there are many more transmission periods in interest rate than exchange rate (65 versus 91), we do not observe an identical proportion increase in the number of counter contagion effects. There are only 33 counter contagion effects. We find only one combination which does not exhibit counter contagion effect in exchange rate, while we have 8 in interest rate: Canada/Chile, Chile/Japan, Chile/Malaysia, Chile/Mexico, Indonesia/Japan, Indonesia/Malaysia, Japan/Philippines and Malaysia/Mexico. It seems that the interest rate correlation does not recover as well as the exchange rate. Indeed, we find 22 changes in direction across all 33 transmission periods, a significant increase compared to the exchange rate (66.7% versus 25%). Among the two ways in which correlation recovers, the interest rate correlations tend to reach new equilibriums rather than gradually returning to their original level. As for the absolute values, it is very hard to find a pattern for the changes compared to the exchange rate. This may be because the interbank rates we used are less regulated by the government than exchange rate. The demand and supply of the market constantly changes, as do the interbank rates.

Table 88: Correlation Results of Stock

	Time Periods	Conditional	T-Statistics	Unconditional	T-Statistics
Stock					
Argentina/Canada	Period 1/Period 2	0.6637/ 0.7883 (0.2787/0.1944)	-2.4435*	0.6919/ 0.8008 (0.2753/0.1597)	-2.5167*
	Period 2/Period 3	0.7883/ 0.6917 (0.1944/0.2345)	1.9655	0.8008/ 0.7203 (0.1597/0.2317)	1.9591
Argentina/Chile	Period 1/Period 2	0.4982/ 0.8408 (0.3516/0.1929)	-7.8016*	0.5276/ 0.8573 (0.3577/0.1597)	-8.4146*
	Period 2/Period 3	0.8408/ 0.5581 (0.1929/0.2902)	6.9996*	0.8573/ 0.5911 (0.1597/0.2974)	7.5946*
Argentina/Hongkong	Period 1/Period 2	0.2241/0.3068 (0.3843/0.3929)	-2.3728*	0.2431/ 0.3231 (0.4085/0.4182)	-2.1532*
Argentina/Indonesia	Period 1/Period 2	0.3045/ 0.5701 (0.4292/0.2418)	-4.1255*	0.3363/0.5991 (0.4544/0.2329)	-4.1422*
	Period 2/Period 3	0.5701/ 0.3027 (0.2418/0.3747)	4.3708*	0.5991/ 0.3237 (0.2329/0.4007)	4.6055*
Argentina/Japan	Period 1/Period 2	0.0422/ 0.1369 (0.4027/0.4016)	-1.8992	0.0422/0.1474 (0.4328/0.4297)	-1.9665
	Period 2/Period 3	0.1369/ 0.0214 (0.4016/0.4027)	2.3257*	0.1474/ 0.0228 (0.4297/0.4377)	2.3321*
Argentina/Malaysia	Period 1/Period 2	0.1771/0.3692 (0.3784/0.3734)	-5.6706*	0.1992/ 0.3942 (0.4149/0.3931)	-5.3203*
Argentina/Mexico	Period 1/Period 2	0.5761/0.7046 (0.2589/0.2838)	-3.7387*	0.6047/0.7298 (0.2551/0.2752)	-3.7309*

	Period 2/Period 3	0.7046/ 0.6605 (0.2838/0.2382)	1.3155	0.7298/0.6947 (0.2752/0.2352)	1.0754
Argentina/Philippines	Period 1/Period 2	0.1423/0.1691 (0.3754/0.4244)	-0.7507	0.1516/ 0.1788 (0.4063/0.4562)	-0.7064
Canada/Chile	Period 1/Period 2	0.4589/0.5557 (0.3781/0.1017)	-2.3661*	0.4848/0.5933 (0.3954/0.1109)	-2.4672*
	Period 2/Period 3	0.5557/ 0.6068 (0.1017/0.2805)	-1.4064	0.5933/0.6391 (0.1109/0.2831)	-1.1738
Canada/Hongkong	Period 1/Period 2	0.2318/0.4362 (0.3735/0.2907)	-2.7202*	0.2525/0.4657 (0.3948/0.3052)	-2.6998*
	Period 2/Period 3	0.4362/ 0.3948 (0.2907/0.3565)	0.5629	0.4657/0.4213 (0.3052/0.3759)	0.5758
Canada/Indonesia	Period 1/Period 2	0.2691/0.2809 (0.3831/0.3393)	-0.3613	0.2891/ 0.3029 (0.4201/0.3687)	-0.3886
Canada/Japan	Period 1/Period 2	0.2021/0.0181 (0.3731/0.3626)	3.8103*	0.2128/0.0249 (0.3947/0.3952)	3.5982*
	Period 2/Period 3	0.0181/0.0764 (0.3626/0.3693)	-1.2024	0.0249/0.0803 (0.3952/0.4005)	-1.0498
Canada/Malaysia	Period 1/Period 2	0.1934/0.3125 (0.3874/0.1833)	-2.1877*	0.2192/0.3495 (0.4235/0.2111)	-2.1036*
	Period 2/Period 3	0.3125/0.3949 (0.1833/0.3183)	-1.6182	0.3495/0.4274 (0.2111/0.3362)	-1.3448
Canada/Mexico	Period 1/Period 2	0.5325/0.7077 (0.3642/0.3518)	-3.7668*	0.5576/0.7411 (0.3536/0.3538)	-3.9056*
	Period 2/Period 3	0.7077/0.7757 (0.3518/0.1683)	-1.6183	0.7411/0.8073 (0.3538/0.1541)	-1.5799
Canada/Philippines	Period 1/Period 2	0.1615/0.3113 (0.3311/0.3308)	-1.7945	0.1771/0.3553 (0.3635/0.3562)	-1.9796
	Period 2/Period 3	0.3113/0.2058 (0.3308/0.3522)	1.2734	0.3553/0.2206 (0.3562/0.3763)	1.5103
Chile/Hongkong	Period 1/Period 2	0.2208/0.2796 (0.4077/0.2587)	-1.0404	0.2364/0.3001 (0.4348/0.2896)	-1.0172
	Period 2/Period 3	0.2796/0.3177 (0.2587/0.3718)	-0.7086	0.3001/0.3371 (0.2896/0.3971)	-0.6207
Chile/Indonesia	Period 1/Period 2	0.2125/0.4327 (0.4258/0.2311)	-2.6812*	0.2266/0.4722 (0.4603/0.2439)	-2.8266*
	Period 2/Period 3	0.4327/0.2676 (0.2311/0.3787)	2.0555	0.4722/0.2868 (0.2439/0.4085)	2.1833
Chile/Japan	Period 1/Period 2	0.0553/-0.0129 (0.4069/0.3478)	1.3562	0.0599/-0.0109 (0.4394/0.3536)	1.2782
	Period 2/Period 3	-0.0129/-0.0292 (0.3478/0.4419)	0.3092	-0.0109/-0.0336 (0.3536/0.4733)	0.3942
Chile/Malaysia	Period 1/Period 2	0.2236/0.4389 (0.4195/0.1958)	-4.4699*	0.2449/0.4732 (0.4533/0.2056)	-4.4657*
	Period 2/Period 3	0.4389/0.3318 (0.1958/0.3661)	2.4204*	0.4732/0.3557 (0.2056/0.3833)	2.5229*
Chile/Mexico	Period 1/Period 2	0.5815/0.5119 (0.2953/0.2654)	1.8239	0.6082/0.5415 (0.3008/0.2844)	1.6524
	Period 2/Period 3	0.5119/0.6145 (0.2654/0.2678)	-2.7208*	0.5415/0.6501 (0.2844/0.2711)	-2.7202*
Chile/Philippines	Period 1/Period 2	0.1452/0.3823 (0.4235/0.1401)	-5.3847*	0.1578/0.4262 (0.4007/0.1995)	-5.7192*
	Period 2/Period 3	0.3823/0.1391 (0.1401/0.4276)	5.5957*	0.4262/0.1501 (0.1995/0.4483)	5.9609*

Hongkong/Indonesia	Period 1/Period 2	0.4622/0.5501 (0.3994/0.1555)	-2.3214*	0.4903/0.5907 (0.4007/0.1104)	-2.6287*
	Period 2/Period 3	0.5501/0.5868 (0.1555/0.3567)	-1.1863	0.5907/0.6212 (0.1104/0.2518)	-1.0201
Hongkong/Japan	Period 1/Period 2	0.5433/0.4717 (0.3825/0.2434)	1.6899	0.5703/0.4962 (0.2971/0.3789)	1.6823
	Period 2/Period 3	0.4717/0.4503 (0.2434/0.4328)	0.5134	0.4962/0.4796 (0.3789/0.2893)	0.3801
Hongkong/Malaysia	Period 1/Period 2	0.4694/0.6065 (0.3462/0.2686)	-4.7944*	0.5026/0.6411 (0.3647/0.2719)	-4.6501*
Hongkong/Mexico	Period 1/Period 2	0.1689/0.3459 (0.3695/0.3775)	-3.7068*	0.1789/0.3769 (0.4253/0.4011)	-3.8892*
	Period 2/Period 3	0.3459/0.4324 (0.3775/0.3255)	-1.9268	0.3769/0.4608 (0.4011/0.3435)	-1.7632
Hongkong/Philippines	Period 1/Period 2	0.4365/0.4831 (0.3006/0.3561)	-1.5944*	0.4735/0.5049 (0.3198/0.3785)	-1.0132*
Indonesia/Japan	Period 1/Period 2	0.4064/0.3983 (0.4154/0.4133)	0.1883	0.4252/0.4302 (0.4336/0.2998)	-0.1111
	Period 2/Period 3	0.3983/0.2906 (0.4133/0.3745)	2.7769*	0.4302/0.3131 (0.2998/0.3311)	2.8403*
Indonesia/Malaysia	Period 1/Period 2	0.4459/0.8056 (0.4084/0.1247)	-8.5392*	0.4702/0.8403 (0.4292/0.1025)	-9.4247*
	Period 2/Period 3	0.8056/0.5681 (0.1247/0.3037)	6.6093*	0.8403/0.5992 (0.1025/0.3115)	7.6499*
Indonesia/Mexico	Period 1/Period 2	0.2527/0.2626 (0.4077/0.3471)	-0.2053	0.2694/0.2824 (0.4293/0.3747)	-0.2501
	Period 2/Period 3	0.2626/0.3232 (0.3471/0.3344)	-1.3112	0.2824/0.3505 (0.3747/0.3556)	-1.3713
Indonesia/Philippines	Period 1/Period 2	0.3541/0.8784 (0.3723/0.3958)	-8.8638*	0.3761/0.9113 (0.3925/0.1764)	-10.7546*
	Period 2/Period 3	0.8784/0.4481 (0.3958/0.3538)	7.5436*	0.9113/0.4691 (0.1764/0.3697)	9.4205*
Japan/Malaysia	Period 1/Period 2	0.3675/0.3109 (0.3723/0.3958)	1.3544	0.4008/0.3402 (0.4978/0.4842)	1.3573
	Period 2/Period 3	0.3109/0.3041 (0.3958/0.3538)	0.1702	0.3402/0.3326 (0.4842/0.4242)	0.1762
Japan/Mexico	Period 1/Period 2	-0.0444/0.0397 (0.3676/0.3376)	-2.6821*	-0.0461/0.0437 (0.4028/0.3701)	-2.6092*
Japan/Philippines	Period 1/Period 2	0.3889/0.3953 (0.3562/0.4181)	-0.1305	0.4201/0.4163 (0.3776/0.4508)	0.0703
	Period 2/Period 3	0.3953/0.3331 (0.4181/0.3384)	1.2776	0.4163/0.3557 (0.4508/0.3549)	1.1584
Malaysia/Mexico	Period 1/Period 2	0.1497/0.3645 (0.4066/0.3471)	-4.6832*	0.1567/0.3881 (0.4348/0.3702)	-4.7231*
	Period 2/Period 3	0.3645/0.4456 (0.3471/0.3661)	-1.8386	0.3881/0.4741 (0.3702/0.3837)	-1.8381
Malaysia/Philippines	Period 1/Period 2	0.4616/0.4896 (0.3582/0.3324)	-0.8911	0.4931/0.5148 (0.3746/0.3467)	-0.6612
Mexico/Philippines	Period 1/Period 2	0.1452/0.3192 (0.3398/0.2891)	-4.5702*	0.1611/0.3506 (0.3727/0.3096)	-4.6052*
	Period 2/Period 3	0.3192/0.1608 (0.2891/0.4511)	3.6833*	0.3506/0.1722 (0.3096/0.4762)	3.9046*

***: significant at 5% level**

The stock market is more stable than the exchange rate and interest rate market. Among all the 64 transmission periods, both conditional and unconditional correlation identified 33 contagions. In this case, the conditional and unconditional correlations are completely consistent with each other. Adjusting for heteroscedasticity only slightly changed the magnitude but not the significance of the t-statistics. Although region does not play an important role in the identification of contagion, we notice that the effect of trade begins to emerge. Only 1 of the top 4 combinations with the highest degree of dependence experience contagion: Indonesia/Japan in Period 2/Period 3. The other 3 combinations, Hong Kong/Japan, Japan/Malaysia and Japan/Philippines are all quite stable. Shockingly, the global financial crisis was strong enough to create a structural change in Indonesia, although the trade links among these countries coordinated their movements and contagion did not occur. Among these four combinations, Indonesia/Japan has the lowest degree of dependence. Thus, after Japan's Economics Minister stated that Japan was facing its worst economic crisis since World War II in February 2009, Hong Kong, Malaysia and Philippines remained unaffected while Indonesia suffered a contagion. While Indonesia does have a strong trade link with Japan, it is not strong enough to endure such a fluctuation. We observe 16 counter contagion effects, a lot less than the 28 counter contagion effects we find in exchange rate, even when our stock case and exchange rate case have almost the same number of transmission periods (64 versus 65). Only 1 of the 16 counter contagion effects experienced a change in direction: Chile/Japan. Their correlation changes from a weak positive one to an even weaker negative one after the shock in December 2008. Judging from the timeline of these two countries, the global financial crisis seems to be the only reason for this change. It seems that the stock market correlations tend to gradually return to their original level after shocks, instead of shaping into new equilibriums. Most of the counter contagion effect experienced an increase in the magnitude of the correlation, followed by a decrease to their original level, although there are 3 exceptions: Canada/Japan, Chile/Japan, and Chile/Mexico. However, the reason why Japan is amongst these exceptions may stem from the reduction in foreign trade with Chile and Canada during the crisis. The cause of the declining correlation between Chile and Mexico may be the energy reforms carried out in Mexico at the end of 2008.

Compared to the study by Forbes and Rigobon (2002), the big difference is that we detected a massive amount of contagion effects using the same conditional and unconditional correlation methods. This result shows the importance of the proper breakpoint test, which has proven to have a significant impact on the identification of contagion. Better than assigning a known date as the structural change, a suitable breakpoint test is much more appropriate. Indeed, we do not reach the conclusion that the unconditional correlation is substantially smaller than the conditional correlation in each sample either. We observe that the absolute values follow no pattern when it comes to this matter. We do notice that the number of contagion effects detected by the unconditional correlation is usually slightly lower than the conditional correlation. In our case, the exchange rate market and interest rate market both find less contagion effects in the unconditional correlation while they are equal to each other in the stock market. The stock market has the lowest proportion of contagion compared to the other markets. It seems that although contagion is transferred through the stock market, interest rate and exchange rate markets are much more important transmission channels. The counter contagion effects were most stable and predictable in the exchange rate market, followed by the stock market. The correlation, both conditional and unconditional, normally increases first before declining to its original level. The interest rate market was the most volatile, while there was no pattern in terms of how the correlation changes. However, because of the interbank rate we used, the interest rate cases reflect the demand and supply of the market better. Moreover, we can see that they continued to change constantly. Since the interbank rate data is the least regulated among all 3 markets, we can see that government regulations tend to make the change in market return more stable and predictable.

7.5 Identification through Heteroscedasticity

We must now examine the split elements and attempt to answer the second question by establishing the degree to which each split elements contribute to the overall movements.

7.5.1 Quantifying the Shock

Table 89 summarises the specifications of the forecasting models.

Table 89: Forecasting Models Specifications

	p_1	p_2	p_3	q_1	q_2	q_3	d
Exchange Rate							
Argentina	0.6147	-0.9986		-0.6069	0.9825		-0.0057
	(0.0035)	(0.0032)		(0.0080)	(0.0235)		(0.0025)
Canada		0.8936			-0.8388		
		(0.0802)			(0.0969)		
Chile		-0.1232					0.0608
		(0.0445)					(0.0364)
Hong Kong			-0.5997			0.6601	
			(0.2919)			(0.2741)	
Indonesia		-0.0880					
		(0.0448)					
Japan			-0.7202			0.7921	
			(0.1937)			(0.1769)	
Malaysia		-0.1423					
		(0.0408)					
Mexico			0.0926				-0.0450
			(0.0444)				(0.0369)
Philippines	0.6813			-0.8370			0.2563
	(0.1143)			(0.0659)			(0.1140)
Interest Rate							
Argentina			-0.1295				
			(0.0258)				
Canada	-0.6349			0.7175			0.2035
	(0.1997)			(0.1731)			(0.0421)
Chile		0.6657			-0.7668		-0.0979
		(0.1206)			(0.1047)		(0.0335)
Hong Kong			-0.5352			0.3989	0.0867
			(0.1715)			(0.1852)	(0.0365)
Indonesia		-0.0964					0.0834
		(0.0485)					(0.0280)
Japan						0.2148	
						(0.0320)	
Malaysia			0.0786				
			(0.0237)				
Mexico		0.9504			-0.9861		
		(0.0129)			(0.0053)		
Philippines	0.6274			-0.3366			-0.1989
	(0.1236)			(0.0958)			(0.1116)
Stock							
Argentina							-0.0015
							(0.0360)
Canada			-0.0706				
			(0.0374)				
Chile			-0.1155				0.1141
			(0.0441)				(0.0365)
Hong Kong		-0.1721					0.0612
		(0.0482)					(0.0369)
Indonesia		0.5973			-0.6903		0.0636
		(0.2614)			(0.2380)		(0.0338)
Japan	0.4309	0.4418	-0.8548	-0.3986	-0.4610	0.9325	-0.1068
	(0.0578)	(0.0801)	(0.0818)	(0.0485)	(0.0655)	(0.0797)	(0.0515)
Malaysia	-0.2821			0.4828			
	(0.1130)			(0.1053)			

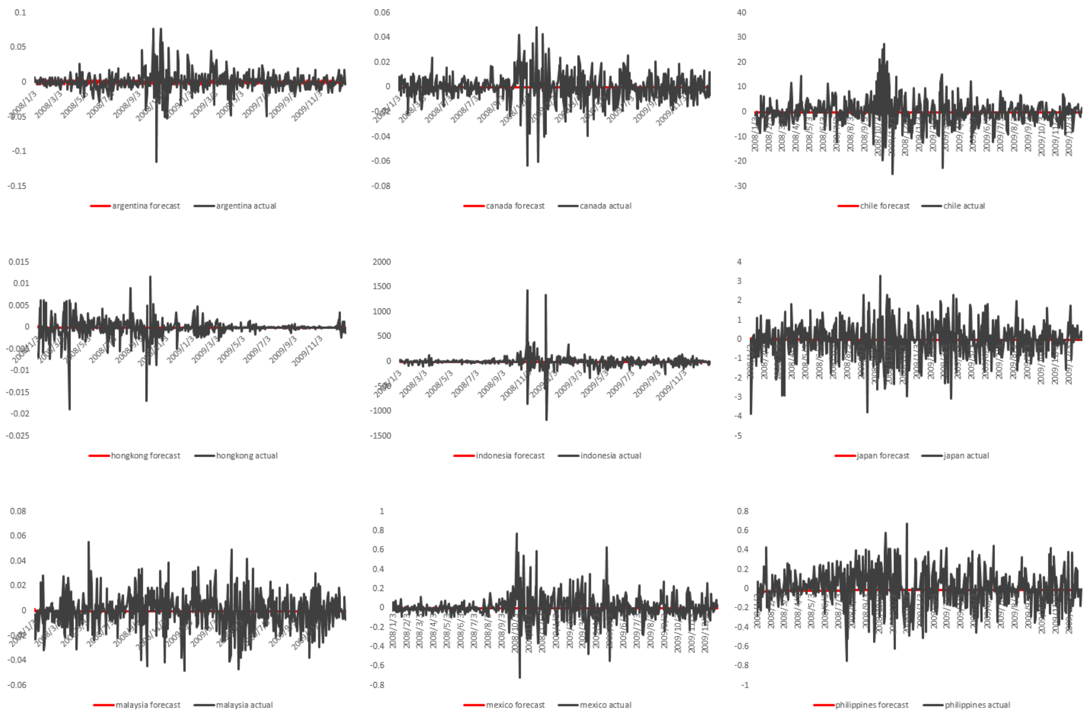
Mexico	-0.4462	0.5718
	(0.1856)	(0.1705)
Philippines	0.5288	-0.4742
	(0.3469)	(0.3666)

The statistics inside the ( ) are Std.Error and all coefficients are significant at 5% level.

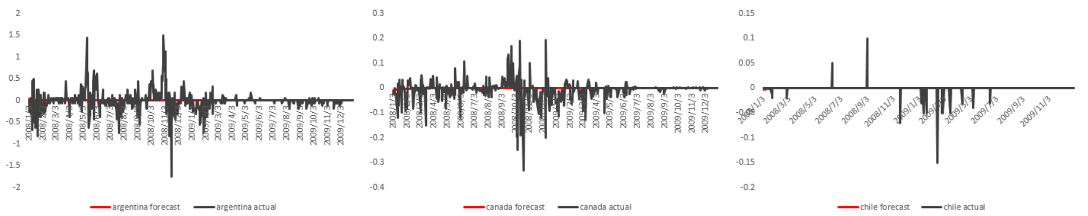
We can see that there are only 8 long memory processes in the above table. Chile and Philippines in the exchange rate market, Canada, Hong Kong and Indonesia in the interest rate market, and Chile, Hong Kong and Indonesia in the stock market. The other 19 are all short memory processes, and as such are very sensitive to the models we use. We observe no correlation between long/short memory feature and region. Both American and Asian countries experience both of the features. Since we are using our most appropriate procedure, the estimation will not be affected. Moreover, because most of the data are short memory processes, we do not expect the shock to have a persistent effect. We then examine the forecast plots.

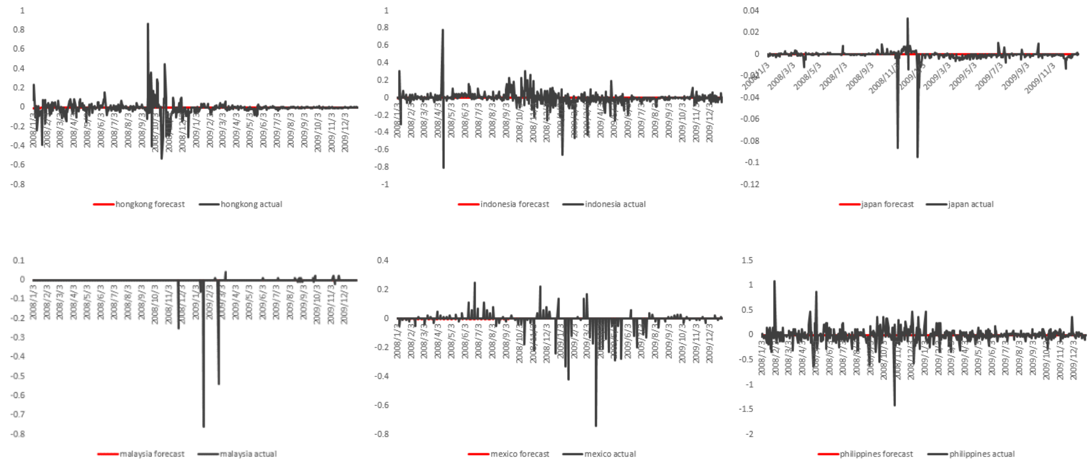
Figure 15: Forecasting Plots

Exchange Rate Forecast

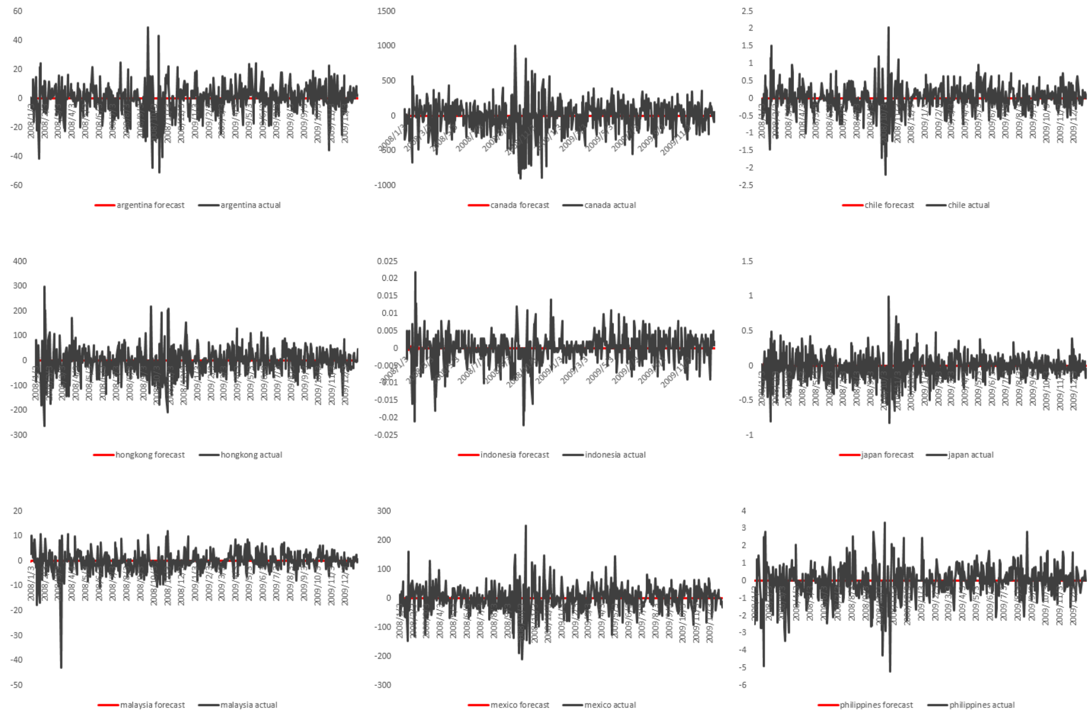


Interest Rate Forecast





Stock Forecast



After taking a quick glance at the plots, we see that the forecast results are just as bad as usual for all countries. This is not affected by the different trade links and regions. We then proceed to the formal tests to see if they confirm our observations.

Table 90: ME, MAE, MSE, MPE and MAPE for Forecasting Models

	ME	MAE	MSE	MPE	MAPE
Exchange Rate					
Argentina	0.0011	0.0094	0.0002	-0.8482	0.8680
Canada	0.0001	0.0076	0.0001	-0.9627	0.9627
Chile	0.0297	3.6333	28.7429	-0.9545	0.9545
Hong Kong	-0.0001	0.0011	5.01E-06	-0.8633	0.8633

Indonesia	0.0602	56.6628	18.0020	-0.9087	0.9087
Japan	-0.0404	0.6700	0.8436	-0.9389	0.9392
Malaysia	0.0002	0.0106	0.0002	-0.9220	0.9220
Mexico	0.0041	0.0819	0.0171	-0.9594	0.9594
Philippines	0.0233	0.1510	0.0385	-1.1483	1.1791
Interest Rate					
Argentina	-0.0037	0.1125	0.0524	-0.5343	0.5343
Canada	-0.0075	0.0198	0.0018	-0.6358	0.6361
Chile	-0.0008	0.0016	0.0001	-0.0304	0.0304
Hong Kong	-0.0055	0.0360	0.0066	-0.8633	0.8633
Indonesia	-0.0006	0.0413	0.0076	-0.7854	0.8753
Japan	-0.0011	0.0019	4.2E-05	-0.6079	0.6079
Malaysia	-0.0028	0.0035	0.0018	-0.0383	0.0383
Mexico	-0.0053	0.0147	0.0033	-0.1688	0.1688
Philippines	-0.0030	0.0899	0.0243	-0.7743	0.7743
Stock					
Argentina	-0.1407	7.6926	119.2974	-0.9904	0.9904
Canada	-5.3224	172.2697	545.8089	-0.9919	0.9919
Chile	0.0069	0.2878	0.1667	-0.9643	0.9766
Hong Kong	-1.6450	44.0069	3641.325	-0.8633	0.8633
Indonesia	-7.1E-05	0.0031	2.03E-05	-0.8180	0.8180
Japan	-0.0075	0.15007	0.0402	-0.9771	0.9771
Malaysia	-0.1187	2.9600	19.1773	-0.9559	0.9559
Mexico	-0.3275	34.8888	2324.409	-0.9908	0.9908
Philippines	-0.0417	0.7220	1.0323	-0.9366	0.9366

The conclusion at which we arrive is identical to that mentioned in the last two chapters. The formal tests of accuracy again confirmed what we observed. The MPE and MAPE tests suggest very high percentage errors. With this said however, there are certain exceptions in the interest rate market, for instance, Chile. This is because the data itself is mostly constant. Again, we see from the forecast results that it doesn't matter what kind of trade links countries have. When shock occurs, it can bring the same changes to all kinds of countries.

The results of the Bai-Perron breakpoint test were presented in the last section, and thus we now proceed to the identification of contagion.

7.5.2 The Identification of Contagion

Tables 91 to 96 provide the result of ‘Identification through Heteroscedasticity’. We will first examine what is happening in the split details and attempt to establish how each element affects the overall movement.

Table 91: Identification of Exchange Rate (idiosyncratic shock)

Argentina Canada					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
-0.9332	2.3076	42.1079*	2.3076	2.23E-5	-0.1982
(0.6383)	(0.3903)		(0.3903)	(512.7169)	
Argentina Chile					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.0058	0.0032	16.5027*	0.0032	54.8699	2.3748*
(0.0003)	(0.0003)		(0.0003)	(35.7371)	
Argentina Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
-3.05E-4	-2.98E-4	-0.0253	-2.98E-4	239.6229	-54.0472*
(52.0672)	(0.0739)		(0.0739)	(11.0954)	
Argentina Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
-1.1879	5.2601	-43.5415*	5.2601	2.91e-5	-0.7399
(0.3998)	(0.5258)		(0.5258)	(19.9351)	
Argentina Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.0967	0.0942	1.9952*	0.0942	1921.4159	-10.4446*
(0.0501)	(0.0102)		(0.0102)	(72.1946)	
Argentina Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.6397	2.0209	14.7706*	2.0209	1.12e-5	1.1238
(0.4511)	(0.3571)		(0.3571)	(118.1782)	
Argentina Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.4567	0.1266	-0.9741	0.1266	1.14E4	-12.9388*
(25.1111)	(0.0138)		(0.0138)	(864.2754)	
Argentina Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.1463	0.1209	12.7901*	0.1209	-7136	11.8418*
(0.0912)	(0.0414)		(0.0414)	(307.2706)	
Canada Chile					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.0017	0.0033	-1.0632			
(0.0095)	(0.0102)				
Canada Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
9.95E-6	134.7279	-62.2579*			
(0.0003)	(3.8564)				
Canada Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat

2.1396	11.9129	-29.2923*	11.9129	5.88E-5	-0.3183
(0.6949)	(0.9742)		(0.9742)	(118.7632)	
Canada Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
0.0709	0.0852	0.1837	0.0852	-6628.7278	166.5272*
(0.4013)	(0.3924)		(0.3924)	(39.8193)	
Canada Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
32.4991	9.3977	5.0839*			
(3.6532)	(2.7020)				
Canada Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
0.6903	0.2156	4.0629*	0.2156	10719	-191.624*
(0.0920)	(0.0719)		(0.0719)	(55.9374)	
Canada Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
6.6509	2.0614	3.9288*	2.0614	2.9341	-0.1646
(1.0413)	(0.5292)		(0.5292)	(5.2752)	
Chile Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
-0.0925	24066	-318.0449*			
(0.0012)	(75.6703)				
Chile Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
1525.25	-1495.98	1.4674	-1495.98	423.3669	0.1481
(3.8257)	(2058.85)		(2058.85)	(367.6969)	
Chile Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
5.7482	14.4823	-37.0241*	14.4823	1076.5	-1.1179
(0.2101)	(0.1072)		(0.1072)	(946.372)	
Chile Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
233.396	155.230	30.6687*			
(2.1920)	(1.3003)				
Chile Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
28.7414	29.6263	-4.0442*	29.6263	4.9870	6.3679*
(0.1778)	(0.1274)		(0.1274)	(3.8011)	
Chile Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
15.3938	23.5230	-59.2728*	23.5230	-60.2676	0.4019
(0.1142)	(0.0758)		(0.0758)	(209.3011)	
Hong Kong Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
0.4478	0.1326	1.4404	0.1326	15.1909	-1.5045
(0.2173)	(0.0256)		(0.0256)	(10.0084)	
Hong Kong Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^*/σ_2^*	T-stat	σ_1 / σ_2	σ_1^*/σ_2^*	T-stat
0.0625	2.3469	-1.3983	2.3469	0.2037	3.2577*
(0.0084)	(1.6335)		(1.6335)	(0.0384)	
Hong Kong Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	

σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
31.3225	8.0265	5.3121*			
(3.6458)	(2.4372)				
Hong Kong Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
13.8849	4.5653	3.4112*	4.5653	29.6562	-1.1181
(2.3720)	(1.3556)		(1.3556)	(22.3997)	
Hong Kong Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
4.0286	1.3010	3.5127*	1.3010	1.8196	-0.3127
(0.6928)	(0.3505)		(0.3505)	(1.6211)	
Indonesia Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
76.0006	279.3618	-47.4601*	279.3618	-24734	0.4615
(1.1214)	(4.1355)		(4.1355)	(53982)	
Indonesia Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-22417	19257.22	-1.3559	19257.22	-3548	0.5000
(5699.87)	(30202)		(30202)	(5736)	
Indonesia Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-197.0625	777.611	-2.5589*	777.611	41283	-2.2873*
(22.0482)	(225.79)		(225.79)	(17707)	
Indonesia Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
488.1732	629.8565	-1.9628			
(25.6557)	(67.4689)				
Japan Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
17.7534	23.8307	-10.3091*	23.8307	57466	-1.8885
(0.3872)	(0.4444)		(0.4444)	(30416)	
Japan Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
1.4362	-2567.26	3.9410*	-2567.26	-160.178	1.6457
(0.0528)	(651.772)		(651.772)	(96.9598)	
Japan Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
5.8331	4.2348	3.6264*	4.2348	1.8984	10.5109*
(0.3849)	(0.2146)		(0.2146)	(0.0578)	
Malaysia Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
0.3384	0.1661	3.2316*	0.1661	-16483	583.626*
(0.0401)	(0.0350)		(0.0350)	(28.2433)	
Malaysia Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
1.0215	-0.6666	1.4488	-0.6666	-4594.41	23.0406*
(0.1463)	(1.1560)		(1.1560)	(199.372)	
Mexico Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
10.6744	10.2380	0.2053	10.2380	1.3274	6.0851*
(1.5407)	(1.4643)		(1.4643)	(0.0011)	

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 92: Identification of Exchange Rate (Common Shock)

Argentina Canada					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-4.1290	4.1289	-2.7950*	4.1289	-878.6307	-0.7978
(0.0003)	(0.0004)		(0.0004)	(8.0695)	
Argentina Chile					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0079	0.0013	-15.2050*	0.0013	0.1673	6.1567
(0.0007)	(0.0003)		(0.0003)	(80.1427)	
Argentina Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0079	-1.16E-4	10.3277*	-1.16E-4	1.58E-5	-10.6125*
(0.0950)	(0.1962)		(0.1962)	(0.0023)	
Argentina Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-11.5567	-11.5589	7.2351	-11.5589	3.19e-6	-3.2005*
(0.0003)	(0.0004)		(0.0004)	(0.0123)	
Argentina Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0457	-0.0458	1.2484	-0.0458	1.8396	-0.1913
(0.0035)	(0.0753)		(0.0753)	(70.3571)	
Argentina Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
5.9521	5.9661	0.6214	5.9661	125.5639	-1.4725
(0.0003)	(0.0171)		(0.0171)	(7.5198)	
Argentina Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0259	0.0293	-3.9133*	0.0293	8.2885	-0.6792
(0.0023)	(0.0012)		(0.0012)	(133.319)	
Argentina Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0412	0.0410	-3.8090*	0.0410	1.1674E-5	-50.9887*
(0.0045)	(0.0078)		(0.0078)	(0.0105)	
Canada Chile					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
9.63E-4	-0.0254	0.3648			
(0.0106)	(0.0290)				
Canada Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-6.67E-5	-627.1259	-2.2128*			
(0.0003)	(12.9453)				
Canada Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.7998	-10.2111	-18.3488*	-10.2111	-1.01E-5	5.2048*
(0.0071)	(0.0260)		(0.0260)	(0.0040)	
Canada Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0591	-0.0596	2.4835*	-0.0596	0.0416	15.2304*

(0.1365)	(0.1089)		(0.1089)	(0.0035)	
Canada Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.1172	0.1998	-0.8948			
(0.3505)	(0.0517)				
Canada Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0496	0.0597	-5.1770*	0.0597	0.0367	9.0795*
(0.0015)	(0.0012)		(0.0012)	(0.0022)	
Canada Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.1022	0.1027	-0.0132	0.1027	0.9707	-29.1107*
(0.0297)	(0.0297)		(0.0297)	(0.0020)	
Chile Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0184	-3.8189	0.9982			
(0.0007)	(3.8072)				
Chile Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-184.6397	-6822.06	113.89*	-6822.06	0.0071	-51.3113*
(58.1117)	(4.3768)		(4.3768)	(0.0087)	
Chile Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
53.4707	-16.6232	0.7557	-16.6232	0.2936	-13.4504*
(82.3499)	(42.6761)		(42.6761)	(0.0207)	
Chile Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
697.728	79.4394	42.0972*			
(14.6435)	(1.1312)				
Chile Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-19.1911	872.3983	-2.7151*	872.3983	0.0015	1.6664
(41.5046)	(325.747)		(325.747)	(0.0013)	
Chile Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
138.5716	34.1970	1.5405	34.1970	0.0016	3.9868*
(65.1870)	(18.4706)		(18.4706)	(0.0019)	
Hong Kong Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0511	-0.0263	2.6424*	-0.0263	15.4140	-4.6826*
(0.0240)	(0.0167)		(0.0167)	(3.2973)	
Hong Kong Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0378	0.0233	1.5314	0.0233	9712.62	-1.3311
(0.0068)	(0.0066)		(0.0066)	(7296.56)	
Hong Kong Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0125	0.0029	17.1204*			
(0.0004)	(0.0003)				
Hong Kong Mexico					
	Period 1/Period 2			**Period 2/Period 3**	

σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0716	0.0723	-0.0215	0.0723	304843	-26.7169*
(0.0223)	(0.0223)		(0.0223)	(304843)	
Hong Kong Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0609	0.0581	0.1087	0.0581	0.9994	-51.3384*
(0.0182)	(0.0183)		(0.0183)	(0.000027)	
Indonesia Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-113.559	839.257	-30.8672*	839.257	-0.0222	7.1425*
(2.1520)	(30.7931)		(30.7931)	(0.0149)	
Indonesia Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-17009	37455	-3.1785*	37455	-0.0293	11.5132*
(17135)	(52.6731)		(52.6731)	(0.0174)	
Indonesia Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-1558.7	-3590.33	0.5815	-3590.33	-0.0283	-13.1595*
(3482.57)	(272.828)		(272.828)	(0.0246)	
Indonesia Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-5.5710	257.554	-4.5882*			
(55.7838)	(13.3030)				
Japan Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-211.6482	-876.8302	1.7898	-876.8302	-0.0062	-2.5689*
(147.0709)	(341.3118)		(341.3118)	(0.0060)	
Japan Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-38.5017	-54.4616	11.7088*	-54.4616	-89.5798	14.0006*
(0.7701)	(1.1246)		(1.1246)	(1.8177)	
Japan Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.7213	1.4393	-6.6823*	1.4393	0.0891	16.4040*
(0.0752)	(0.0766)		(0.0766)	(0.0299)	
Malaysia Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0244	0.0302	-6.2922*	0.0302	0.0234	4.5412*
(0.0006)	(0.0006)		(0.0006)	(0.0013)	
Malaysia Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0164	-0.0042	4.2571*	-0.0042	0.5373	-37.6852*
(0.0026)	(0.0041)		(0.0041)	(0.0137)	
Mexico Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
10.0940	7.8502	3.4824*	7.8502	0.0169	20.1071*
(0.5131)	(0.3895)		(0.3895)	(0.0034)	

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Indeed, 39 transmission periods (60%) of the idiosyncratic shocks are identified as contagion and 44 transmission periods (63.1%) of the common shocks are identified as contagion. We found 18 counter contagion effects in idiosyncratic shocks, and 7 of them finally changed in direction. Common shock had 16 counter contagion effects, while only 4 of them finally changed in direction. Referring back to the exchange rate correlation results, we found exactly the same proportion of change in direction with the common shock. In this regard, the effects of the common shock overpower the idiosyncratic shock as they represent the overall effect in a better way. As for the way in which the ratios change in those counter contagion effects, there was hardly any pattern in terms of how they change in idiosyncratic shocks. However, most of the ratios increased first before declining in the common shock, just like the overall effect. The effect of the common shock prevails again. It's also worth noticing that if we look at the common shock and idiosyncratic shock separately, they both have fewer contagion effects compare to that of the overall correlation. In most cases, such as Argentina and Canada, Canada and Chile, the corresponding contagion effects in both common shock and idiosyncratic shock are not significant, however, they become significant if we put them together. This result further illustrate that the correlation methods are biased due to the lack of details and the techniques only focus on common shock are also biased because they ignore the importance of idiosyncratic shock.

Table 93: Identification of Interest Rate (Idiosyncratic Shock)

Argentina Canada											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-2.1859	2.3336	-2.82*	2.3336	1.6716	-8.86*	1.6716	1.8337	-0.95	1.8337	-0.0334	5.45*
(1.5777)	(0.2902)		(0.2902)	(0.0911)		(0.0911)	(0.1425)		(0.1425)	(0.3427)	
Argentina Chile											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
1.9614	10.8067	-8.60*	10.8067	-1.2579	10.45*						
(0.1858)	(1.0110)		(1.0110)	(0.5565)							
Argentina Hong Kong											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
1470.5	-29.886	17.25*	-29.886	20.091	-0.64	20.091	12.001	0.36			
(86.926)	(1.1077)		(1.1077)	(19.187)		(19.187)	(11.237)				
Argentina Indonesia											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
106.27	-5314.1	7.33*	-5314.1	-0.5658	8.49*	-0.5658	-4243	4.08*			
(5.1612)	(739.43)		(739.43)	(2.9143)		(2.9143)	(1038.4)				
Argentina Japan											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
2.6863	14.328	-9.09*	14.328	15.549	-6.93*	15.549	0.0478	7.79*			
(0.2431)	(1.2569)		(1.2569)	(1.9827)		(1.9827)	(0.1647)				

	Period 1/Period 2			Period 2/Period 3			Period 3/Period 4			Period 4/Period 5		
	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
Argentina Malaysia	4.47E5	6.75E5	-1.43	6.75E5	1.5221	5.11*	1.5221	6675.1	-7.51*			
	(87686)	(1.32E5)		(1.32E5)	(0.0036)		(0.0036)	(888.32)				
Argentina Mexico	25.120	0.2938	-1.56	0.2938	4.3594	2.32*	4.3594	0.6461	7.29*			
	(0.4412)	(14.752)		(14.752)	(0.4051)		(0.4051)	(0.3086)				
Argentina Philippines	17.076	8.3415	6.32*	8.3415	1.0111	4.92*	1.0111	0.0509	6.13*			
	(1.2893)	(0.4941)		(0.4941)	(0.0011)		(0.0011)	(0.1565)				
Canada Chile	0.4865	-1.14E5	3.46*	-1.14E5	-188.63	-0.17	-188.63	-4859.1	3.98*			
	(0.0004)	(33057)		(33057)	(183.58)		(183.58)	(1219.4)				
Canada Hong Kong	84.903	1.5651	3.49*	1.5651	-2186.7	4.53*						
	(23.838)	(0.0298)		(0.0298)	(483.24)							
Canada Indonesia	4.2309	4.5297	-1.85	4.5297	0.3159	36.81*	0.3159	-369.34	1.80	-369.34	308.02	-1.36
	(0.1132)	(0.1144)		(0.1144)	(0.0027)		(0.0027)	(204.51)		(204.51)	(334.31)	
Canada Japan	-17.083	20.023	-123*	20.023	32.486	-0.69	32.486	-1821.6	4.08*			
	(0.1907)	(0.2308)		(0.2308)	(16.348)		(16.348)	(445.67)				
Canada Malaysia	5.2613	0.7274	57.15*	0.7274	0.7305	-0.09	0.7305	-436.95	4.41*			
	(0.0725)	(0.0321)		(0.0321)	(0.0004)		(0.0004)	(99.187)				
Canada Mexico	7.1674	1.8941	57.49*	1.8941	1.7482	0.03	1.7482	13673	-4.07*			
	(0.0816)	(0.0418)		(0.0418)	(4.7948)		(4.7948)	(3347.3)				
Canada Philippines	0.7341	0.3057	11.41*	0.3057	0.6946	3.41*	0.6946	0.5858	1.74			
	(0.0218)	(0.0305)		(0.0305)	(0.0313)		(0.0313)	(0.0539)				
Chile Hong Kong	4.9377	2.8040	1.4803		2769.5	-4.84*						
	(0.8238)	(1.1826)			(571.05)							
Chile Indonesia	13.841	13.572	0.07	13.572	2.0659	6.63*						
	(2.3759)	(2.4322)		(2.4322)	(0.1641)							
Chile Japan			3.12*			-1.04						

1922.2	11.763		11.763	47.543							
(610.70)	(3.3472)		(3.3472)	(34.083)							
Chile Malaysia											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
6.8844	0.4240	38.2*	0.4240	-4651.5	10.59*						
(0.1622)	(0.0469)		(0.0469)	(439.31)							
Chile Mexico											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
7.9257	1.2014	14.5*	1.2014	0.1960	4.85*						
(0.4117)	(0.2071)		(0.2071)	(0.0004)							
Chile Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
1.6509	2.3487	-0.59	2.3487	10022	-5.04*						
(0.2686)	(1.1405)		(1.1405)	(1985.5)							
Hong Kong Indonesia											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
48.429	31.010	6.69*	31.010	52.125	-1.49	52.125	-4525.0	3.93*			
(2.1943)	(1.3991)		(1.3991)	(45.456)		(45.456)	(1152.0)				
Hong Kong Japan											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-52.821	-1.4943	-24.9*	-1.4943	365.23	-0.88						
(2.0536)	(0.1621)		(0.1621)	(409.21)							
Hong Kong Malaysia											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
4.0927	1.0843	45.16*	1.0843	-24.298	0.12						
(0.0607)	(0.0273)		(0.0273)	(207.77)							
Hong Kong Mexico											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
32.724	6.7342	2.18*	6.7342	33.567	-0.11						
(11.850)	(0.7616)		(0.7616)	(184.59)							
Hong Kong Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
3.7057	3.5901	1.17	3.5901	597.74	-0.68						
(0.0721)	(0.0671)		(0.0671)	(856.45)							
Indonesia Japan											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
9.3031	15.736	-2.08*	15.736	-1.25E5	3.31*	-1.25E5	35.846	-3.32*			
(0.8733)	(2.9645)		(2.9645)	(37713)		(37713)	(28.633)				
Indonesia Malaysia											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
465.96	66.674	22.8*	66.674	1.0914	21.1*	1.0914	0.7419	-3.86*			
(17.381)	(2.1278)		(2.1278)	(0.0004)		(0.0004)	(0.0252)				
Indonesia Mexico											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
1583.1	2.0986	2.66*	2.0986	-10989	4.74*	-10989	-500.56	-4.49*			
(594.01)	(0.1731)		(0.1731)	(2319.0)		(2319.0)	(239.69)				
Indonesia Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
803.88	1.2898	4.43*	1.2898	32911	-205.6*	32911	-3012.8	164.8*			
(180.78)	(0.0857)		(0.0857)	(160.01)		(160.01)	(36.541)				
Japan Malaysia											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		

σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
1.2489	0.0091	0.39	0.0091	-2319.0	7.05*						
(3.1275)	(0.0426)		(0.0426)	(328.82)							
Japan Mexico											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
117.38	25.431										
(19.493)	(8.008)										
Japan Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
6.7285	2.2097	3.63*	2.2097	2.4905	-0.10*						
(1.0941)	(0.5882)		(0.5882)	(2.7321)							
Malaysia Mexico											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
11.761	3.5063	1.25	3.5063	-218.92	1.43						
(1.1986)	(6.4847)		(6.4847)	(177.15)							
Malaysia Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
2.3873	0.6971	64.36*	0.6971	2724.2	-3.82*						
(0.0241)	(0.0102)		(0.0102)	(711.28)							
Mexico Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
2663.5	8.7475	6.87*	8.7475	8375.1	-5.05*						
(386.08)	(1.2816)		(1.2816)	(1652.3)							

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 94: Identification of Interest Rate (Common Shock)

Argentina Canada											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat
340.48	-146.15	4.59*	-146.15	24.729	-8.81*	24.729	-227.12	4.05*	-227.12	0.3984	-4.24*
(104.14)	(19.334)		(19.334)	(3.8927)		(3.8927)	(61.998)		(61.998)	(0.0691)	
Argentina Chile											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat
3.01E4	-230.51	28.87*	-230.51	0.1309	-32.1*						
(1052.5)	(7.2029)		(7.2029)	(0.0304)							
Argentina Hong Kong											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat
24.212	-27.454	48.89*	-27.454	-5.8189	26.49*	-5.8189	1.7903	-33.1*			
(0.5928)	(0.8748)		(0.8748)	(0.2234)		(0.2234)	(0.0547)				
Argentina Indonesia											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat
18.516	97.383	-38.9*	97.383	0.0081	24.39*	0.0081	0.2578	-0.96			
(0.4626)	(1.9721)		(1.9721)	(0.0021)		(0.0021)	(0.2068)				
Argentina Japan											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat
-2568.5	-263.81	-0.98	-263.81	254.68	-16.2*	254.68	0.2260	10.02*			
(2333.7)	(7.8213)		(7.8213)	(25.391)		(25.391)	(0.0511)				
Argentina Malaysia											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma_{c1}^* / \sigma_{c2}^*$	T-stat
0.4829	8.4012	-2.84*	8.4012	0.0296	2.84*	0.0296	0.6324	-18.6*			
(0.0667)	(3.0102)		(3.0102)	(0.0067)		(0.0067)	(0.0277)				

	Period 1/Period 2			Period 2/Period 3			Period 3/Period 4			Period 4/Period 5		
	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
Argentina Mexico	-17.742	-17.742	89.53*	-17.742	-4.3570	5.18*	-4.3570	0.2384	-5.18*			
	(0.1855)	(0.1855)		(0.1855)	(0.8840)		(0.8840)	(0.0585)				
Argentina Philippines	23.069	51.116	-17.7*	51.116	4.4731	-7.71*	4.4731	0.3151	7.68*			
	(0.6964)	(1.4201)		(1.4201)	(0.5356)		(0.5356)	(0.0746)				
Canada Chile	10252	-3.13E5	207.7*	-3.13E5	0.0384	-61.7*	0.0384	-0.7688	1.08			
	(1537.3)	(242.82)		(242.82)	(0.0081)		(0.0081)	(0.7920)				
Canada Hong Kong	0.0085	-0.0004	19.83*	-0.0004	0.0384	-1.06						
	(0.0003)	(0.0003)		(0.0003)	(0.0087)							
Canada Indonesia	-0.0139	-0.8151	3.42*	-0.8151	0.0017	-16.2*	0.0017	1.0360	-69.2*	1.0360	0.1023	51.19*
	(0.2283)	(0.0504)		(0.0504)	(0.0004)		(0.0004)	(0.0070)		(0.0070)	(0.0175)	
Canada Japan	0.0030	0.0047	-3.45*	0.0047	0.0022	4.25*		9.8062	-4.04*			
	(0.0003)	(0.0003)		(0.0003)	(0.0004)			(2.3913)				
Canada Malaysia	0.0707	-0.0128	0.91	-0.0128	0.0019	-19.1*	0.0019	0.6988	-24.5*			
	(0.0917)	(0.0006)		(0.0006)	(0.0004)		(0.0004)	(0.0236)				
Canada Mexico	0.0029	-0.0047	13.38*	-0.0047	0.0023	-10.3*	0.0023	1.3324	-15.5*			
	(0.0003)	(0.0004)		(0.0004)	(0.0004)		(0.0004)	(0.0741)				
Canada Philippines	-0.1137	-0.0108	-0.73	-0.0108	-1.6090	2.91*	-1.6090	0.4355	-3.28*			
	(0.1395)	(0.0180)		(0.0180)	(0.6189)		(0.6189)	(0.0670)				
Chile Hong Kong	0.0286	0.0242	0.4082		0.3877	-1.91						
	(0.0075)	(0.0076)			(0.1848)							
Chile Indonesia	0.0347	0.0357	-0.06	0.0357	55.926	-5.67*						
	(0.0111)	(0.0111)		(0.0111)	(9.8252)							
Chile Japan	-26073	3254.4	-7.17*	3254.4	0.1428	3.01*						
	(3940.3)	(1081.8)		(1081.8)	(0.0222)							
Chile Malaysia												

σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0011	-0.0005	3.19*	-0.0005	0.3328	-18.9*						
(0.0003)	(0.0004)		(0.0004)	(0.0142)							

Chile Mexico

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0008	0.0126	-23.7*	0.0126	0.0037	11.50*						
(0.0003)	(0.0004)		(0.0004)	(0.0006)							

Chile Philippines

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0236	0.0211	0.27	0.0211	1.2087	-49.9*						
(0.0066)	(0.0066)		(0.0066)	(0.0202)							

Hong Kong Indonesia

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-31.564	57.308	-1.21	57.308	0.0065	1.06	0.0065	0.1568	-0.42			
(10.337)	(72.866)		(72.866)	(0.0016)		(0.0016)	(0.2429)				

Hong Kong Japan

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
95.469	53.772	2.30*	53.772	0.0341	4.01*						
(5.3112)	(17.288)		(17.288)	(0.0073)							

Hong Kong Malaysia

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0027	-0.0077	1.61	-0.0077	0.0017	-14.4*						
(0.0064)	(0.0005)		(0.0005)	(0.0004)							

Hong Kong Mexico

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
230.62	18.141	28.78*	18.141	0.0289	13.23*						
(7.3467)	(0.7179)		(0.7179)	(0.0067)							

Hong Kong Philippines

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0034	-0.0134	1.26	-0.0134	0.0231	0.21						
(0.0057)	(0.0054)		(0.0054)	(0.0055)							

Indonesia Japan

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
2804.5	23.281	21.45*	23.281	-33.817	2.29*	-33.817	0.0732	-40.9*			
(128.02)	(20.446)		(20.446)	(0.8268)		(0.8268)	(0.0153)				

Indonesia Malaysia

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-2196.7	-16.402	-50.4*	-16.402	0.0040	-30.5*	0.0040	700.45	-23.3*			
(43.183)	(0.3388)		(0.3388)	(0.0008)		(0.0008)	(181.01)				

Indonesia Mexico

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0061	0.0157	-6.64*	0.0157	0.0502	0.03	0.0502	0.9934	-69.9*			
(0.0010)	(0.0010)		(0.0010)	(0.0132)		(0.0132)	(0.0022)				

Indonesia Philippines

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0469	-0.0473	0.30	-0.0473	0.0277	-40.8*	0.0277	0.0595	-5.02*			
(0.0009)	(0.0009)		(0.0009)	(0.0015)		(0.0015)	(0.0039)				

Japan Malaysia

Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0051	-0.0022	-6.38*	-0.0022	0.8157	-84.4*						

(0.0003)	(0.0003)		(0.0003)	(0.0089)							
Japan Mexico											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0934	0.0936										
(0.0274)	(0.0274)										
Japan Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0886	0.0894	-0.02	0.0894	1.0054	-34.1*						
(0.0268)	(0.0268)		(0.0268)	(0.0004)							
Malaysia Mexico											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.1287	0.3757	-13.7*	0.3757	0.0301	0.17						
(0.0323)	(0.0172)		(0.0172)	(0.0071)							
Malaysia Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0007	0.0076	-13.7*	0.0076	0.0690	-2.99*						
(0.0003)	(0.0003)		(0.0003)	(0.0106)							
Mexico Philippines											
Period 1/Period 2			**Period 2/Period 3**			**Period 3/Period 4**			**Period 4/Period 5**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
7.9195	5.4368	4.81*	5.4368	2.0706	12.08*						
(0.4249)	(0.2930)		(0.2930)	(0.1807)							

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

There are 66 transmission periods (72.5%) of the idiosyncratic shocks identified as contagion and 70 transmission periods (76.9%) of the common shocks identified as contagion. We found 39 counter contagion effects in idiosyncratic shocks, while 15 of them finally changed in direction. Common shock had 34 counter contagion effects, with 14 of these finally changing direction. Common shock is again closer to the overall effect, which has 33 counter contagions. However, the number of changes in direction for both shocks is very different from the overall effect (22). This result again confirmed that both shock must be combined together to analyse the behaviour of the overall effects. We do not observe much similar pattern in interest rate as we did with exchange rate. Neither shock can represent the overall effect alone. They both play an important role in the combined result. As for the way in which the ratios change in those counter contagion effects, there was hardly any pattern in terms of how they change in both shocks, just as was the case with the overall effect of interest rate market. Recall that we detected the most significant breakpoints for interest rate and no significant breakpoints for exchange rate. Both market identified large proportion of contagion, yet exchange rate market's common shock clearly has more similar pattern with the overall correlation. Therefore we conclude that significant structural changes have more effects on common shock.

Table 95: Identification of Stock (Idiosyncratic Shock)

	Period 1/Period 2			Period 2/Period 3	
Argentina Canada					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
277.8551	0.1176	1.2334	0.1176	-179.0615	5.9788*
(225.1721)	(0.0448)		(0.0448)	(30.1558)	
Argentina Chile					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
5.5392	-30.8283	26.5464*	-30.8283	74.9204	-0.0086
(0.3244)	(1.3309)		(1.3309)	(7430.30)	
Argentina Hong Kong					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-0.2144	9889.4	-43.5157*			
(0.0030)	(227.26)				
Argentina Indonesia					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-6622.2241	2128.9356	-4.1972*	2128.9356	-4048.5118	1.2221
(2084.9493)	(6.7821)		(6.7821)	(5054.9687)	
Argentina Japan					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
29.5564	67.6240	-11.1874*	67.6240	40.7575	-8.9354*
(0.0204)	(3.4026)		(3.4026)	(4.6176)	
Argentina Malaysia					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
11.5262	-155.7981	2.6161*			
(10.3651)	(63.1119)				
Argentina Mexico					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
0.4035	0.0574	1.2366	0.0574	-768.0446	4.0735*
(0.2361)	(0.1501)		(0.1501)	(188.3499)	
Argentina Philippines					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
9.0676	-10.1725	4.0334*			
(0.0093)	(4.7701)				
Canada Chile					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
7556.3607	-14518.3627	3.1949*			
(2263.9418)	(6527.9153)				
Canada Hong Kong					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-4.6558	171.6911	-1.8342	171.6911	-18.9469	1.9554
(0.7161)	(96.1397)		(96.1397)	(16.1641)	
Canada Indonesia					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
3.3353	524.4557	-5.2328*			
(0.0787)	(99.5861)				
Canada Japan					
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
258.5141	224.7814	1.7982	224.7814	132249.7564	-2.5248*
(13.3957)	(13.1312)		(13.1312)	(52290.6301)	

Canada Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-9132089.2195	260231.3272	-29.9586*	260231.3272	-467.0282	7.2523*
(311441.9897)	(35946.7002)		(35946.7002)	(34.2205)	
Canada Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
1.9858	-896.1948	13.9238*	-896.1948	1129.7514	-0.0838
(0.7608)	(64.5023)		(64.5023)	(14511.1233)	
Canada Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
129.4729	223.0070	-2.2017*	223.0070	4898.6616	-0.2165
(0.8381)	(42.4738)		(42.4738)	(21347.3979)	
Chile Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
255.4468	0.1390	0.2673	0.1390	1362.8471	-5.3131*
(955.0266)	(0.5453)		(0.5453)	(256.9860)	
Chile Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-34.0332	5702.9946	-3.9444*	5702.9946	32.4447	-7.3240*
(14.3173)	(1454.3926)		(1454.3926)	(4.4152)	
Chile Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
10.6389	11.2649	-2.8195*	11.2649	-324.6052	1.0581
(0.1427)	(0.1700)		(0.1700)	(337.2960)	
Chile Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
0.2975	4045.3267	-8.8450*	4045.3267	0.0791	8.8455*
(0.0144)	(457.3215)		(457.3215)	(0.0623)	
Chile Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
0.0109	-1123.0621	1.0273	-1123.0621	-0.8588	-1.6601
(0.0022)	(1093.1345)		(1093.1345)	(0.8498)	
Chile Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-1.0489	0.9216	-37.7050*	0.9216	-104.4717	0.3207
(0.0324)	(0.0409)		(0.0409)	(328.5673)	
Hong Kong Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-13145.2625	-24053.1597	1.7778	-24053.1597	-288.6628	-7.9314*
(5364.0093)	(2978.7309)		(2978.7309)	(323.3265)	
Hong Kong Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-84.3027	41.0255	-15.6546*	41.0255	405.8773	-0.6848
(7.5293)	(2.7205)		(2.7205)	(532.7674)	
Hong Kong Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1/σ_2	σ_1^*/σ_2^*	T-stat	σ_1/σ_2	σ_1^*/σ_2^*	T-stat
-19.4682	896.2542	-3.0774*			
(0.1129)	(297.5576)				
Hong Kong Mexico					
	Period 1/Period 2			**Period 2/Period 3**	

σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.3643	-853.6771	9.2036*	-853.6771	70.5851	-0.8218
(0.1747)	(92.7931)		(92.7931)	(55.6104)	
Hong Kong Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
-2938981.1710	102.2826	-100.1221*			
(29354.8641)	(81.4064)				
Indonesia Japan					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.1498	955.9914	-1.0821	955.9914	0.1562	1.0821
(0.0225)	(883.3116)		(883.3116)	(0.0005)	
Indonesia Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.3667	0.0926	2.5237*	0.0926	0.5316	-0.4833
(0.1084)	(0.0051)		(0.0051)	(0.4075)	
Indonesia Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.0036	0.0124	-2.9045*	0.0124	-0.0329	2.1084*
(0.0021)	(0.0022)		(0.0022)	(0.0218)	
Indonesia Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.0852	0.0568	1.6302	0.0568	4516.0689	-1.2889
(0.0145)	(0.0095)		(0.0095)	(3503.7302)	
Japan Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
-0.0409	-4740.1973	633.8263*	-4740.1973	0.0018	-633.8321*
(0.0004)	(7.4786)		(7.4786)	(0.0003)	
Japan Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
-0.0027	3560.5800	-444.8297*			
(0.0006)	(8.0043)				
Japan Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.5724	-12875.6541	6.7901*	-12875.6541	0.5441	-6.7901*
(0.0242)	(1896.3071)		(1896.3071)	(0.0852)	
Malaysia Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
0.1285	0.1031	0.6937	0.1031	6039.3517	-528.4273*
(0.0222)	(0.0290)		(0.0290)	(11.4286)	
Malaysia Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
-4.8826	47.2087	-1.1574			
(0.1142)	(45.0044)				
Mexico Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
σ_1 / σ_2	σ_1^* / σ_2^*	T-stat	σ_1 / σ_2	σ_1^* / σ_2^*	T-stat
17.1069	5.9038	31.1936*	5.9038	365.4191	-1.3259
(0.1786)	(0.3115)		(0.3115)	(265.5621)	

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

Table 96: Identification of Stock (Common Shock)

Argentina Canada					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0454	-0.0072	2.5702*	-0.0072	0.5086	-2.8949*
(0.0044)	(0.0200)		(0.0200)	(0.0284)	
Argentina Chile					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
150.6200	31.2364	1.0018	31.2364	41.6138	-28.2121*
(119.1074)	(3.5516)		(3.5516)	(0.5007)	
Argentina Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0997	0.8421	-12.0416*			
(0.0047)	(0.0614)				
Argentina Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
1226.8772	155.2068	40.5301*	155.2068	0.0001	353.4517*
(26.4377)	(0.4391)		(0.4391)	(0.0003)	
Argentina Japan					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
222.9250	55.8151	560.3289*	55.8151	-402.8994	6.0719*
(0.1956)	(0.2251)		(0.2251)	(66.5752)	
Argentina Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
4.5582	-1.0786	35.8427*			
(0.0568)	(0.1466)				
Argentina Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.1136	0.0717	1.1396	0.0717	0.3882	-1.3936
(0.0096)	(0.0355)		(0.0355)	(0.0104)	
Argentina Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
20.0339	0.5026	26.6771*			
(0.0302)	(0.7315)				
Canada Chile					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
110.7649	1226.8846	-43.6063*			
(25.5654)	(1.2367)				
Canada Hong Kong					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
3.2241	4.4537	-0.7529	4.4537	-0.0039	4.0931*
(1.2172)	(1.0890)		(1.0890)	(0.0042)	
Canada Indonesia					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
7.1166	-3.4134	12.9501*			
(0.1079)	(0.8059)				
Canada Japan					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
979.1849	129.9216	49.4232*	129.9216	-0.0054	18.7745*
(15.7283)	(6.9203)		(6.9203)	(0.0081)	
Canada Malaysia					

Period 1/Period 2			Period 2/Period 3		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
1.8518	19.4892	-5.6487*	19.4892	-0.0040	6.4550*
(0.7933)	(3.0198)		(3.0198)	(0.0026)	
Canada Mexico					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
4.0182	38.9217	-11.9134*	38.9217	7.5470	-17.4205*
(0.4118)	(2.9006)		(2.9006)	(0.1985)	
Canada Philippines					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
137.7458	284.0081	-19.1141*	284.0081	-0.0055	116.9870*
(7.5722)	(1.1023)		(1.1023)	(0.0042)	
Chile Hong Kong					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.2982	2.4911	-0.8199	2.4911	0.7277	0.9819
(0.3929)	(2.6454)		(2.6454)	(0.0281)	
Chile Indonesia					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
613.2111	12.0066	4.1058*	12.0066	223.7125	1.5584
(146.3553)	(4.5414)		(4.5414)	(20.4658)	
Chile Japan					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0062	-0.0032	6.1833*	-0.0032	17.4758	-4.5883*
(0.0011)	(0.0009)		(0.0009)	(3.8039)	
Chile Malaysia					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0634	0.2328	-6.8655*	0.2328	0.0820	6.3322*
(0.0156)	(0.0190)		(0.0190)	(0.0142)	
Chile Mexico					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0124	31.2094	-11.8897*	31.2094	0.0493	-4.3232*
(0.0004)	(2.6238)		(2.6238)	(0.0098)	
Chile Philippines					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0811	0.0231	1.9531	0.0231	1.0222	-219.2265*
(0.0293)	(0.0045)		(0.0045)	(0.0003)	
Hong Kong Indonesia					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
159.1362	14394.2644	-1201.5629*	14394.2644	-0.0002	1216.7047*
(0.6277)	(11.8305)		(11.8305)	(0.0004)	
Hong Kong Japan					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
204.9191	94.7338	14.1145*	94.7338	-0.0044	40.4430*
(7.4467)	(2.3424)		(2.3424)	(0.0083)	
Hong Kong Malaysia					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
13.3506	1.9560	35.0374*			
(0.0946)	(0.3111)				
Hong Kong Mexico					
Period 1/Period 2			**Period 2/Period 3**		
σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	σ_{c1}/σ_{c2}	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
		-1.5016			-15.4411*

1.1404	1.9784		1.9784	2.4437	
(0.5147)	(0.2154)		(0.2154)	(0.1325)	
Hong Kong Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
52.2616	0.0958	206.3633*			
(0.2527)	(0.0056)				
Indonesia Japan					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0167	0.0197	-4.8537*	0.0197	0.0039	19.2745*
(0.0004)	(0.0004)		(0.0004)	(0.0007)	
Indonesia Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
-0.0112	0.0076	-2.2917*	0.0076	0.1029	-0.1223
(0.0049)	(0.0065)		(0.0065)	(0.0167)	
Indonesia Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0065	0.0086	-0.6791	0.0086	0.0180	-2.2728*
(0.0020)	(0.0023)		(0.0023)	(0.0032)	
Indonesia Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0332	0.0241	1.1259	0.0241	0.7724	-41.1672*
(0.0057)	(0.0056)		(0.0056)	(0.0172)	
Japan Malaysia					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0384	15.8742	-8.7145*	15.8742	0.0021	8.7346*
(0.0003)	(1.8171)		(1.8171)	(0.0004)	
Japan Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0017	-446.3305	2.7592*			
(0.0004)	(161.7572)				
Japan Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0876	-0.0082	1.4571	-0.0082	0.0406	-0.8286
(0.0305)	(0.0583)		(0.0583)	(0.0089)	
Malaysia Mexico					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
0.0228	0.0262	-1.3940	0.0262	0.0009	11.6742*
(0.0011)	(0.0021)		(0.0021)	(0.0002)	
Malaysia Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
3.9375	0.4734	66.7633*			
(0.0251)	(0.0453)				
Mexico Philippines					
	Period 1/Period 2			**Period 2/Period 3**	
$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat	$\sigma_{c1} / \sigma_{c2}$	$\sigma^*_{c1}/\sigma^*_{c2}$	T-stat
333.7004	112.6477	0.7483	112.6477	219.5209	-10.6372*
(293.1267)	(36.4544)		(36.4544)	(6.3319)	

***denotes significance at 5%, **denotes significance at 1%, the value reported in the table are not mean but convergent values, standard errors are reported in parentheses.**

In total, 39 transmission periods (60.9%) of the idiosyncratic shocks are identified as contagion and 44 transmission periods (68.8%) of the common shocks are identified as contagion. We found 22 counter contagion effects in idiosyncratic shocks, with 7 of them finally changing in direction. Common shock had 22 counter contagion effects, with 6 of them finally changing in direction. Both of the shocks have more than enough contagion effects to match the number of the overall effect. Again, their effect must be combined to reflect the entire movement. The same holds for the change in direction. The overall effects have only 1 change in direction in all the counter contagion effects while both shocks have many more than this. Compare to the results of the exchange rate market, where the effects of the split shocks accumulate, their effects in stock market tend to offset against each other and their number reduced across the whole movement.

7.6 Causality Test and Impulse Response Analysis

We will now examine the statistical linkage between the countries. Many empirical work used granger causality test to identify contagion. The idea is to test for chances in the causal relationships between adjoining regimes. If statistically significant changes were detected, they are interpreted as contagion. For example, by using daily exchange rate, Gray (2009) found significant contagion among the EU-8 countries. Gómez-Puig and Sosvilla-Rivero (2014) also showed that the causal relationships increases as the sovereign debt crisis reveals itself in the euro zone. We will answer the third question in an attempt to establish the duration of the contagion effects. Tables 97 to 102 summarise the result of the co-integration test and the granger causality test (please see the Appendix 5 for figures related to the impulse response analysis).

Table 97: Co-Integration Test of Exchange Rate

	Period 1	**Period 2**	**Period 3**
Argentina/Canada	140.0466**[1]	39.2835**[1]	209.0907**[6]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Chile	130.0764**[1]	63.4993**[2]	208.5479**[7]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Hongkong	148.9087**[1]	55.7697**[3]	225.4183**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Indonesia	140.9844**[1]	46.2026**[2]	183.1506**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Japan	150.6864**[1]	90.1005**[1]	255.0334**[2]

	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Malaysia	164.2532**[2]	46.9793**[1]	205.9827**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Mexico	125.8343**[2]	138.6982**[3]	194.7523**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Philippines	134.4451**[1]	67.5816**[2]	220.1541**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Chile	156.5203**[1]	278.9570**[2]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Canada/Hongkong	175.6907**[1]	320.7493**[3]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Canada/Indonesia	75.8827**[7]	42.4747**[1]	343.6075**[5]
	{I(0)/I(1)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Japan	170.7021**[2]	41.7166**[1]	248.3971**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Malaysia	182.0709**[1]	282.1387**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Canada/Mexico	167.3198**[6]	104.5103**[1]	177.7468**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Philippines	158.2902**[3]	13.1066*[1]	261.5137**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Hongkong	180.7352**[1]	279.2957**[4]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Chile/Indonesia	93.9644**[8]	42.4714**[8]	302.7068**[3]
	{I(0)/I(1)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Japan	177.7029**[1]	46.7417**[2]	236.7184**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Malaysia	191.6041**[1]	232.5014**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Chile/Mexico	196.5399**[8]	100.3627**[2]	174.1124**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Philippines	169.0359**[1]	17.7182*[8]	197.1615**[3]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Hongkong/Indonesia	152.9140**[2]	8.3162[1]	223.7636**[3]
	{I(0)/I(0)}	{I(0)/I(1)}	{I(0)/I(0)}
Hongkong/Japan	209.1921**[1]	47.7845**[2]	284.2963**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Hongkong/Malaysia	208.6380**[1]	292.1417**[3]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Hongkong/Mexico	185.9402**[5]	115.9367**[2]	170.1024**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Hongkong/Philippines	189.2871**[1]	14.7469[3]	258.3258**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Indonesia/Japan	165.2991**[7]	31.3241**[8]	237.3968**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}

Indonesia/Malaysia	208.6380**[1]	13.7214[8]	281.3893**[3]
	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}
Indonesia/Mexico	215.8915**[1]	74.7368**[2]	184.7288**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Indonesia/Philippines	202.8513**[1]	258.3258**[2]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Japan/Malaysia	206.5733**[1]	30.1782**[1]	247.5257**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Japan/Mexico	245.4628**[1]	62.3711**[2]	204.0074**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Japan/Philippines	206.6517**[4]	21.5941**[8]	264.0239**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Malaysia/Mexico	199.8879**[5]	82.5156**[1]	171.4536**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Malaysia/Philippines	181.9270**[1]	18.7672*[8]	213.2274**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Mexico/Philippines	224.3423**[8]	69.7367**[4]	164.0337**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}

The statistics in this table are trace statistics. ** indicates significant at 1% level. The number in [] and {} are the number of the best fitting lag terms and the integration level respectively.

Table 98: Granger Causality Test of Exchange Rate

	AR	**CA**	**CH**	**HK**	**IN**	**JA**	**MA**	**ME**	**PH**
Period 1									
AR		4.2614*	1.4093	0.0672	0.1959	0.3677	0.6263	0.0451	0.0132
CA	0.0858		2.8259	1.1912	2.1814	0.0516	0.0078	8.6233*	1.4551
CH	3.4862	64.3156*		1.6755	7.5718*	14.5362*	16.7982*	83.4860*	0.1455
HK	2.7705	3.2744	0.0037		0.0855	0.3497	1.2008	0.0942	1.0348
IN	1.1598	4.6034*	0.2234	0.5674		8.1173*	1.2008	0.0955	1.0384
JA	0.0724	1.2766	1.0051	8.6697*	4.7925*		0.5245	18.7026*	1.1953
MA	0.2937	16.5384	0.0031	1.4484	1.4484	0.0862		21.0107*	1.5834
ME	0.0013	0.1221	0.0574	1.9628	1.7297	0.7551	0.0148		0.2780
PH	1.7079	14.2516*	3.1539	0.0123	0.0369	31.9654*	44.8464*	21.6111*	
Period 2									
AR		4.0404	0.1746	0.2617	0.0372	0.0003	1.3812	11.0567*	0.9066
CA	0.1853		3.9438*	1.6125	4.6597*	0.1156	0.3133	0.4347	0.1498
CH	10.1621*	34.9300*		3.1504	0.3561	3.7172	3.3154	5.7997*	0.1010
HK	0.6141	0.2293	0.3507		1.3587	0.8754	1.2146	1.2153	0.2791
IN	2.7295	11.1985*	0.3360	2.7988		1.1685	0.0004	2.2679	0.1190
JA	6.9334*	2.4835	0.2473	0.5301	9.1193*		0.0963	19.8764*	0.0034
MA	0.2961	41.6237*	0.0556	1.4586	4.8040*	0.0431		5.7134*	0.0354
ME	0.3417	1.9013	5.8493*	7.0776*	5.9476*	0.0175	0.0317		0.2196
PH	4.4585*	1.9188	3.4670	0.1048	2.8034	2.9135	18.6241*	5.6764*	
Period 3									
AR		0.0942	2.2821	2.3247	0.6841	0.2549	1.6043	11.0567*	8.9147*

CA	0.2437				7.7068*	0.1094		1.3281	1.2761
CH	1.8982				0.0395	0.0610		18.1158*	0.0001
HK	1.0875				0.0725	0.9606		4.3854*	0.1190
IN	3.2435*	15.0397*	1.0163	0.9392		0.2493	1.3823	3.1619	
JA	0.0016	4.4913*	0.1710	0.6787	0.5372		1.0101	3.3424	0.6393
MA	0.7569				0.8998	0.0557		24.6951*	0.9206
ME	0.3417	0.9011	0.0088	0.1041	0.2514	0.3761	0.8515		0.1953
PH	0.0125	37.6833*	4.1921*	2.8034		4.2030*	145.304*	1.3063	

*** indicates significant at 5% level.**

The results of the co-integration test reveal that only 3 sub-periods are not statistically co-integrated: Period 2 of Hong Kong/Indonesia, Hong Kong/Philippines, and Indonesia/Malaysia. The time period is November 2008, during the global crisis. The statistical relationship in terms of the above combinations was discontinued for less than a month due to the fluctuation of the economy. The results of the granger causality test suggest that although the countries seem to be statistically connected, the underlying relationship could be very different. During the first transmission period, the casual relationship of 20 of the combinations changed, that is, 55.6%. During the second transmission period, 15 of the combinations' causal relationships changed, equating to 41.6%. The 14% drop suggests that the countries' economies begin to recover from the shock and stabilise following this. We expect to see similar results in the interest rate and the stock markets. However, we found that some of the results from the granger causality test are not consistent with the correlation test, e.g. Canada/Philippines and Chile/Mexico. The correlation is a criterion with which to measure the strength of the relationship between two data sets, although it does not suggest a causal relationship. Indeed, while these two areas can have a strong correlation, there is no statistically significant causal relationship. We do not view this inconsistency as a problem, but instead take the view that combining the results of these tests together helps to more effectively explain contagion. Significant changes in both correlation and causality are taken as contagion. As for the impulse response figures in Appendix 5, we can see that most of the impacts die out within 5 days, with the exception of 4 combinations: Argentina and Indonesia in the 2nd period, Canada and Indonesia in the 1st period, Canada and Philippines in the 2nd period, and Chile and Indonesia in the 1st period. For Argentina/Indonesia, and Canada/Philippines, their impact on each other is quite volatile. Given a positive shock in one country, the other will suffer from a turbulence lasting 10 to 15 days. While in the case of Canada/Indonesia and Chile/Indonesia, the effects are quite stable. A positive shock in Indonesia will give rise to a positive effect in Chile and a negative effect in Canada lasting for 30 to 40 days.

Table 99: Co-Integration Test of Interest Rate

	Period 1	Period 2	Period 3	Period 4	Period 5
Argentina/Canada	58.3689**[1]	61.7911**[1]	13.1402[4]	41.6324**[1]	234.0141**[7]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Chile	59.9159**[1]	83.3098**[2]	207.0432**[8]		
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}		
Argentina/Hongkong	82.8492**[2]	92.4937**[2]	12.0386[1]	178.3860**[8]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}	
Argentina/Indonesia	99.7837**[2]	58.7638**[2]	119.8383**[3]	133.6921**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Argentina/Japan	45.7203**[2]	100.1082**[2]	26.9253**[8]	76.6926**[8]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Argentina/Malaysia	55.3251**[1]	890.6796**[1]	164.2532**[5]	46.9793**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Argentina/Mexico	64.8578**[1]	93.8324**[2]	33.3350**[8]	42.1204**[7]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Argentina/Philippines	71.4014**[2]	67.5585**[5]	23.2660**[4]	208.9621**[8]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Canada/Chile	132.4342**[1]	45.0871**[1]	170.4536**[8]	203.3133**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Canada/Hongkong	160.2221**[6]	60.2147**[3]	141.4111**[1]		
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}		
Canada/Indonesia	167.9259**[1]	22.5461**[8]	58.7514**[1]	77.2112**[1]	104.9445**[4]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Japan	99.9051**[1]	35.1501**[1]	19.2473*[7]	131.7375**[2]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}	
Canada/Malaysia	7.2475[8]	886.8967**[7]	224.4375**[1]	85.4352**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Canada/Mexico	169.5683**[5]	42.4761**[1]	15.8900*[1]	183.2078**[5]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}	
Canada/Philippines	131.4670**[1]	60.2102**[1]	167.2223**[2]	78.3755**[5]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Chile/Hongkong	176.1460**[1]	190.6605**[8]	187.6405**[1]		
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}		
Chile/Indonesia	201.3414**[1]	132.8004**[1]	132.7912**[1]	158.9366**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Chile/Japan	172.6561**[1]	20.8603**[8]	117.0241**[2]		
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}		
Chile/Malaysia	55.2468**[6]	636.5282**[4]	191.6041**[2]		
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}		
Chile/Mexico	196.5399**[1]	45.0121**[6]	221.5525**[6]		

	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Chile/Philippines	150.9323**[1]	224.1824**[1]	115.8235**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Hongkong/Indonesia	215.8677**[7]	10.6636[1]	121.4353**[1]	119.5632**[3]
	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Hongkong/Japan	85.4242**[7]	34.4240**[1]	97.0311**[5]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Hongkong/Malaysia	59.6822**[1]	876.1720**[2]	162.3233**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Hongkong/Mexico	178.7995**[5]	39.1277**[1]	195.0950**[6]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Hongkong/Philippines	148.9356**[4]	27.2417**[2]	212.6720**[8]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Indonesia/Japan	113.7174**[1]	67.2175**[1]	104.1904**[3]	53.5257**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Indonesia/Malaysia	69.0191**[1]	365.5976**[7]	147.8165**[1]	13.7214[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Indonesia/Mexico	200.1105**[5]	38.3744**[1]	117.2997**[5]	136.0915**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Indonesia/Philippines	188.5820**[1]	20.8616**[1]	143.0839**[1]	127.2036**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Japan/Malaysia	188.1869**[1]	27.8287**[1]	851.8021**[2]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Japan/Mexico	203.2295**[6]	255.3611**[5]		
	{I(0)/I(0)}	{I(0)/I(0)}		
Japan/Philippines	114.8301**[2]	49.1635**[5]	115.5563**[8]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Malaysia/Mexico	205.7516**[5]	31.0157**[1]	901.0259**[6]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	
Malaysia/Philippines	82.4884**[1]	880.2931**[7]		
	{I(0)/I(0)}	{I(0)/I(0)}		
Mexico/Philippines	156.0841**[5]	54.3924**[1]	214.1199**[5]	
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}	

The statistics in this table are trace statistics. ** indicates significant at 1% level. The number in [] and {} are the number of the best fitting lag terms and the integration level respectively.

Table 100: Granger Causality Test of Interest Rate

	AR	CA	CH	HK	IN	JA	MA	ME	PH
Period 1									
AR		0.0197	4.2585*	1.9804	1.6165	0.0031	1.0649	0.1112	0.0702
CA	0.0056		0.0722	33.1267*	0.0960*	3.8499	0.0102	2.2451	5.9975*
CH	12.1749*	3.0509		1.8948	0.6668	0.0157	0.1065	0.0008	8.5126*
HK	0.2752	1.3447	0.2682		2.6778	4.0025*	0.5628	0.1381	0.1506
IN	0.4408	5.3025*	1.8722	0.5126		1.2111	0.2117	0.0406	0.1505
JA	4.7420*	3.5919	0.0195	3.1157*	2.4892		30.7316*	1.8431	1.1953

MA	0.0230	1.3060	2.4028	0.5734	0.2110	1.1535		0.0046	0.1402
ME	0.1562	0.6790	0.0005	0.1943	0.3141	49.1882*	0.0042		0.0016
PH	0.9209	0.0001	1.3949	0.3071	0.5332	0.0103	0.0301	0.7164	
Period 2									
AR		0.3717	0.1977	0.0041	0.4980	8.9692*	0.1448	0.0266	0.2638
CA	1.3208		0.0282	3.6344	0.7397	0.1026	0.9893	0.1907	1.5663
CH	0.1489	0.0023		0.1006	0.6760	0.0072	39.4898*	82.6375*	0.5031
HK	0.5857	0.5061	0.0347		6.6160*	0.1856	3.8961*	0.3854	2.4791
IN	0.1046	0.0443	0.1602	0.0082		0.8388	0.8223	2.2641	0.6543
JA	22.9379*	0.3000	0.0265	2.9870	1.4861		0.0752	1.7610	0.0034
MA	1.7242	22.8389*	0.0551	0.6898	0.4195	0.0838		0.0682	0.8671
ME	3.3598	0.2824	0.1645	1.2269	4.4504*	2.9850*	0.0007		0.6131
PH	0.4155	0.9308	4.2528*	5.6039*	1.2454	0.7207	0.0020	0.3911	
Period 3									
AR		1.3559	0.8644	0.0796	2.1392	0.7534	0.5678	0.1385	1.8399
CA	0.2362		0.8587	0.0116	0.8666	0.2500	1.1299	3.0207	0.5715
CH	19.0690*	0.8648		0.0161	0.0861	0.0333	2.8453	0.5802	1.3566
HK	0.2284	0.4407	0.4011		0.0725	1.6668	0.6933	0.5936	12.9265*
IN	0.3285	1.6782	0.0348	0.9392		0.2493	1.0170	1.3776	0.2927
JA	1.0164	0.0437	0.0129	72.3084*	0.5372		0.2840		0.9595
MA	1.8273	0.7235	0.0721	0.8354	0.0846	0.1294		0.7423	
ME	0.3965	0.8422	9.4042*	0.2107	1.9840		4.8222*		2.8341
PH	0.1061	1.1704	0.4735	19.2231*	0.9959	1.7475		0.2457	
Period 4									
AR		0.2771		1.8174	0.6395	0.0386	1.6043	1.2918	1.7745
CA	0.0036		2.3048		0.5984	0.2191	3.4403	0.0700	1.2761
CH		1.6603			2.1425				
HK	0.8535				2.3524				
IN	0.6087	2.4137	0.4011	1.7306		2.0304	1.3823	0.2282	0.0808
JA	8.1894*	0.9852			0.6137				
MA	0.7569	0.0066			0.8998				
ME	1.2291	0.1611			0.0081				
PH	0.0052	37.6833*			0.7542				
Period 5									
AR		2.8596							
CA	1.0383				1.1365				
CH									
HK									
IN		0.2291							
JA									
MA									
ME									
PH									

*** indicates significant at 5% level.**

An additional number of time periods were not co-integrated due to the increase in the number of breakpoints: Canada/Malaysia in Period 1, Hong Kong/Indonesia in Period 2, Argentina/Canada and Argentina/Hong Kong in Period 3, and Indonesia/Malaysia in Period 4. As for the causality test, we found that the relationships of 19 combinations changed, (14 in the second period and 2 in the third period). This agrees with what we anticipated in terms of exchange rate. The interest rate market exhibited similar behaviour. Indeed, the number of changes in causal relationship decreased regularly with the passage of time due to the fact that the countries are gradually recovering from the crisis while both the economy and the casual relationship are stabilising. The results of impulse response analysis are quite similar to those of the exchange rate market. Most of the impacts fade away in less than 5 days, with the exception of 4 combinations: Argentina/Mexico in period 4, Hong Kong/Japan in period 3, Hong Kong/Philippines in period 2, and Japan/Mexico in period 2. The effect lasts from 10 to 20 days across all of these 4 combinations. Hong Kong has a negative reaction and Mexico has a positive reaction to a positive shock in Japan while the responses of all other combinations to each other are very volatile.

Table 101: Co-Integration Test of Stock

	Period 1	Period 2	Period 3
Argentina/Canada	180.7061**[1]	26.6029**[2]	307.3600**[2]
	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}
Argentina/Chile	153.1458**[1]	33.7459**[8]	243.9566**[1]
	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}
Argentina/Hongkong	185.1066**[3]	319.2193**[5]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Argentina/Indonesia	16.2343*[1]	267.1058**[8]	183.1506**[1]
	{I(0)/I(0)}	{I(1)/I(0)}	{I(0)/I(0)}
Argentina/Japan	187.9559**[3]	112.0539**[8]	209.9756**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Malaysia	192.7965**[1]	279.7391**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Argentina/Mexico	172.5813**[4]	83.7016**[2]	179.8376**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Argentina/Philippines	153.9304**[1]	283.4737**[5]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Canada/Chile	184.5262**[2]	16.4981*[1]	240.3194**[4]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Hongkong	186.2131**[3]	37.0500**[7]	319.2676**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}

Canada/Indonesia	191.6332**[1]	291.7384**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Canada/Japan	243.8776**[3]	100.0945**[1]	214.1870**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Malaysia	203.7142**[1]	28.7830**[7]	300.3893**[3]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Mexico	196.3756**[4]	82.3990**[1]	185.1490**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Canada/Philippines	158.4511**[1]	27.2907**[7]	273.6232**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Hongkong	166.8783**[1]	37.6684**[4]	260.6226**[4]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Indonesia	160.1245**[1]	36.4866**[3]	241.3526**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Japan	232.0590**[3]	71.0268**[1]	220.4077**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Malaysia	178.5974**[2]	36.8727**[8]	240.3057**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Mexico	194.3241**[2]	55.3229**[1]	179.7993**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Chile/Philippines	149.8900**[1]	35.2104**[8]	236.4205**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Hongkong/Indonesia	155.1626**[1]	34.2678**[8]	258.1889**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Hongkong/Japan	228.3733**[2]	113.1412**[4]	201.3333**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Hongkong/Malaysia	210.6165**[2]	264.2220**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Hongkong/Mexico	186.0583**[2]	125.0175**[2]	231.7350**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Hongkong/Philippines	171.0564**[1]	291.5815**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Indonesia/Japan	222.3252**[3]	83.4177**[1]	188.6119**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Indonesia/Malaysia	197.9368**[2]	16.6331*[8]	253.3888**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Indonesia/Mexico	170.4331**[1]	94.2743**[2]	176.3232**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Indonesia/Philippines	160.9010**[1]	23.7806**[8]	258.6348**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Japan/Malaysia	222.9677**[1]	97.8163**[3]	195.3620**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Japan/Mexico	326.6384**[4]	205.5193**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Japan/Philippines	184.3861**[1]	121.8940**[6]	197.2869**[1]

	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Malaysia/Mexico	188.6729**[1]	80.0073**[3]	180.2953**[1]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}
Malaysia/Philippines	180.3467**[1]	262.7015**[1]	
	{I(0)/I(0)}	{I(0)/I(0)}	
Mexico/Philippines	161.3993**[1]	110.1434**[7]	164.6006**[2]
	{I(0)/I(0)}	{I(0)/I(0)}	{I(0)/I(0)}

The statistics in this table are trace statistics. ** indicates significant at 1% level. The number in [] and {} are the number of the best fitting lag terms and the integration level respectively.

Table 102: Granger Causality Test of Stock

	AR	CA	CH	HK	IN	JA	MA	ME	PH
Period 1									
AR		0.1690	1.4044	2.2897	3.1271	0.8991	0.1491	0.0451	0.0132
CA	0.2678		1.2847	0.7179	0.2104	0.9672	1.4543	8.0102*	0.0302
CH	0.1383	2.1774		0.8578	1.0972	14.5362*	2.0081	6.1170*	0.7835
HK	31.8625*	39.3414*	22.4567*		0.1030	1.0589	0.1234	61.5955*	1.1804
IN	25.1662*	26.7660*	17.5414*	0.0289		1.4517	0.2622	43.1467*	2.1286
JA	69.4733*	95.6375*	92.3416*	11.5272*	9.0061*		2.9652	157.931*	3.1577
MA	22.0396*	21.3638*	18.2217*	2.9701	4.8631*	0.1557		30.7888*	0.8218
ME	4.7485*	1.5057	3.5246	3.3774	0.8137	3.0744	10.0318*		3.1945
PH	31.2070*	29.4202*	35.3370*	2.2472	5.5576*	0.5780	0.4259	95.2648*	
Period 2									
AR		0.6890	2.3375	9.7245*	0.0014	14.0141*	1.3812	3.3337	6.4931*
CA	0.0005		0.1527	0.0495	0.8335	0.8056	1.3690	0.0221	0.7032
CH	5.5E-06	1.1934		0.3339	0.0611	0.0020	3.3289	0.4894	2.0E-06
HK	50.6814*	7.2961*	5.7990*		2.1765	5.5965*	0.5100	31.6319*	0.5261
IN	1.5765	28.8865*	1.9425	5.7678*		0.7476	1.3111	15.4298*	0.0086
JA	22.9432*	19.2831*	13.6062*	1.8360	1.6077		0.7275	51.9141*	0.1231
MA	43.5858*	6.6452*	5.5255*	0.3607	7.0351*	2.5027		15.0592*	0.7633
ME	3.3001	0.2042	1.0349	1.0656	2.7558	0.0028	10.2591*		0.0061
PH	79.8337*	15.4820*	8.2544*	5.8021*	0.0011	3.2583	4.7563*	66.9712*	
Period 3									
AR		8.9021*	4.9949*		2.7871	2.2884		5.7754*	
CA	0.0436		1.1626	1.0118		0.9095	0.9432	2.8528	0.0016
CH	0.2509	0.4187		0.1281	0.3064	0.0080	0.1943	0.6652	0.0128
HK		43.4836*	31.3864*		2.2907	4.2020*		55.4538*	
IN	27.5036*		10.1826*	0.5021		3.9881*	1.1736	14.2562*	0.5878
JA	29.7197*	56.9207*	42.6368*	7.4287*	9.1872*		11.0877*		1.2472
MA		36.7263*	23.5160*		2.5670	1.2095		21.3310*	
ME	1.7730	0.7922	0.1860	0.0795	0.5601		0.0269		1.3559
PH		107.988*	45.9077*		9.0218*	1.3653		38.1280*	

*** indicates significant at 5% level.**

Stock market again exhibited the most stable behaviour. All of the time periods are statistically co-integrated. The casual relationships of 16 combinations changed in the first transmission period while 14 changed in the second. This result indicates that although contagion occurred, the countries are still statistically related. However, this results also imply that it is hard for market participants to make investment decisions due to the variety of market linkages. As for the impulse response analysis, only the impacts of 2 combinations lasted longer than 5 days: Canada/Malaysia in period 2, and Indonesia/Hong Kong in period 2. Their impacts on each other are very volatile and last for 15 to 25 days.

To sum up, while we still observe some contagion effects with this methodology, there are not as many as with the correlation methodology. We did not detect many changes in the co-integration relationships. Indeed, they seem to be always co-integrated, with the exception of some rare samples. With this said, the granger causality test reveals that there is something else going on. The underlying relationship is much more complicated than the co-integration test suggests. While the data may still be co-integrated, the causal relationship may change more than once.

7.7 Conclusion

We have identified and analysed contagion using 3 different methods. The results we have obtained do not support the importance of the relationship between trade links and region, as was the case with many of the previous studies. Although it has been argued that geographic proximity tends to increase the probability of contagion (Forbes and Rigobon, 2002), our results do not support that conclusion.

The neighbourhood effect (Gregorio and Valdés, 2001) is trivial to our study. Indeed, its role in our study are quite weak, with the exception of the correlation tests in the stock market. In this case, we found that countries with a high degree of dependence on foreign trade are less likely to experience contagion. This result is not consistent with our conclusion in Chapter 6 where we argued that higher trade linkages bring more transmission channels. However, it seems that not only can trade bring more possibilities of aggressive contagion effect, it can also dilute negative transmission. The two-sided nature of trade linkages in regard to contagion are worthy of great attention. This further illustrate the complications of foreign trade policy. A country-specific evaluation of trade policy is strongly recommended. During the process, we also found that excessive volatility can be adjusted, and that the change during transmission periods might not be as significant once the volatility has been adjusted. By analysing the overall and the split shocks separately, we are able to see how the common shock and idiosyncratic shock affect the overall movement.

In this empirical study, we found that common shock prevails in determining the contagion in exchange rate, while the effect of both shocks must be considered in order to understand the overall movement in interest rate and stock markets. Moreover, the impulse response analysis suggests that the contagion effects do not normally last longer than 5 days, although they will occasionally last longer than 10 days. This result does not support the suggestion that long-run policy adjustment is more helpful in dealing with financial contagion (Gravelle, Kichian and Morley, 2006). Since contagion appears to transfer within a very short time interval, immediate or short-run adjustment might turn out to be much more useful to overcome the negative fluctuation caused by contagion.

Chapter 8 Conclusion

This thesis has introduced a number of new features with a view to filling the existing gaps in the literature. In doing so, we have also studied financial contagion under a more comprehensive definition.

In general, the word ‘contagion’ suggests that the changes in one market somehow affect the structure of another market. In order to gain a more precise understanding, we reviewed the definitions of contagion used in empirical work. To our knowledge there are five definitions. Indeed, in undertaking this review we find that studies under these definitions tend to include an increasing number of features. The studies of contagion have become more and more comprehensive, while we can also identify the gaps still to be filled in the definitional context.

While previous studies have examined the effects of the macroeconomic fundamentals from many angles, the shock component is completely ignored as that which cannot be directly explained by fundamentals. This is the main definitional gap that we are trying to fill. Moreover, in our study, this gap is filled by what we define as ‘pure contagion’ which, in turn, is identified by using our revised version of the ‘Identification through Heteroscedasticity’ procedure.

It was our intention to benefit from the advantages offered by previous techniques, should they fit our purpose. Moreover, we have sought to take inspiration from their disadvantages and to bring in new features so as to make possible improvements. With this in mind, we have also reviewed certain representative methods used in previous studies in order to outline the reasons behind the use of our methodology.

Following the review, we conclude that there are two advantages we would like to use.

The first relates to using the ability of the ‘Identification through Heteroscedasticity’ procedure to split shocks into common shock and idiosyncratic shock in order to address our ‘pure contagion’. Secondly, we felt that the capacity of the Correlation Method to capture overall effects would be extremely useful.

Meanwhile, we have also noticed certain gaps which need filling. In the first place, we bring in the long and short memory feature to measure the effects of autocorrelation, thus answering the question of whether or not long persistence autocorrelation affects contagion in the same way as short persistence autocorrelation. In the second place, while the literature adjusted for heteroscedasticity by direct calculation, we were curious as to whether this could be achieved in another way.

We hence designed a methodology to address the above issues. The pure contagion feature was addressed by splitting the shock into common shock and idiosyncratic shock using the ‘Identification through Heteroscedasticity’ procedure. The long and short memory feature was addressed by employing the ARFIMA model to obtain the residuals for the testing procedure. However, we would like to see how the results look when this feature is not properly addressed, and thus we will also check the results of the ARMA model. In addition to this, the heteroscedasticity feature was addressed by using the Bai-Perron breakpoint test, which has a better performance under heteroscedasticity.

Nonetheless, we would like to compare the results with those of the Andrews-Ploberger test, which also requires homoscedasticity, so that we can check the effect of the adjustment. Finally, we cannot use the original Markov-Switching regime to solve our system, entailing that we must use a new algorithm; namely, the nonlinear iterative method.

The interbank rate from seven European countries has served as our first dependent variable. By estimating exogenously the breakpoints before the contagion test and introducing the long memory and short memory feature, we may improve the power of the tests compared to Gravelle, Kichian and Morley (2006). In order to fulfil our intention of highlighting the effect of pure contagion, each of the pairs of research targets has low degree of dependence on foreign trade in relation to each other. The results from the four testing procedures suggest a massive proportion of cross border contagion effects in both interdependence and pure contagion, which is consistent with previous studies (see Gallegati, 2012; Peng and Ng, 2012).

As for our findings in regard to the pure contagion, they not only confirmed our hypothesis but also helped to fill the blank in existing empirical work, that which concludes that the contagion effects in the price movements are excessively related to fundamentals (Kodres and Pritsker, 2002). On the contrary, our results suggests that pure contagion is the reason for the excess co-movement in the fundamentals. Therefore, the observation from previous studies is biased due to the fact that pure contagion is not properly considered.

In addition to this, we also found that interdependence and pure contagion usually move in the same direction. Excessive variance was repeatedly found during the crisis period (Chiang, Jeon and Li, 2007). Our results confirm this conclusion. However, it also leads to greater hedging risk as it damages the benefit of international diversification. This concern is also shared by other studies.

Baur (2012) finds that due to the limited effectiveness of portfolio diversification, both countries and markets are very vulnerable during a financial crisis. Therefore, pure contagion brings more uncertainty to diversification strategies. The effect of news on contagion has been widely studied in empirical work. Important related news - for instance, the rescue plan for Greece - has a significant effect on asset prices (Mink and De Haan, 2013). In addition, the effects of negative and positive news on the correlation between markets are not very different (Yiu, Ho and Choi, 2010).

Moreover, our results suggest that the government's macroeconomic regulations, as well as personnel adjustments and elections, can result in breakpoints for the period chosen. This suggests that we should consider as confidential information by the government not only news related directly to fundamentals, but also the news that imply possible changes in fundamental. Last but not least, unlike with previous literature, we have also observed counter-contagion effects. Inci, Li and McCarthy (2011) may have observed no reverse contagion effects, but we observed that the counter-contagion period usually offsets the previous contagion effect and it sometimes bent back so hard that it changed the direction of contagion. As a result, being that the market tend to be self-revision, we conclude that long-run regulation is unnecessary when the sole purpose of the government is to deal with financial crisis. However, short-run adjustments may be needed just in case the turbulence grows out of control.

We will then widen our study by including trade links in our analysis. Here we will choose three pairs of European countries that have the highest degree of dependence on foreign trade among all combinations as research targets. We would assume that the stronger trade links might make the countries more vulnerable to events which imply political changes. The results of our breakpoint tests and the chronology support this assumption, which is consist with previous studies (Gravelle, Kichian and Morley, 2006; Rijckeghem and Weder, 2001). Moreover, as indicated by our causality tests, the dissemination of contagion is easier, being that more causal relationships are detected indicating that more trade related channels may become available.

This conclusion shows that governments should pay more attention to the evaluation of their foreign trade policy, and should take this evaluation into consideration when building their financial immunity system. However, all of these differences seem trivial when identifying contagion. On the one hand, the effects of the econometric features (i.e. the long and short memory, heteroscedasticity) are not affected by the change in trade links. On the other hand, the extra sensitivity in long memory processes suggest an increased number of fundamental related transmission channels resulting from the higher degree of trade links. This result further supports the theory that the transmission of contagion does depend on the completeness of the financial and political structure (Allen and Gale, 1998). Unlike the conclusions of previous empirical work (Syllignakis and Kouretas, 2011), we conclude that the explanatory power of trade linkage is much less significant and limited within the boundary of fundamental interdependence. In addition, the decrease in the number of the fundamental related events suggests that the higher trade link does not diminish our ability to identify contagion, especially pure contagion.

After examining the split shocks and the new features, we assessed the region, the overall effects, and the roles of the split shocks and the duration of the identified contagion effects. Surprisingly, the role of region, having been emphasised by many empirical studies (Glick and Rose, 1999; Gregorio and Valdés, 2001; Hernandez and Valdes, 2001; Rigobon, 2002) is trivial in our study. The results do not support the neighbourhood effect. Contrary to the conclusions of previous research (Kaminsky and Reinhart, 2000), we argue that crisis tends to be global, not regional. However, countries in different regions do react differently to crisis as Naoui, Liouane and Brahim (2010) have illustrated. Therefore, government should bear in mind that the economic experience of other countries may not be very helpful in view of the difference between country characteristics.

Trade links appear to have a different function. Instead of bringing more possibilities into contagion, trade link dilute them. It appears that instead of worrying about their neighbours, countries should pay more attention to their global trade partners. We also found that our overall shock has many contagion effects, so disagreeing with Forbes and Rigobon's (2002) conclusion that there is 'no contagion, only interdependence'. By combining the results of the overall shocks and the split shocks together, we are then able to fill a blank in contagion literature and examine how the split effects affect the overall movement. In our case, we found that the role of common shock is slightly more important than that of the idiosyncratic shock, especially in regard to the exchange rate.

Last but not least, the impulse response analysis suggests that the contagion effects do not normally last long and die out in a short period of time. This result is not in line with Gravelle, Kichian and Morley's (2006) work. Like Degryse, Elahi and Penas (2010), we believe that the transmission of contagion is too fast for long-run policies to come into play, entailing that short-run or immediate adjustments will be much more effective.

It would be appreciated if future studies can fill the following gaps:

1. Our method is based on the study by Gravelle, Kichian and Morley (2006) and we were unable to change one of their assumptions. That is, the initial correlation between the common shocks of two countries is 1 and the idiosyncratic shock is independent of the common shock. We must admit that the initial correlation could very well be any value other than 1, while it is possible that the idiosyncratic shock has a certain linkage with common shock. The power of our method would be improved if there was any way to identify these initial correlations.

2. Although we can see that the roles of common shock and idiosyncratic shock vary depending on different research targets, we are unable to ascertain the reason behind these differences. Therefore, the question seems to be: is there any other feature which we must consider, or is this simply a random result? Indeed, it would be even more helpful if countries understood their vulnerability to shocks once this question has been answered.

Appendix 1 Financial Crisis Since 1927

	Time Period	Countries Affected	Summary
Great Depression	Started in 1929 and lasted until the late 1930s or early 1940s	Almost every country	Started with the fall in stock prices that began around September 4, 1929 and became worldwide news with the stock market crash of October 29, 1929 (Black Tuesday). Unemployment rose, adverse impact on price, massive bank failures and stock market crash.
Oil Crisis	Oct 1973-Mar 1974	East Asia, West Europe, Latin America, Australia, U.S.	Followed by the 1973-1974 stock market crash, caused certain economy shifting from oil-intensive industries to more fuel efficient industries. The Western nations' central banks decided to sharply cut interest rates to encourage growth. The U.S. power was under attack even in Latin America after the oil embargo.
Stock Market Crash	Jan 1973-Dec 1974	U.S., Europe, East Asia	Dow Jones Industrial Average lost over 45% of its value, FT 30 lost 73% of its value, and Hong Kong Hang Seng Index fell from 1800 to 300.
Latin American Debt Crisis	Early 1980s	Latin America	Mexico's Finance Minister declared that Mexico would no longer be able to service its debt. In the wake of Mexico's default, Most commercial banks reduced significantly or halted new lending to Latin America. As much of Latin America's loans were short-term, the crisis ensued when their refinancing was refused.
Saving and Loan Crisis	1986-1995	U.S.	More than 1600 banks insured by the Federal Deposit Insurance Corporation were closed or received financial assistance. The federal government ultimately appropriated 105 billion dollars to resolve the crisis.
Japanese Banking Crisis	1990-2003	Japan	Stock market reduced 60% from Oct 1989 to Aug 1992, the central bank lowered the interest rate form 6% to 0.5% in ten years, massive bank failure, and overall recession.
Mexico Crisis	Dec 1994-Mar 1995	Started in Mexico, global currency crisis	Sudden devaluation of peso, inflict heavy losses on stock markets.
Asian Crisis	Jun 1997-1999	Asia	Start with the devaluation of Thai Baht, Currency declines spread rapidly throughout South Asia, in turn causing stock market declines, reduced import revenues and even government upheaval.
Russian Financial Crisis	Oct 1997-1999	Started in Russia,	It was triggered by the Asia financial crisis, real income reduced dramatically, significant rise

		triggered global crisis.	in price level, especially import goods, great loss in commercial banks. The crisis spread to the U.S., Europe, Latin America, triggered global effect.
Subprime Crisis	2007-2010	Started in the U.S., triggered global crisis	It's a situation created due to subprime lending. Investment funds were forced to close, resulting lack of liquidity in nearly all major financial markets.
European Sovereign Debt Crisis	2010-present	Europe	In May 2010, the Greek government deficit was estimated to be 13.6%, which is one of the highest in the world relative to GDP. Accumulated government debt is forecast, according to some estimates, to hit 120% of GDP in 2010. On 27 April 2010, the Greek debt rating was decreased to the first levels of 'junk' status by Standard & Poor's amidst fears of default by the Greek government. The crisis spread beyond Greece, reduced confidence in other European economies

Appendix 2 Degree of Dependence on Foreign Trade

	Belgium	Bulgaria	Croatia	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Iceland
Belgium		0.034033	0.007215	0.031242	0.015222	0.019131	0.043488	0.041593	0.009907	0.029189	0.003812
Bulgaria	0.002868		0.002916	0.003113	0.000589	0.00056	0.00064	0.001361	0.009239	0.005184	4.48E-05
Croatia	0.000851	0.004233		0.003505	0.000626	0.000434	0.000422	0.00128	0.000504	0.006609	0.000113
Czech Republic	0.01161	0.01359	0.010468		0.004819	0.004149	0.003737	0.019786	0.001685	0.039915	0.000649
Denmark	0.010287	0.001938	0.003518	0.0087		0.019528	0.003365	0.010906	0.00314	0.007854	0.012345
Finland	0.01002	0.003444	0.0019	0.005936	0.015136		0.002137	0.005715	0.002175	0.007378	0.002003
France	0.244429	0.043949	0.020158	0.056958	0.027998	0.022945		0.05987	0.019223	0.05526	0.003664
Germany	0.305877	0.118495	0.079122	0.394954	0.119013	0.080361	0.07851		0.039717	0.32717	0.024121
Greece	0.006297	0.070402	0.002672	0.002967	0.002946	0.002614	0.002164	0.003427		0.003525	0.000379
Hungary	0.007992	0.016165	0.015172	0.029929	0.003252	0.003901	0.00272	0.012268	0.00153		0.000372
Iceland	0.000394	5.23E-05	9.69E-05	0.000183	0.001937	0.000399	7.28E-05	0.000344	6.63E-05	0.000133	
Italy	0.072029	0.098065	0.106122	0.054643	0.021808	0.019192	0.038469	0.040835	0.033573	0.069081	0.004536
Latvia	0.000643	0.000609	0.000144	0.001282	0.002052	0.003199	0.0002	0.000672	7.6E-05	0.00107	0.002449
Lithuania	0.001717	0.001192	0.000367	0.00253	0.003025	0.002526	0.000534	0.001199	0.000113	0.001867	0.005718
Netherlands	0.250135	0.018411	0.009362	0.051156	0.035302	0.035453	0.025073	0.054663	0.013657	0.046653	0.026397
Norway	0.013145	0.000968	0.001668	0.005212	0.034236	0.016078	0.004008	0.009201	0.000888	0.001966	0.012934
Poland	0.017714	0.016085	0.008361	0.068759	0.013368	0.011093	0.005623	0.020883	0.002146	0.045166	0.002157
Romania	0.003583	0.048205	0.004235	0.008703	0.000991	0.000837	0.002148	0.004336	0.004778	0.039718	0.0002
Sweden	0.029044	0.009198	0.006077	0.015732	0.080634	0.07284	0.00579	0.012385	0.003154	0.017193	0.008145
Switzerland	0.01864	0.030668	0.008012	0.016255	0.006242	0.006085	0.01248	0.02566	0.004053	0.01324	0.003343
Ukraine	0.002017	0.007486	0.001847	0.009214	0.001286	0.002239	0.000557	0.00215	0.001526	0.017	0.000742

	Italy	Latvia	Lithuania	Netherlands	Norway	Poland	Romania	Sweden	Switzerland	Ukraine
Belgium	0.015513	0.013598	0.023366	0.147642	0.015972	0.020195	0.013041	0.029478	0.017824	0.008551
Bulgaria	0.001738	0.001071	0.001385	0.000943	0.000101	0.00157	0.013989	0.000724	0.01034	0.00062
Croatia	0.002735	0.00037	0.000615	0.000667	0.000247	0.001175	0.00187	0.000736	0.000933	0.000927
Czech Republic	0.004332	0.009827	0.012809	0.011479	0.002276	0.029103	0.011075	0.005952	0.005635	0.013909
Denmark	0.003174	0.029932	0.028914	0.014067	0.028418	0.010315	0.002293	0.05542	0.004048	0.003673
Finland	0.002162	0.035986	0.01861	0.010958	0.010384	0.006598	0.001447	0.038735	0.003042	0.004797
France	0.046581	0.024619	0.041621	0.08311	0.028226	0.035978	0.043626	0.033088	0.067049	0.013167
Germany	0.064906	0.107001	0.123489	0.235991	0.083103	0.173689	0.112228	0.092493	0.179813	0.065396
Greece	0.004626	0.001052	0.001483	0.005137	0.000696	0.00156	0.01136	0.002039	0.002505	0.004202
Hungary	0.004107	0.00603	0.007113	0.007673	0.000675	0.014275	0.037256	0.004809	0.003507	0.019018
Iceland	0.000101	0.001962	0.002685	0.001534	0.001606	0.00025	7.64E-05	0.000863	0.000338	9.74E-05
Italy		0.024596	0.03257	0.048288	0.012772	0.041972	0.108242	0.022206	0.069254	0.041828
Latvia	0.000245		0.070523	0.000705	0.000719	0.002396	0.000142	0.002268	0.002387	0.000413
Lithuania	0.000505	0.106474		0.001851	0.001146	0.0064	0.000355	0.002804	0.000695	0.006279
Netherlands	0.017659	0.024848	0.041581		0.039444	0.02973	0.018994	0.037219	0.021619	0.014892
Norway	0.002203	0.012279	0.013026	0.019318		0.006606	0.003242	0.039769	0.00293	0.002847
Poland	0.008	0.04319	0.076134	0.015636	0.007077		0.014976	0.015736	0.004216	0.044095
Romania	0.006114	0.000884	0.001449	0.003228	0.001131	0.005036		0.001412	0.001478	0.010621
Sweden	0.004708	0.048103	0.037902	0.021629	0.048105	0.017721	0.004937		0.006309	0.004801
Switzerland	0.015648	0.011979	0.011017	0.013319	0.003735	0.005121	0.005439	0.006707		0.003654
Ukraine	0.002156	0.009199	0.021018	0.002187	0.000825	0.012355	0.009204	0.001153	0.000872	

Appendix 3 Chronology

	Germany		Greece		Latvia
2005	**May** - Parliament ratifies EU constitution.	**2005**	**May** - Parliament ratifies EU constitution.	**2005**	**May** - Parliament ratifies EU constitution.
2006	**July** - Parliament approves far-reaching changes to the way in which Germany is governed; the reforms are intended to speed up decision-making. **November** - Unemployment falls below 4 million for the first time in four years.	**2006**	**September** - Greece, Russia and Bulgaria back a long-awaited deal to build an oil pipeline which will carry Russian oil to Europe via Alexandropoulis in Greece.	**2006**	**October** - Parties in coalition government led by Aigars Kalvitis together win parliamentary majority in general election.
2007		**2007**	**August** - Wildfires sweep through tinder-dry forests across the mainland and islands, killing dozens of people.	**2007**	**December** - Prime Minister Kalvitis resigns, bowing to pressure over attempts to sack the country's anti-corruption chief. His coalition is returned to power in a parliamentary vote, with Ivars Godmanis as new prime minister.
2008	**October** - Germany agrees a $68bn plan to save one of the country's largest banks, Hypo Real Estate, from collapse. **November** - Germany is declared to be officially in recession.	2008		**2008**	**May** - Latvian parliament approves European Union's Lisbon Treaty. Financial crisis. **December** - International Monetary Fund (IMF) approves 1.68bn euro rescue package to help Latvia ride out severe economic slump.
2009	**February** - Parliament approves $63bn stimulus package aimed at shoring up recession-hit economy.	**2009**	**October** - Opposition Pasok socialist party wins snap election called by	**2009**	**June** - The Central Bank spends almost a billion euros in 2009 to

August - Figures are released showing that economy grew by 0.3% in last quarter, bringing country out of recession. **October** - The parties reach agreement on major tax cut proposals. Official data shows the German economy shrank by 5% in 2009, hit by a slump in exports and investment.	PM Karamanlis.	support the lat currency, prevent devaluation and avoid a domino effect elsewhere in Eastern Europe. **August** - Government, trade unions and employers agree deep public spending cuts aimed at saving the country from bankruptcy and getting the IMF to release a further tranche of rescue loans. **October** - Government agrees to slash budget deficit in 2010 in order to meet targets imposed by EU in exchange for 7.5bn rescue loans.
2010May - Germany's parliament votes to approve a 22.4bn euro German contribution to bail out debt-ridden Greece, prompting widespread public anger. **September** - Cabinet approves controversial plan to extend lifespan of Germany's nuclear reactors, reversing 2001 decision to phase out nuclear energy by 2021.	**2010** **January~March** - Government announces two more rounds of tough austerity measures, and faces mass protests and strikes. **April~May** - Fears of a possible default on Greece's debts prompt eurozone countries to approve a $145bn (110bn euros; £91bn) rescue package for the country. **October** - Government announces new, tougher, austerity measures in 2011 draft budget. Measures include new taxes and higher rate of VAT.	**2010January** - Unemployment soars to 20%, giving Latvia the highest jobless rate in the EU. **March** - Largest coalition party leaves government following repeated disagreements over austerity measures, depriving PM Valdis Dombrovskis of his majority.
2011 **January** - Provisional figures show the economy grew by 3.6% in 2010, its fastest	**2011** **February** - International lenders say	2011

	pace since reunification in 1990. Economists attributed the rate to a recovery in exports.				austerity measures so far implemented do not go far enough, and that Greece must speed up reforms to get its finances back on track.		
	Iceland		**Bulgaria**		**Romania**		**Lithuania**
2005		2005		**2005**	**May** - Parliament ratifies EU constitution.	2005	
2006	**June** - Prime Minister Halldor Asgrimsson resigns and amid concerns about the economy.	2006		**2006**	**September** - European Commission confirms that Romania - and Bulgaria - will join the EU at the start of 2007, although under strict conditions.	2006	
2007		2007		2007		2007	
2008	**April** - The government warns that it may intervene in the country's currency and stock markets to fight hedge funds that it says are attacking Iceland's financial system. **October** - The government takes over control of all three of Iceland's major banks in an effort to stabilise the financial system, which has been hit hard by the global financial crisis.	**2008**	**September** - European Commission permanently strips Bulgaria of half of the aid frozen in July over what it says is the government's failure to tackle corruption and organised crime.	2008		**2008**	**October** - The conservative Homeland Union party becomes largest party after parliamentary elections, pushing Prime Minister Gediminas Kirkilas's Social Democrats into second place.

2009 **July** - Iceland formally applies for EU membership after parliament votes in favour of accession.	2009	2009	**2009** **April** - National statistics office publishes figures showing that Lithuania's GDP plunged 12.6% in the first quarter of 2009, compared to the same period last year.
2010 **February** - Unemployment soars to over 15,000 (over 9% of work force) - up from just over 1,500 (1% of work force) at the beginning of 2008, before the financial crisis took hold.	**2010June** - EU expresses concern over reliability of Bulgarian national statistics and says these may have to be subjected to EU scrutiny. **July** - Former PM Sergei Stanishev is accused of failing to return files containing state secrets relating to security and organised crime after losing the 2009 election, and is charged with mishandling classified documents. **September** - EU calls on Bulgaria to take urgent action to tackle crime and corruption.	**2010** **February** - Romanian Defence Council agrees to host missile interceptors as part of new US defence shield, subject to parliamentary approval.	2010
2011 February - Parliament approves new deal to settle UK banking dispute with UK and Netherlands.	2011	2011	2011

Find more at: http://news.bbc.co.uk/1/hi/country_profiles/default.stm

Appendix 4 Bai-Perron Breakpoint Test Results

Latvia and Germany's Risk premium

Specifications					
z_t =ar(1)	q =1	p =0	h =202	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
31.85 *	25.38*	17.00*	22.48 *	18.22*	35.36*
$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$	
2.19	2.19	2.19	31.85*	39.97*	
Number of breaks selected					
Sequential Procedure:	2				
LWZ:	1				
BIC:	1				
Breakpoint found					
642, 844 (2009/10/12, 2010/07/21)					
Note					
m **:** maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level					

Greece and Germany's Risk premium

Specifications					
z_t =ar(1)	q =1	p =0	h =202	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
36.49 *	209.4*	135.7*	160.9 *	128.8*	62.62*

$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$
5.42	0.65	0.00	209.4*	282.7*

Number of breaks selected

Sequential Procedure:	2
LWZ:	2
BIC:	2

Breakpoint found

658, 1022 (2009/11/03, 2011/03/28)

Note

m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level

Iceland and Germany's Risk premium

Specifications

z_t =ar(9) q =1 p =0 h =200 m =5 ε =0.15

Tests

$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
10.08 *	4.96	4.92	5.97	4.32	1.09

$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$
4.66	1.54	0.00	10.08*	10.26*

Number of breaks selected

Sequential Procedure:	1
LWZ:	1
BIC:	1

Breakpoint found

385 (2008/10/16)

Note

m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level

Bulgaria and Germany's Risk premium

Specifications					
z_t =ar(1)	q =1	p =0	h =202	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
30.34*	25.82*	18.91*	16.86*	14.23*	9.51*
$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$	
3.50	1.64	0.38	30.34*	31.23*	
Number of breaks selected					
Sequential Procedure:	2				
LWZ:	1				
BIC:	2				
Breakpoint found					
430, 1119 (2008/12/18, 2011/8/10)					
Note					
m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level					

Romania and Germany's Risk premium

Specifications					
z_t =ar(1)	q =1	p =0	h =202	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
53.16*	75.29*	67.92*	57.52*	3.39	109.8*

$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$
0.74	0.00	0.00	75.29*	98.90*

Number of breaks selected

Sequential Procedure:	2
LWZ:	2
BIC:	2

Breakpoint found

390, 592 (2008/10/23, 2009/08/03)

Note

m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level

Lithuania and Germany's Risk premium

Specifications

z_t =ar(1) q =1 p =0 h =202 m =5 ε =0.15

Tests

$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
2.56	3.06	5.26	11.43*	9.04*	8.46

$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$
8.81	39.73	2.05	11.43*	19.84*

Number of breaks selected

Sequential Procedure:	0
LWZ:	1
BIC:	2

Breakpoint found

402 (2008/11/10)

Note

m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level

Netherlands and Germany's Risk premium

Specifications					
z_t =ar(1)	q =1	p =0	h = 78	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
1.59	1.76	1.76	1.42	1.06	1.78
$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$	
1.96	0.58	0.00	1.76	2.53	
Number of breaks selected					
Sequential Procedure:	0				
LWZ:	0				
BIC:	0				
Breakpoint found					
0					
Note					
m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level					

Belgium and Germany's Risk premium

Specifications					
z_t =ar(1)	q =1	p =0	h = 78	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
20.36*	61.01*	47.72*	37.81*	38.79 *	105.19 *

$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$
22.89*	4.94	4.94	61.01*	85.12*

Number of breaks selected

Sequential Procedure:	3
LWZ:	2
BIC:	2

Breakpoint found

202, 280, 360 (2008/10/08, 2009/01/26, 2009/05/18)

Note

m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level

Latvia and Germany's Risk premium

Specifications

z_t =ar(9) q =1 p =0 h = 78 m =5 ε =0.15

Tests

$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
22.94*	14.41*	10.22*	12.39*	7.71*	17.44*
$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$	
20.02*	12.66*	0.00	22.94*	22.94*	

Number of breaks selected

Sequential Procedure:	3
LWZ:	0
BIC:	2

Breakpoint found

113, 191, 388 (2008/06/05, 2008/09/23, 2009/06/25)

Note

m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level

Lithuania and Germany's Risk premium

Specifications					
z_t =ar(1)	q =1	p =0	h = 78	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
25.92*	11.63*	12.38*	11.92*	9.54*	14.42*
$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$	
8.02	7.66	0.00	25.92*	25.92*	
Number of breaks selected					
Sequential Procedure:	2				
LWZ:	0				
BIC:	2				
Breakpoint found					
190, 398 (2008/09/22, 2009/07/09)					
Note					
m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level					

Denmark and Germany's Risk premium

Specifications					
z_t =ar(1)	q =1	p =0	h = 78	m =5	ε =0.15
Tests					
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
13.76*	8.41*	5.71	4.59	3.63	8.17

$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$
6.26	1.52	0.00	13.76*	13.76*

Number of breaks selected

Sequential Procedure:	1
LWZ:	0
BIC:	0

Breakpoint found

242 (2008/12/03)

Note

m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level

Sweden and Germany's Risk premium

Specifications

z_t =ar(1)	q =1	p =0	h = 78	m =5	ε =0.15

Tests

$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	$SupF_T(2\|1)$
0.89	0.44	10.78*	8.08	6.45	0.67

$SupF_T(3\|2)$	$SupF_T(4\|3)$	$SupF_T(5\|4)$	$UD\max$	$WD\max$
5.05	0.51	0.00	10.78*	15.52*

Number of breaks selected

Sequential Procedure:	0
LWZ:	0
BIC:	0

Breakpoint found

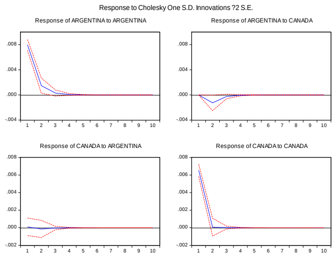
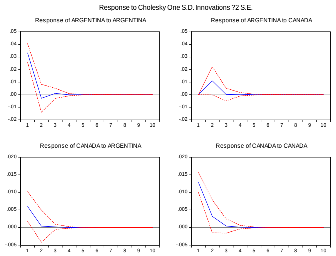
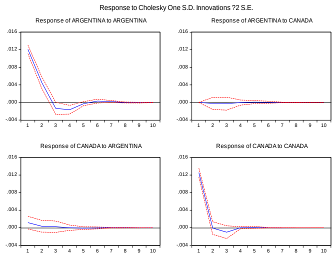
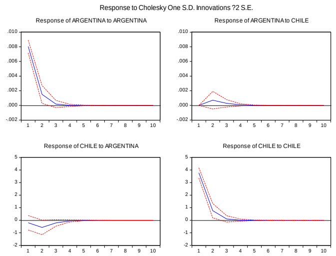
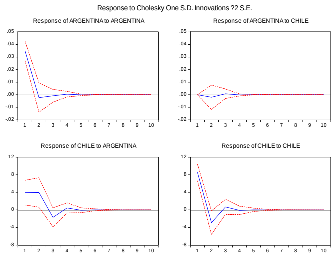
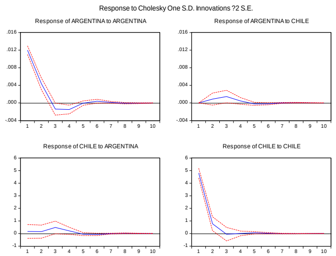
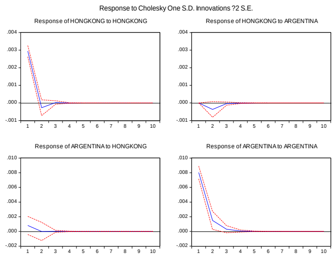
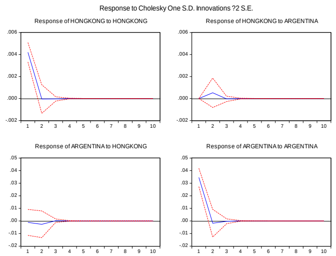
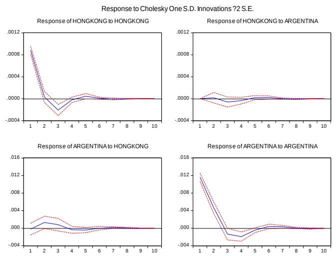
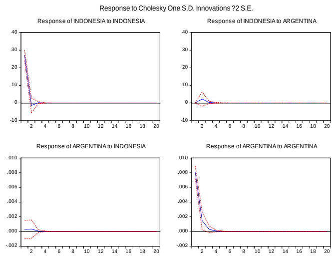
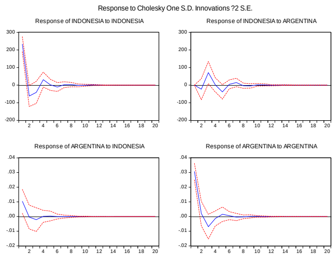
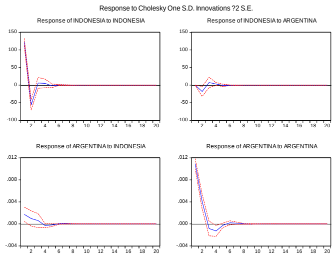
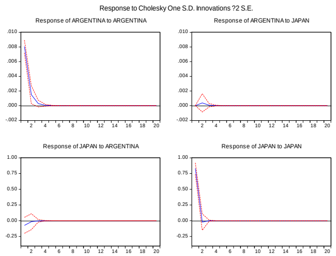
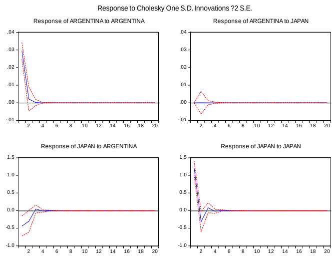
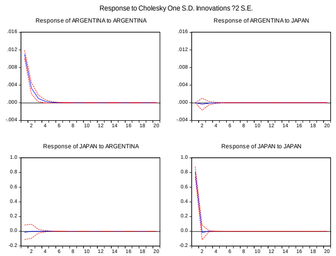
238 (2008/11/27)

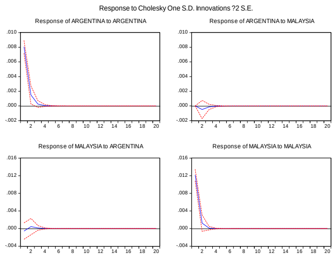
Note

m : maximum number of breakpoint; h : minimum length of distance; *: significant at 5% level

Appendix 5 Impulse Response

Exchange rate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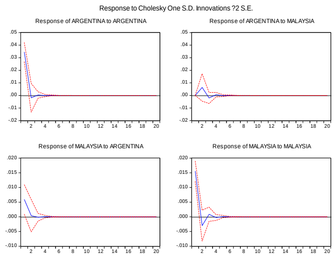
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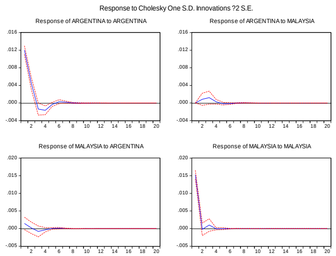
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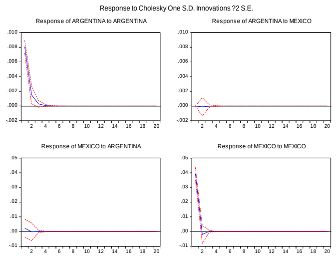
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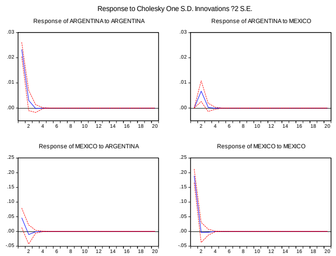
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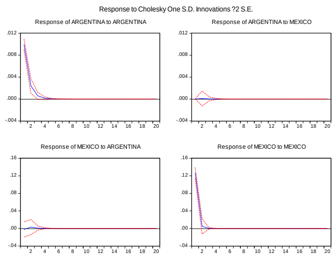
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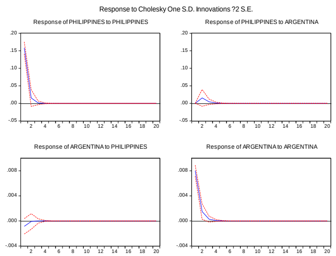
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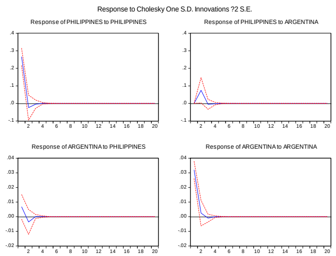
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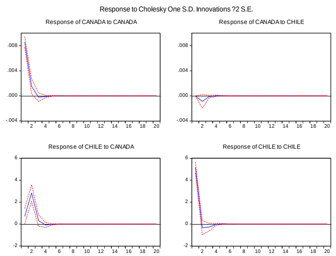
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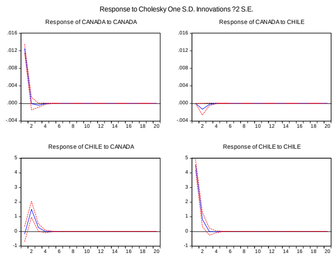
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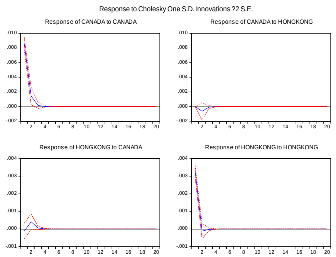
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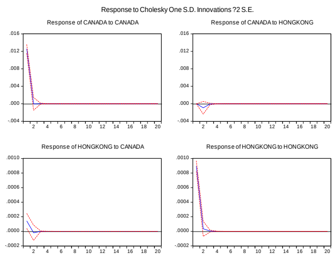
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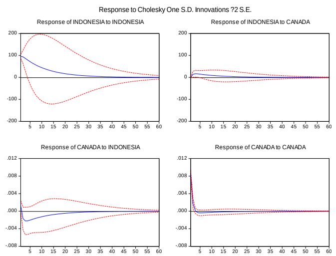
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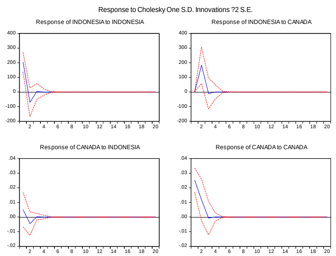
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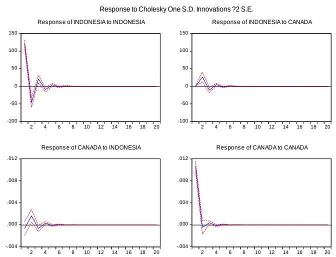
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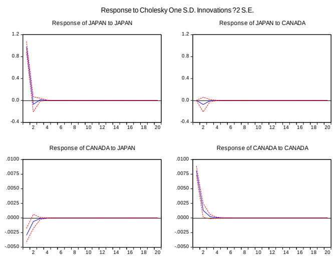
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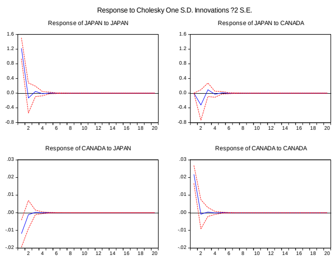
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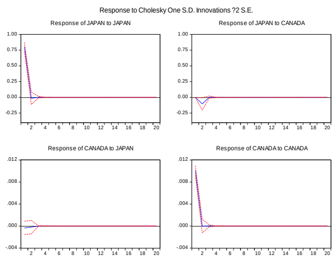
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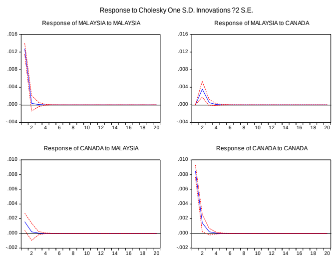
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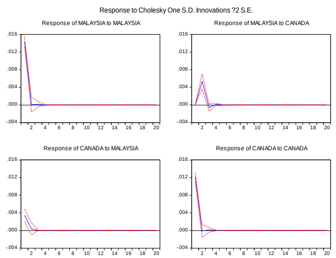
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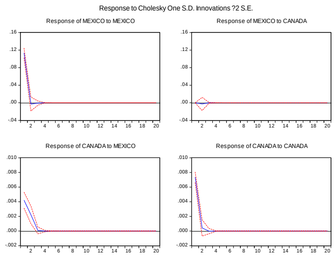
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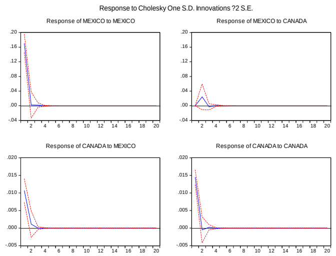
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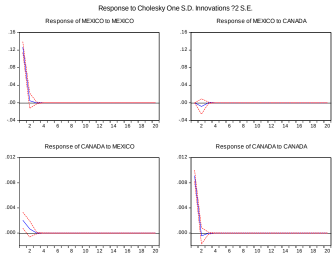
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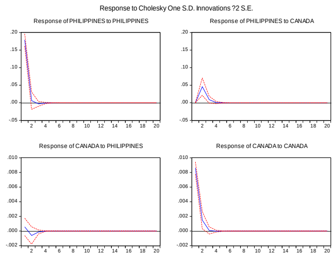
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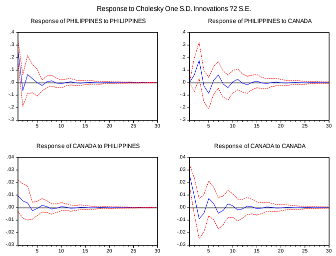
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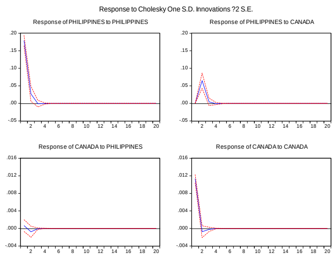
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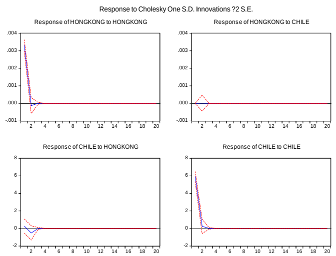
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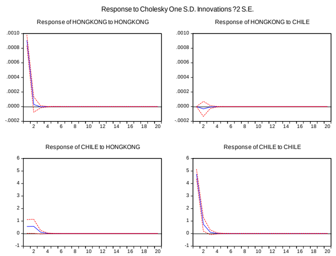
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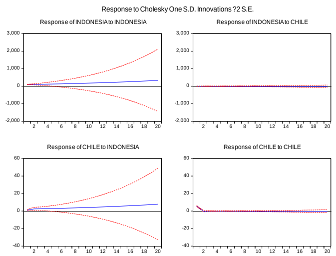
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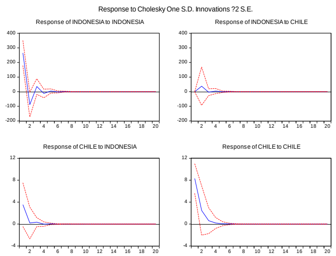
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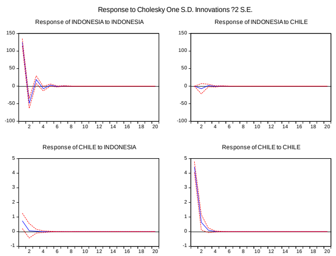
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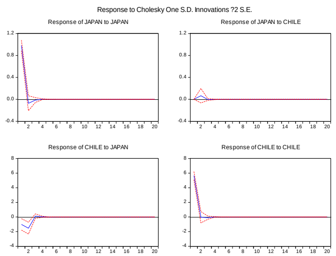
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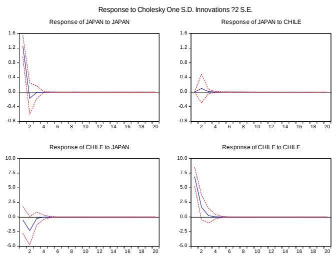
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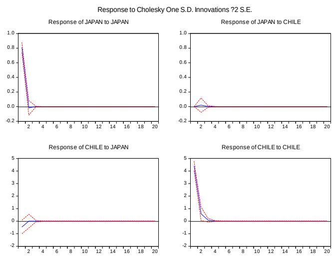
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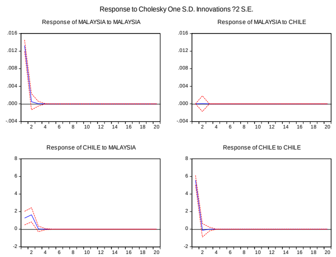
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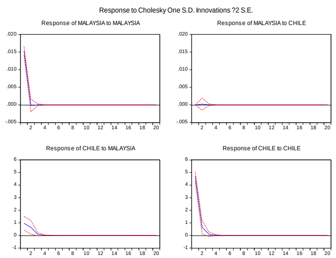
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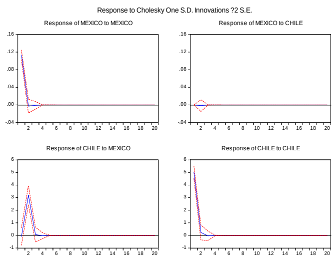
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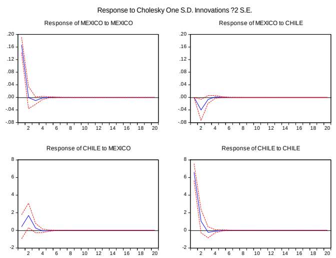
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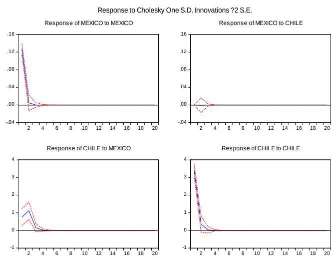
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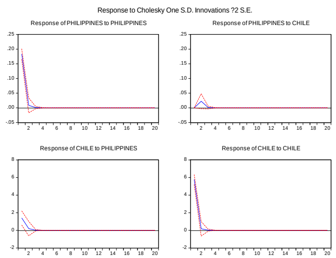
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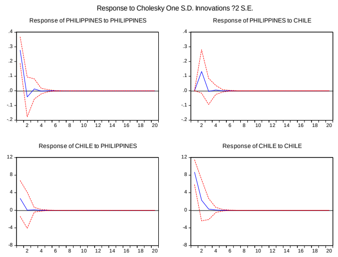
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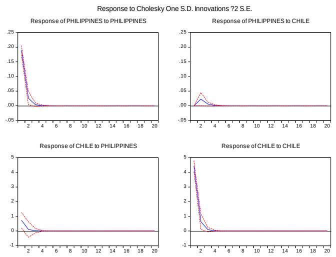
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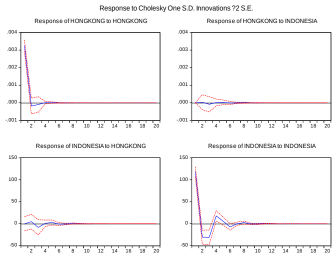
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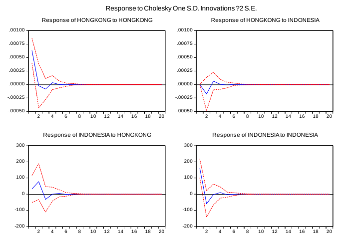
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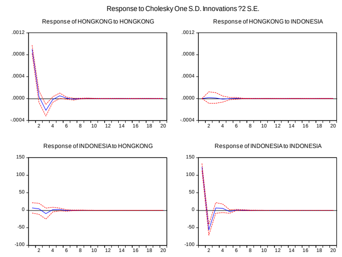
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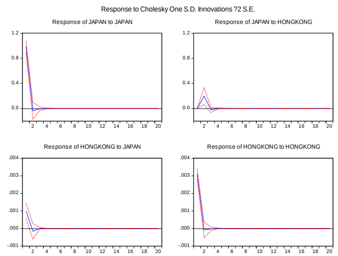
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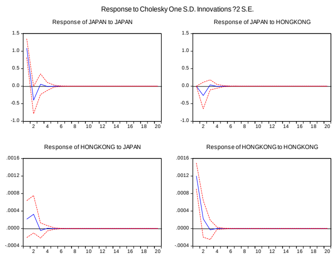
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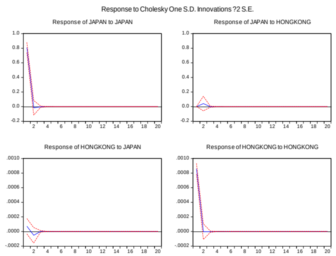
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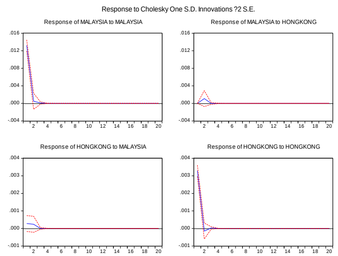
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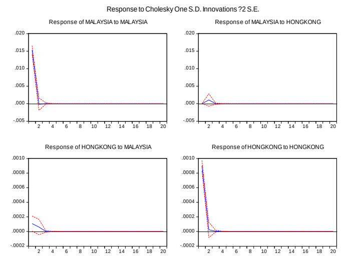
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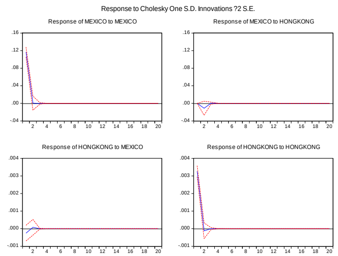
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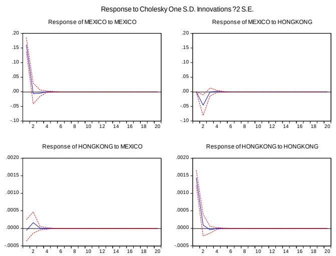
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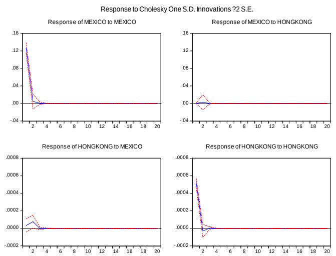
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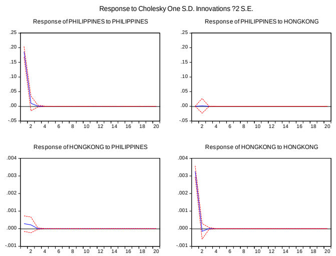
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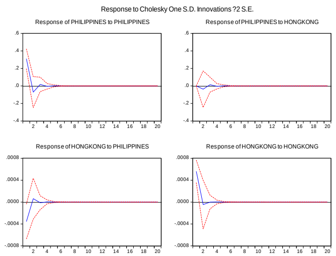
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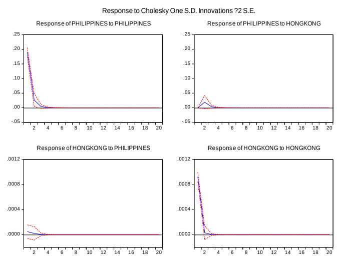
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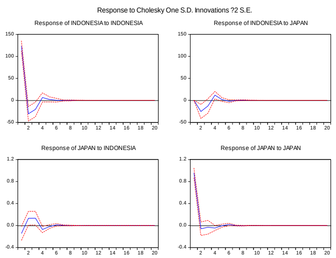
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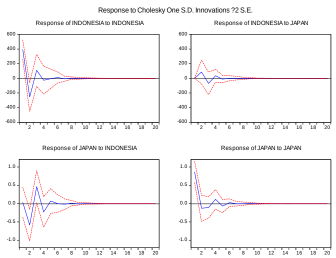
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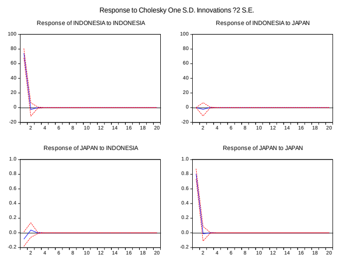
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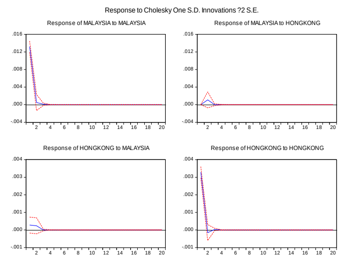
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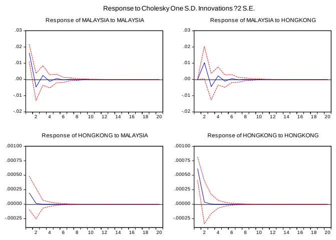
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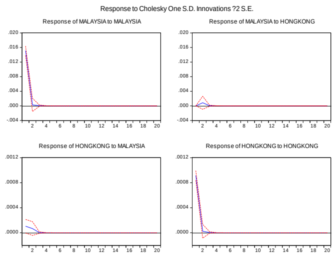
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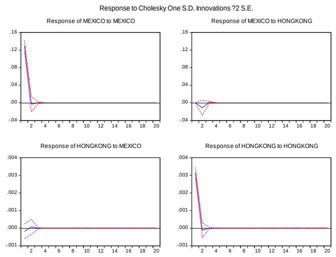
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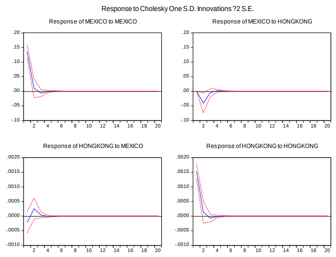
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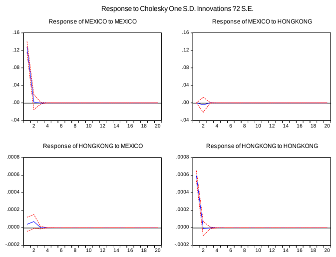
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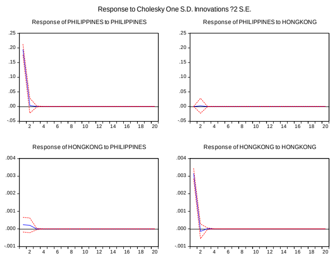
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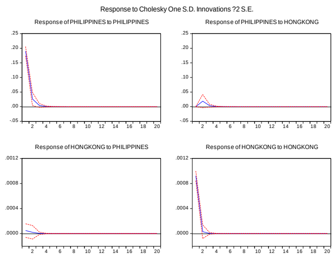
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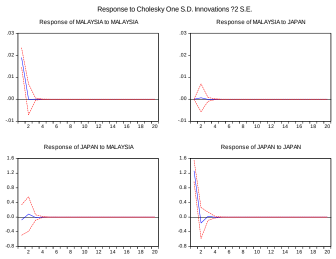
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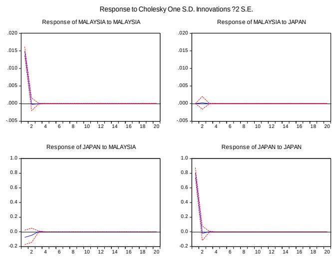
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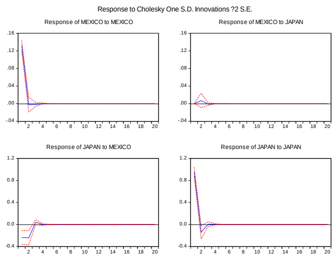
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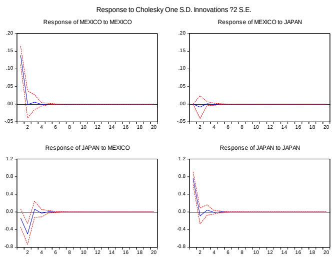
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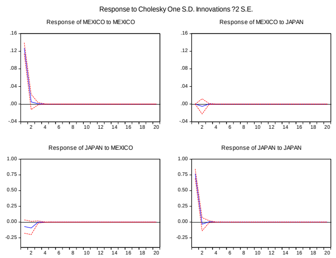
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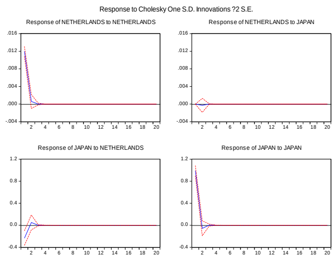
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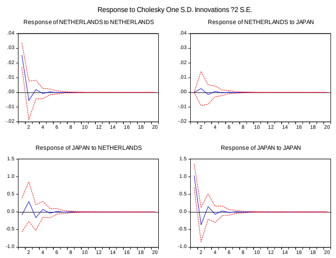
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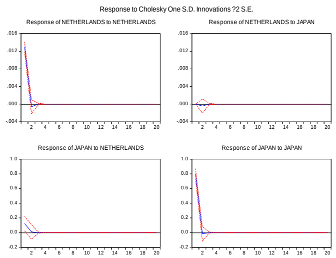
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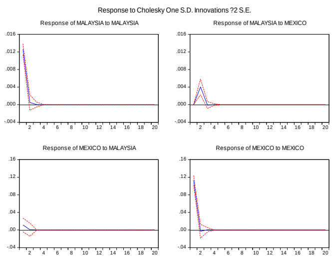
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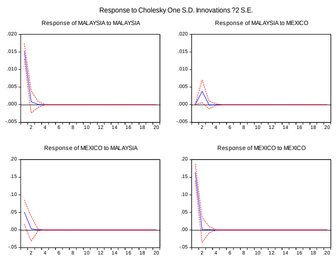
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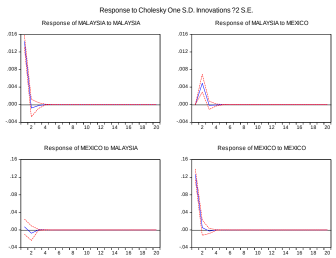
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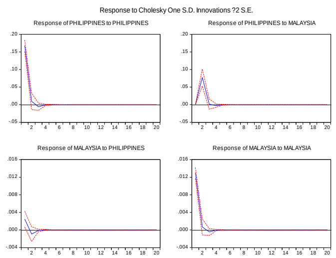
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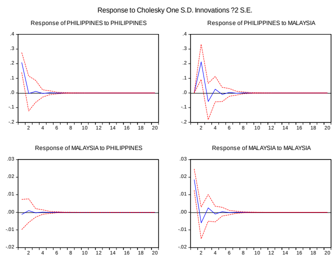
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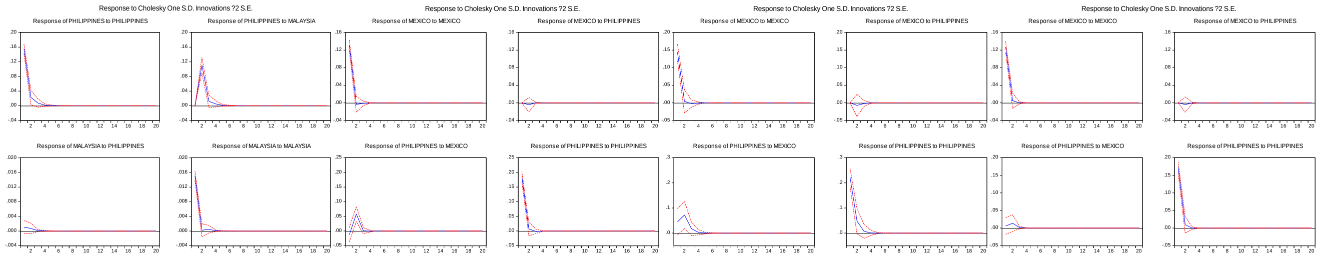

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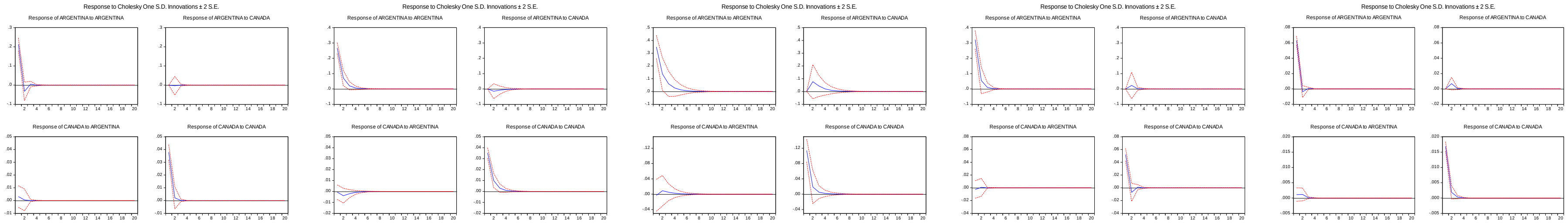

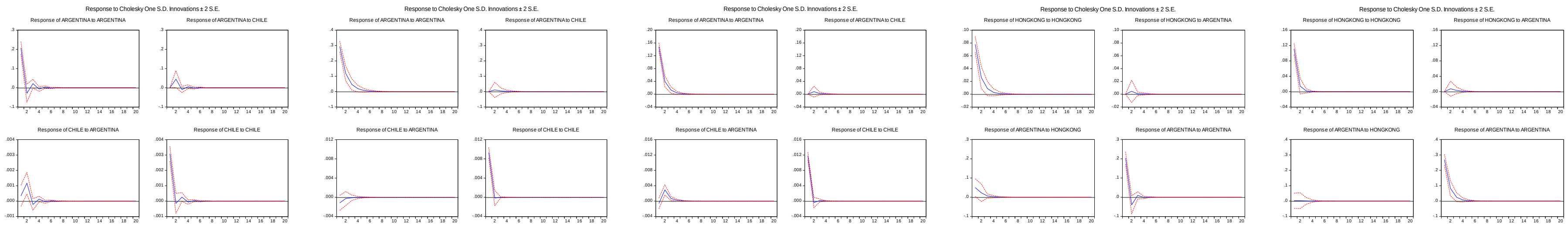

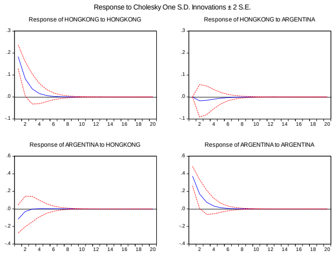
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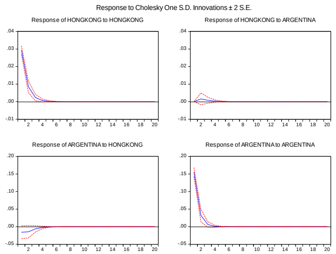
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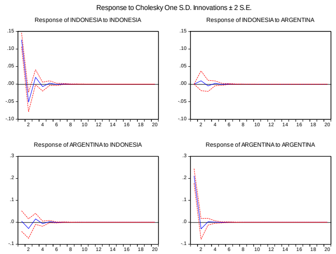
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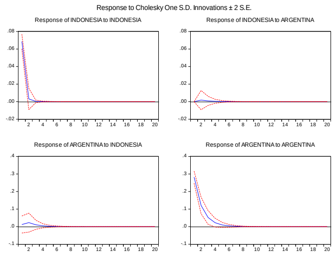
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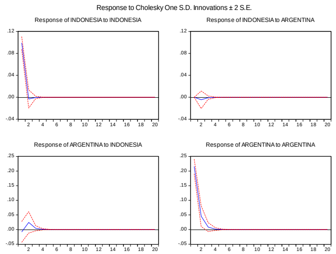
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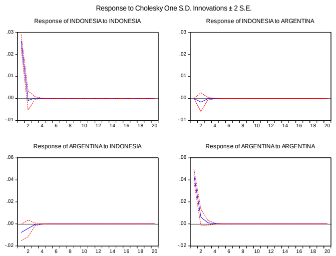
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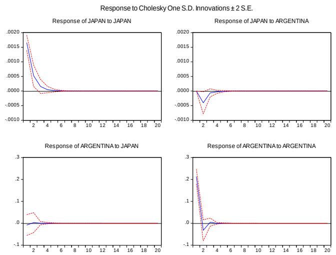
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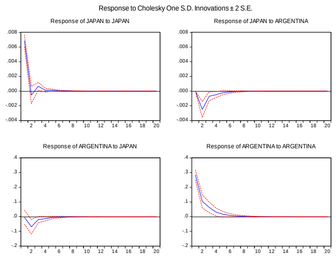
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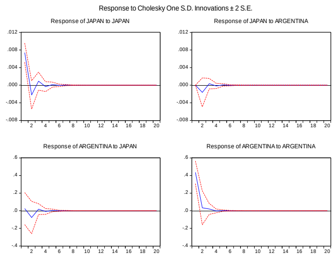
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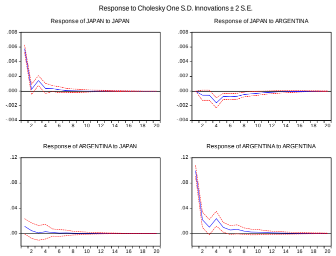
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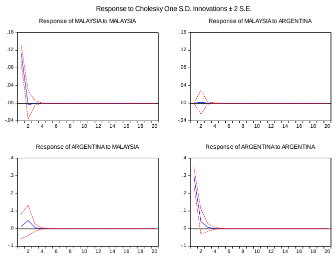
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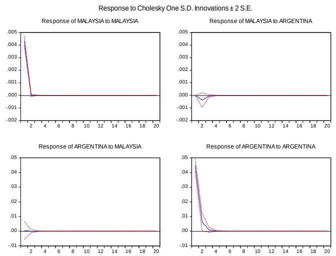
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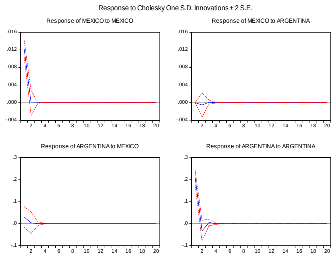
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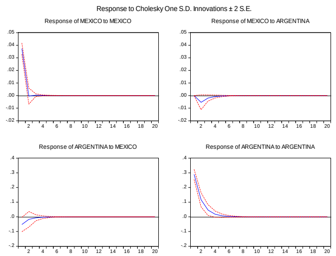
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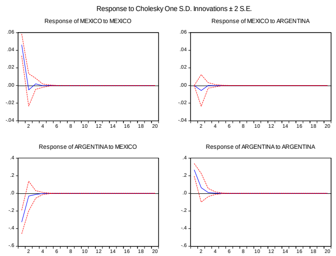
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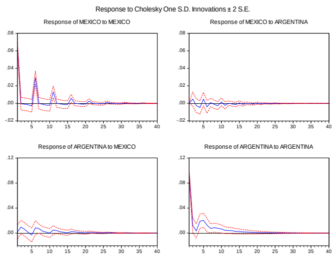
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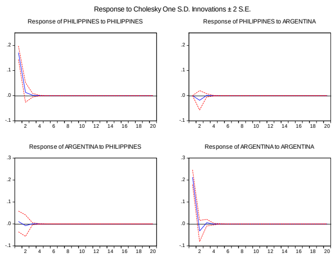
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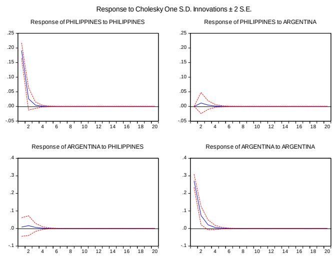
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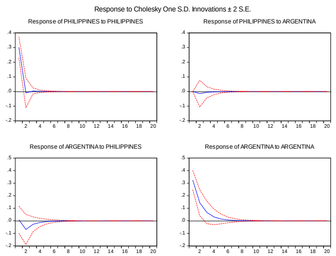
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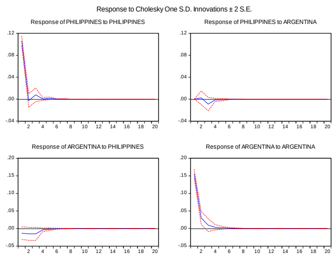
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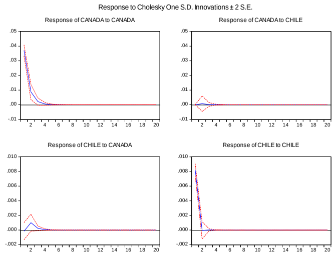
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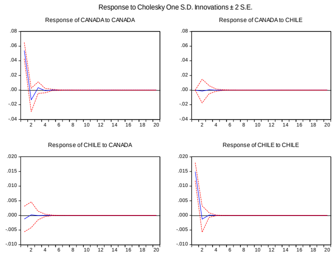
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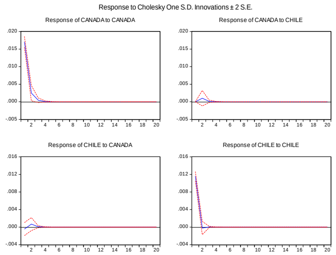
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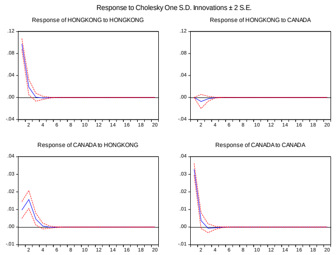
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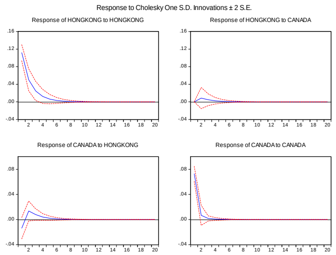
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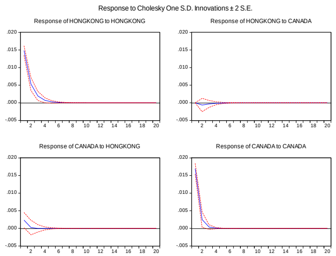
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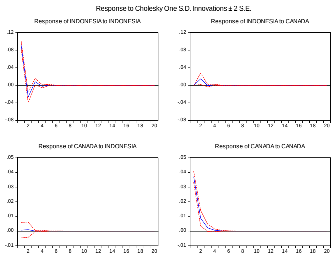
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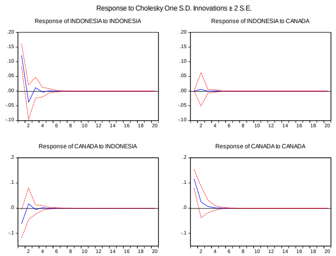
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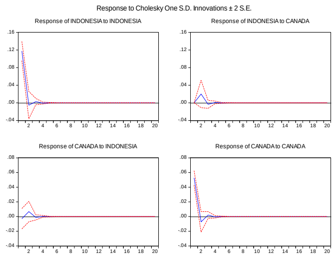
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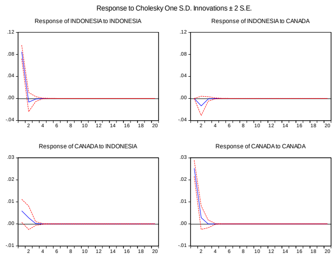
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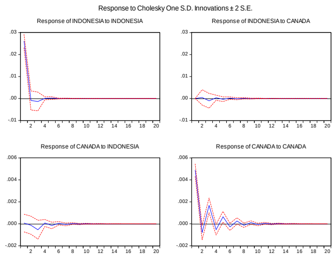
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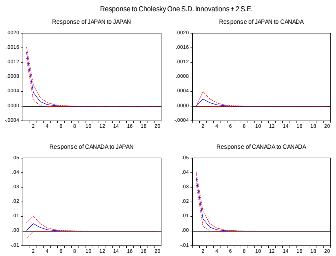
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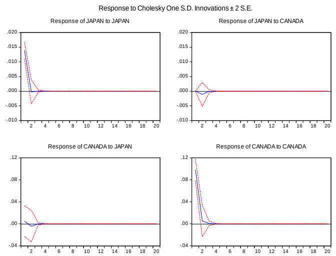
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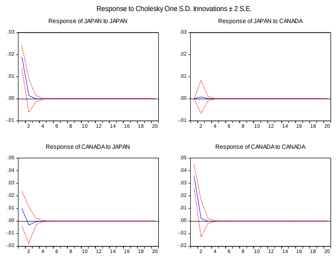
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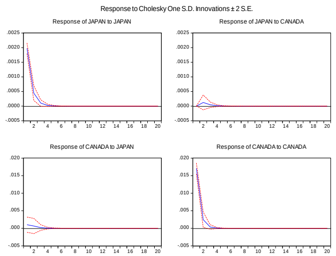
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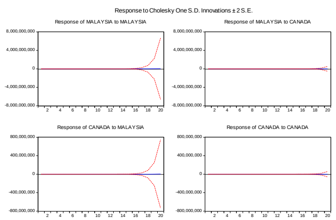
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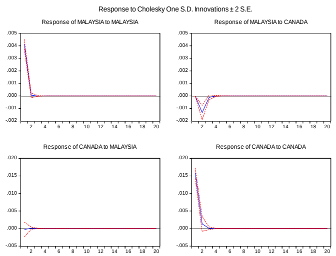
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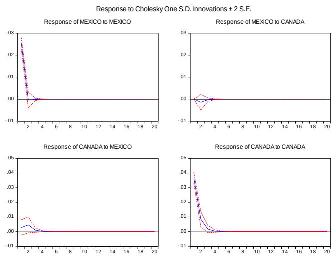
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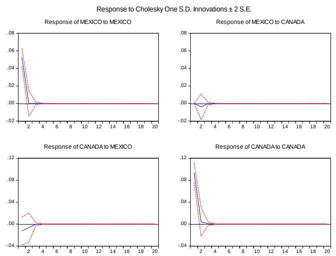
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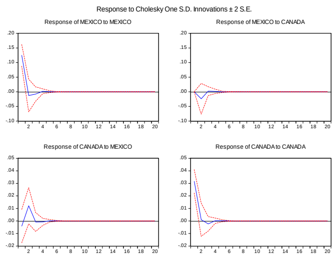
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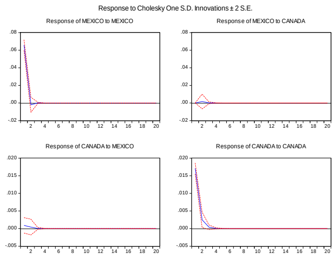
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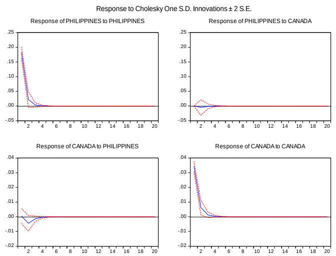
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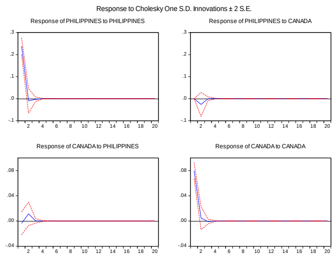
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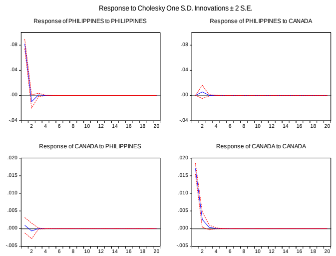
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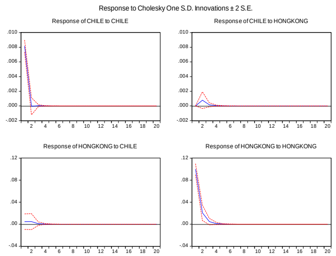
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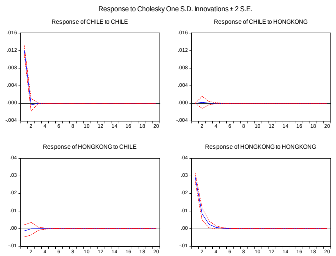
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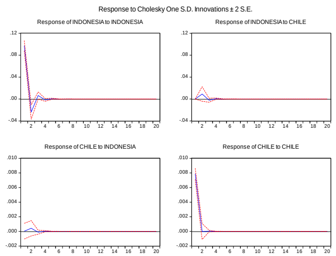
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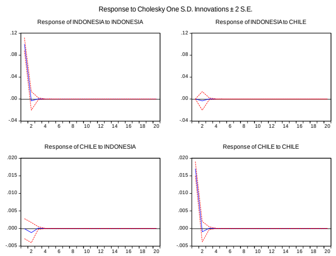
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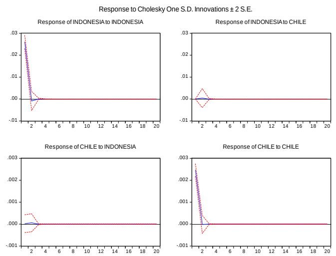
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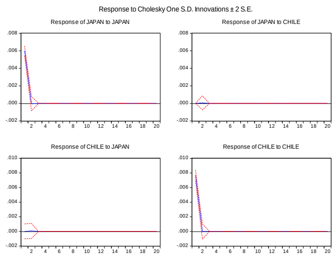
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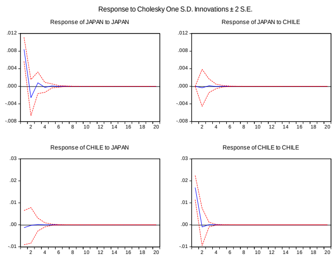
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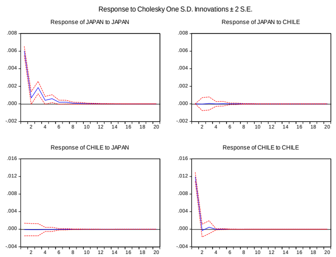
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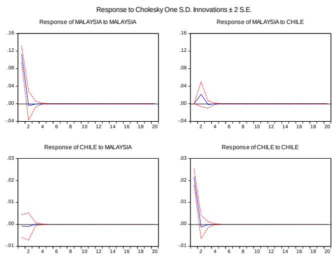
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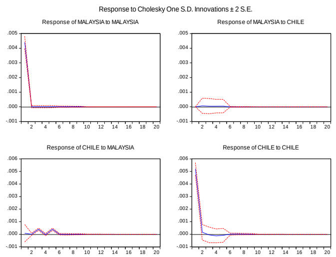
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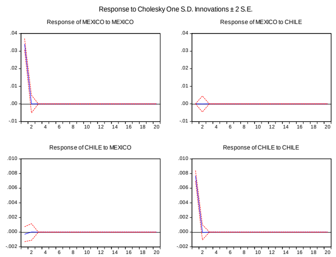
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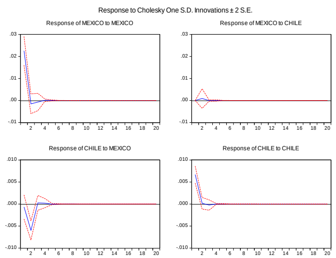
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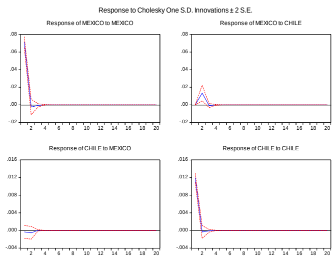
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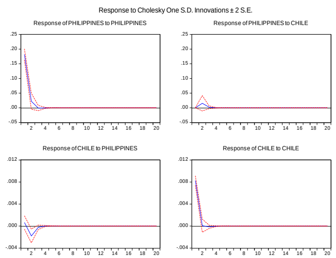
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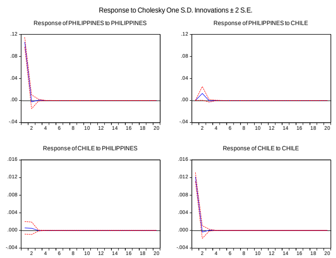
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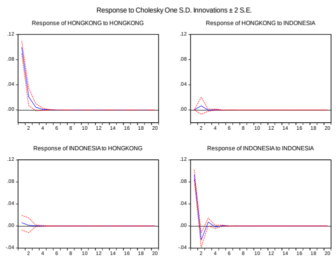
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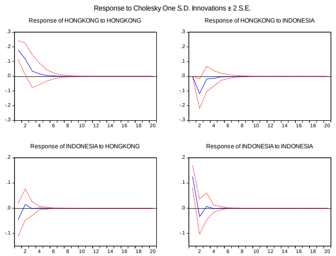
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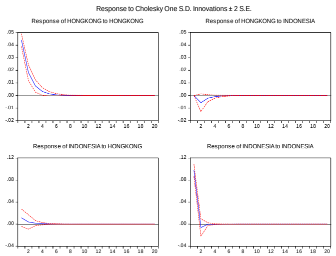
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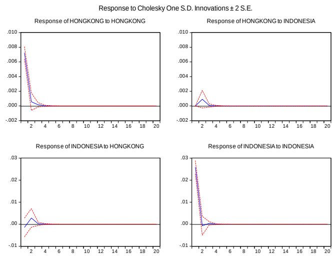
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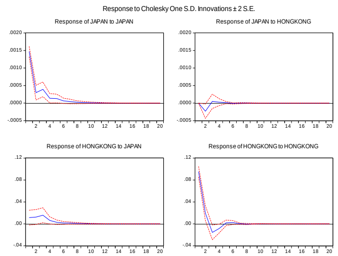
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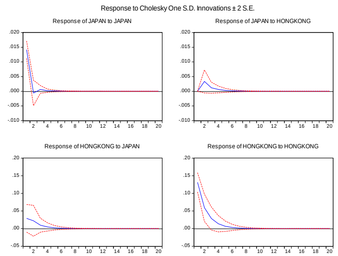
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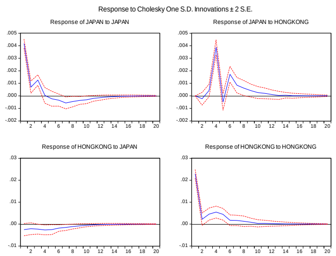
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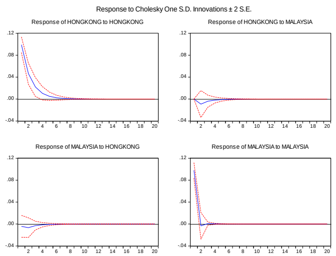
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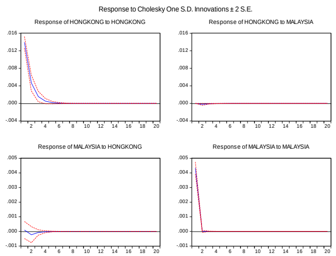
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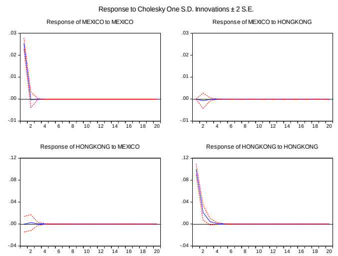
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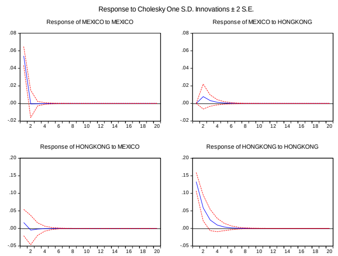
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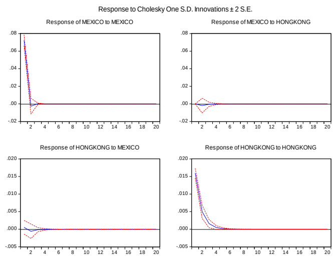
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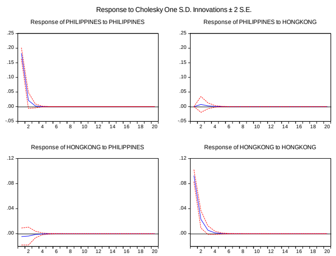
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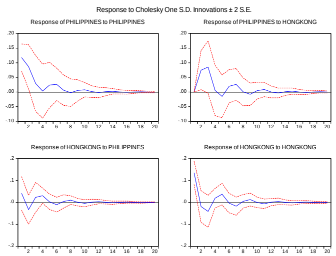
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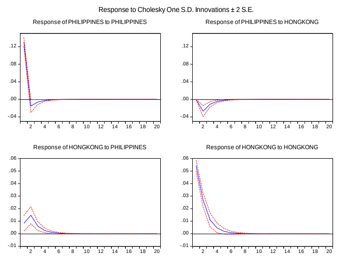
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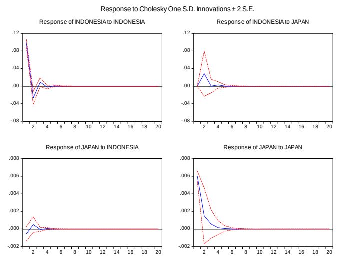
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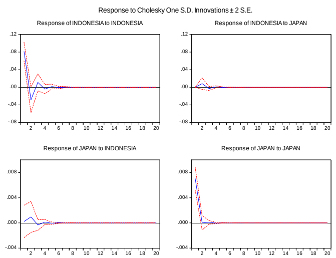
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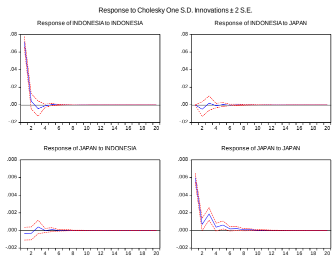
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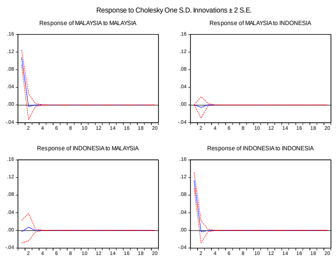
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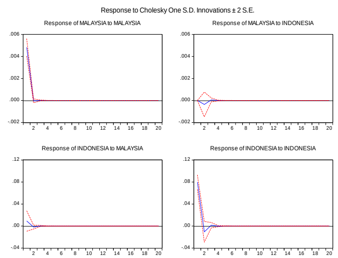
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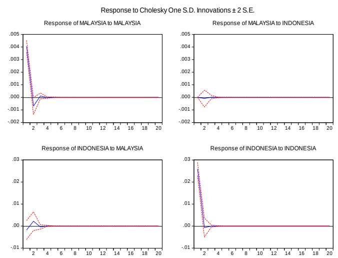
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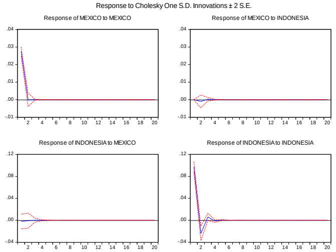
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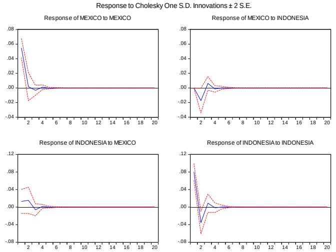
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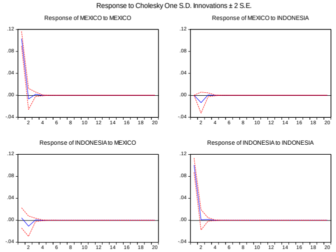
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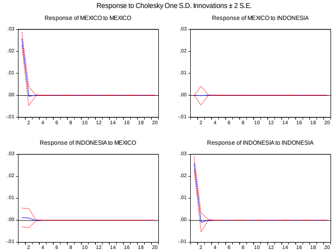
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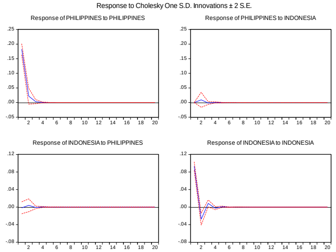
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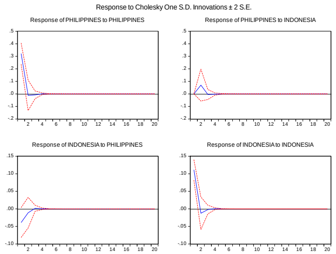
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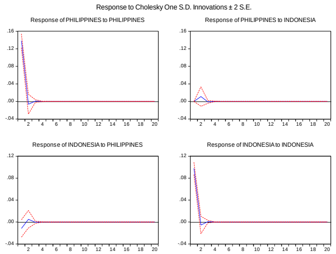
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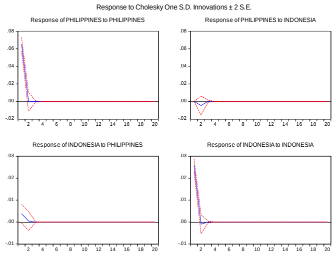
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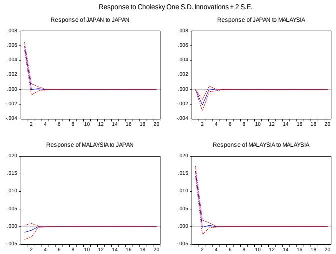
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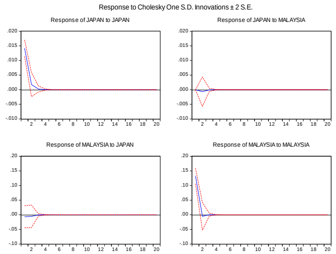
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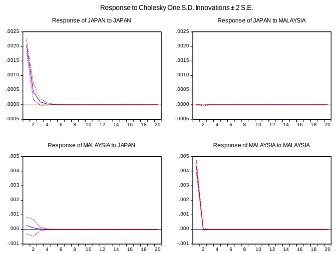
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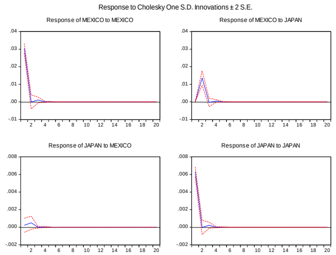
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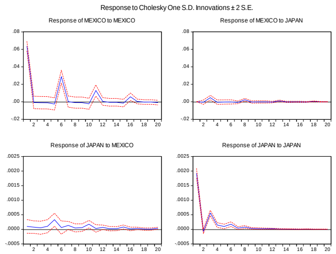
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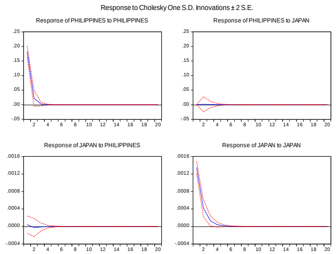
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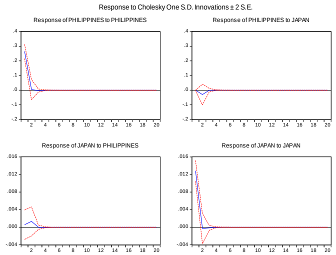
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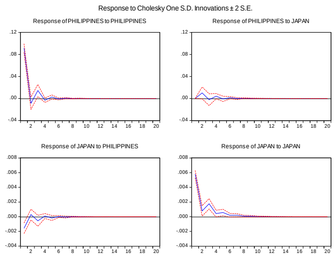
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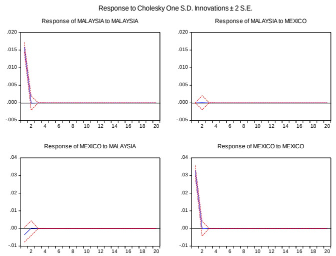
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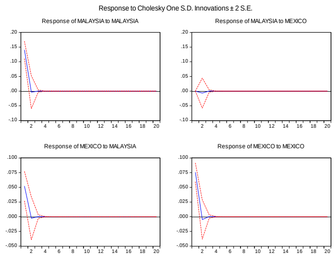
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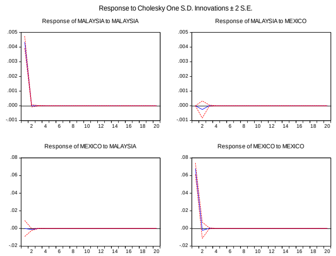
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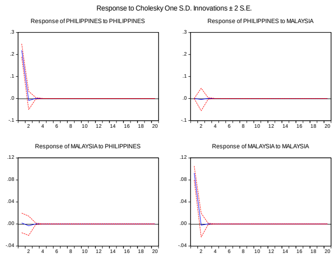
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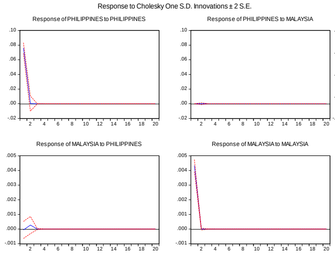
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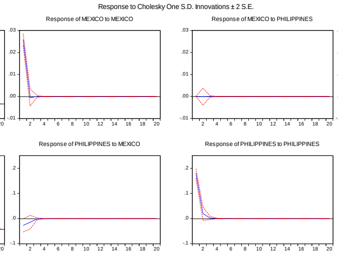
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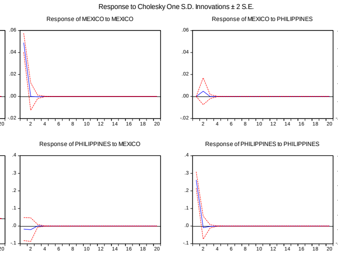
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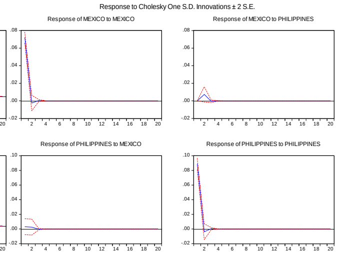
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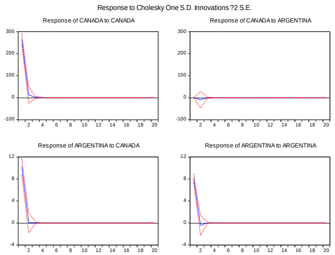
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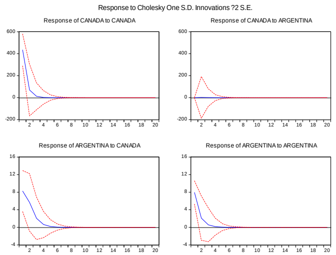
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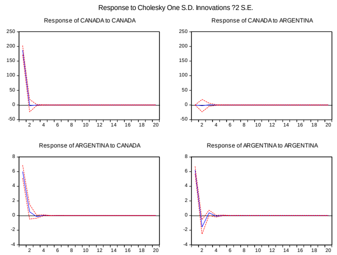
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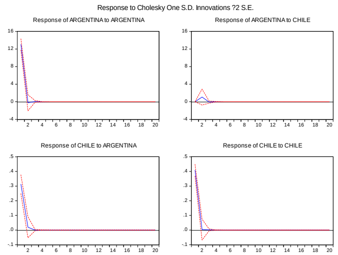
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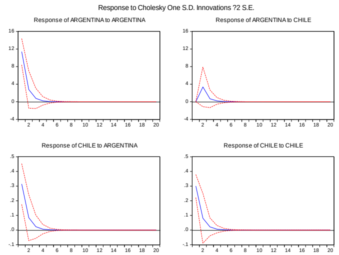
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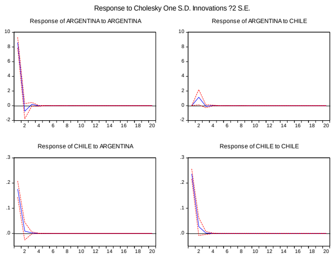
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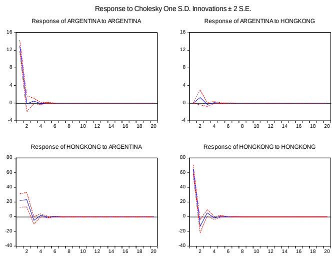
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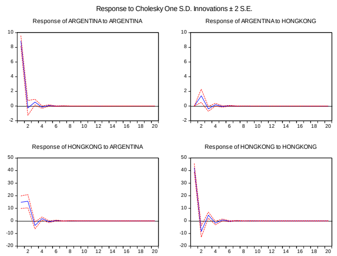
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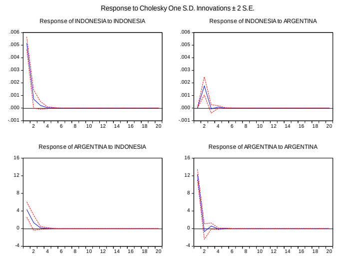
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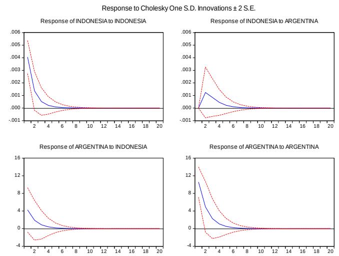
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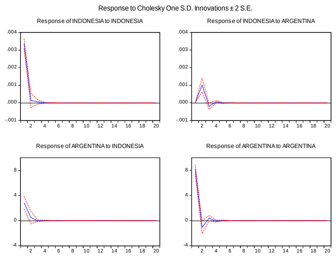
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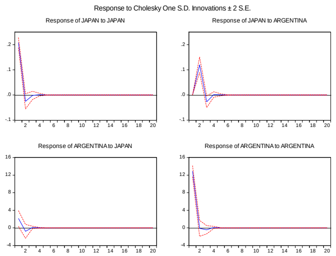
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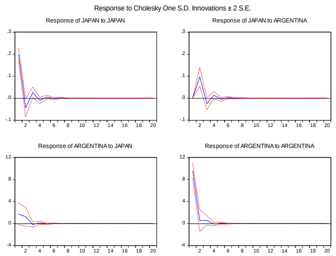
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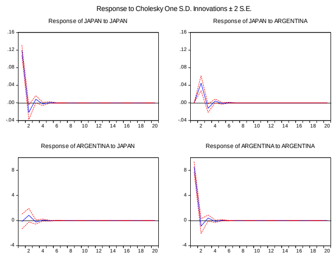
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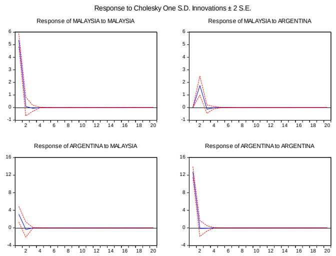
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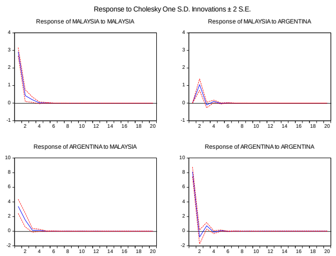
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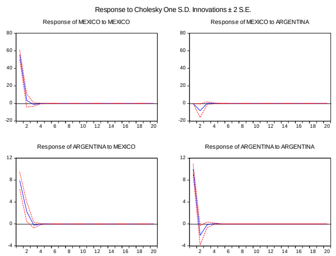
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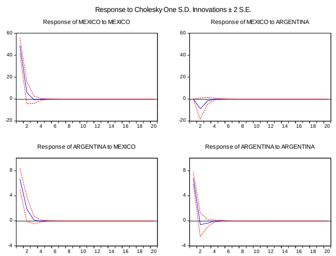
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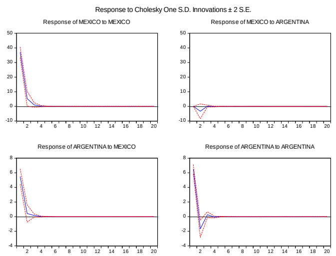
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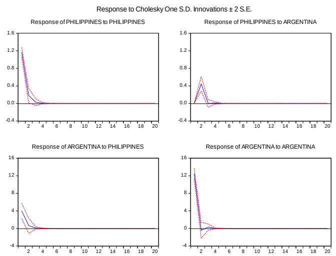
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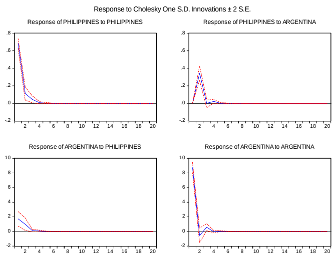
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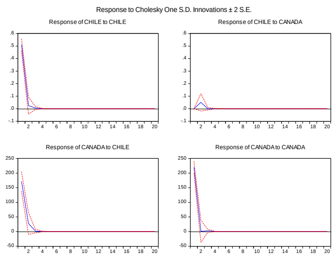
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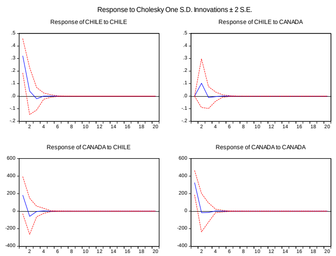
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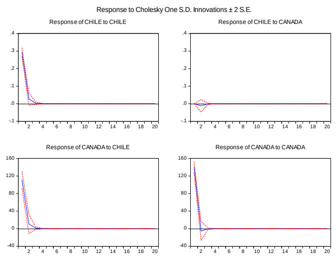
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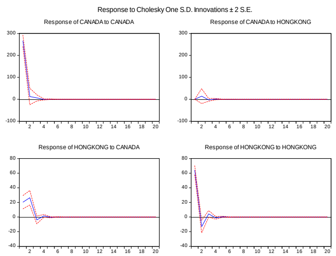
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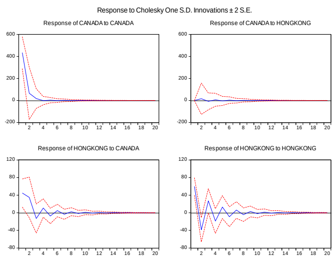
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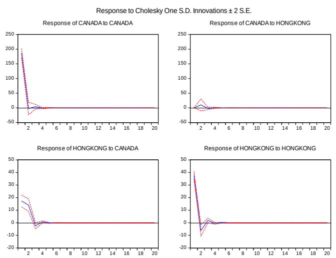
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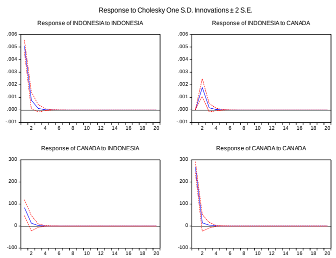
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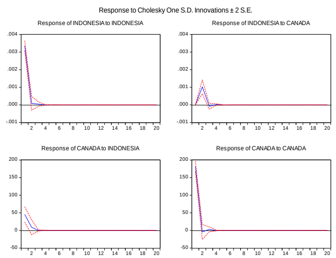
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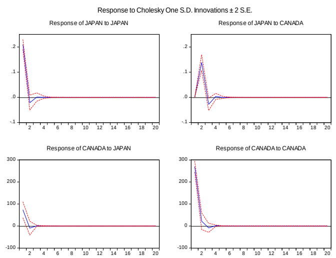
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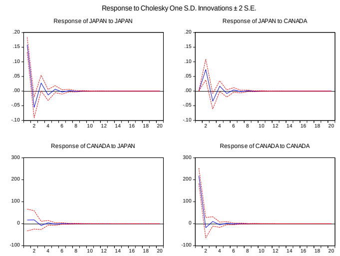
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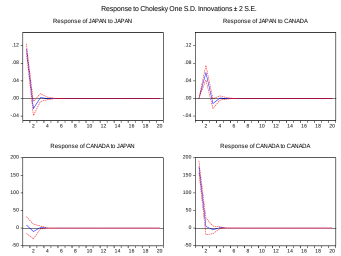
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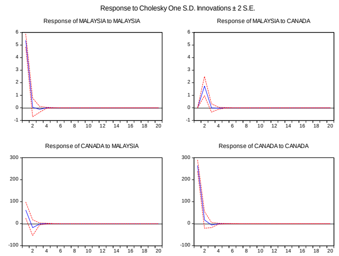
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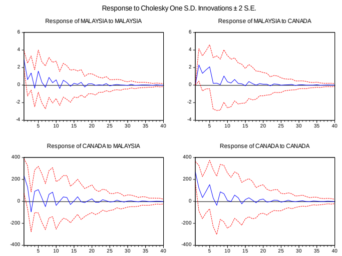
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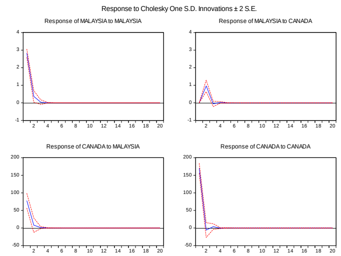
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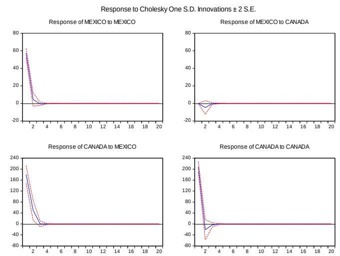
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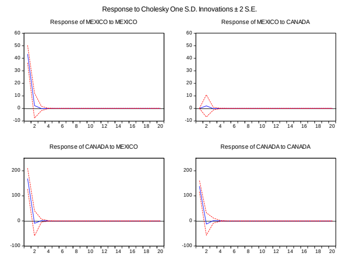
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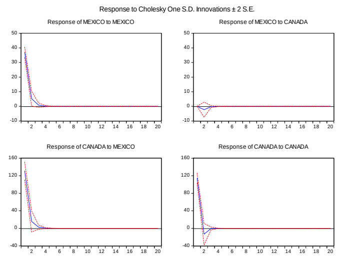
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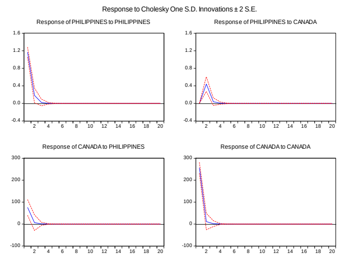
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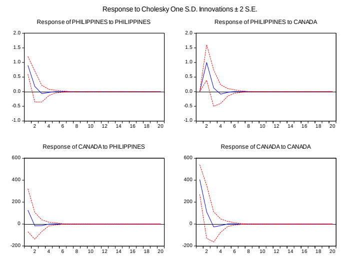
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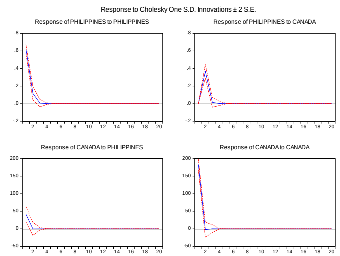
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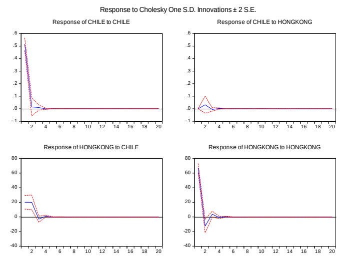
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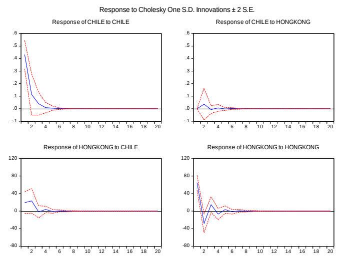
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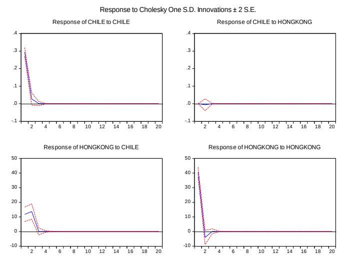
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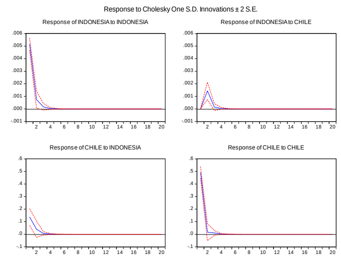
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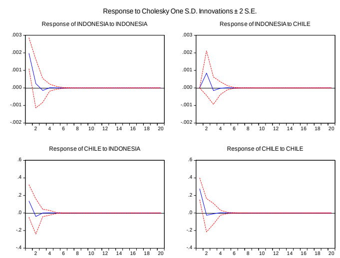
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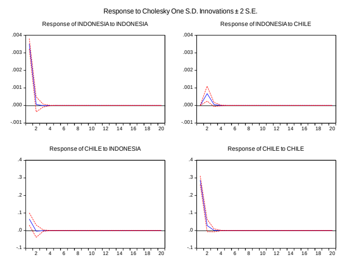
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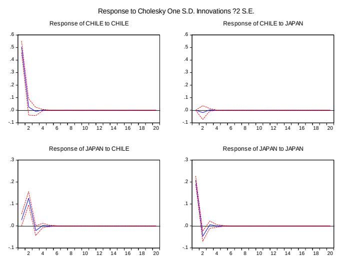
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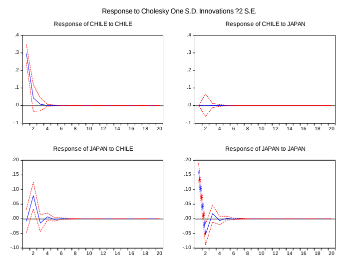
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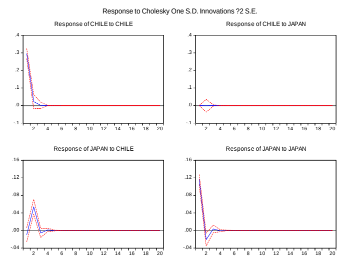
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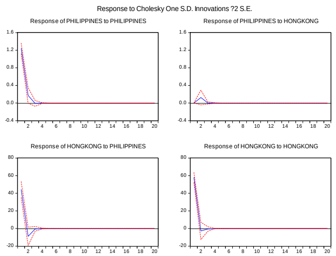
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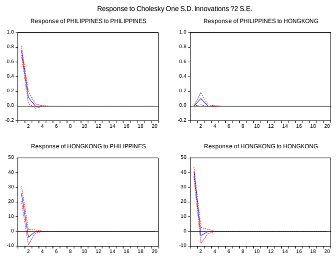
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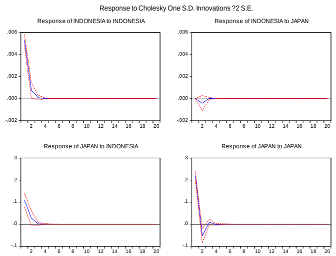
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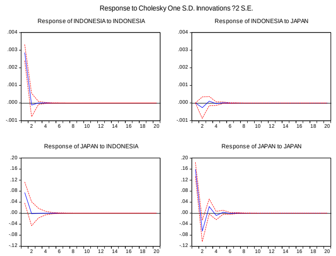
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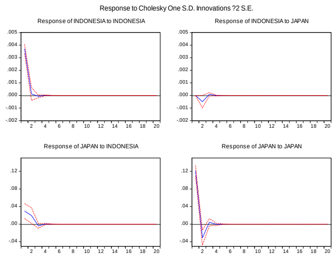
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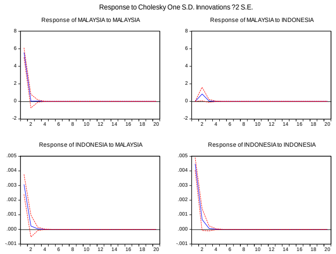
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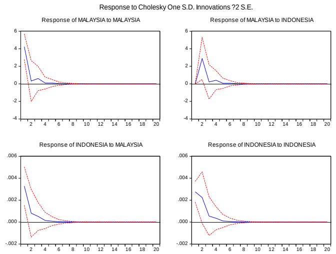
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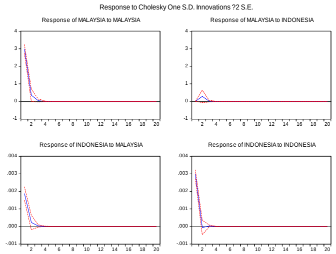
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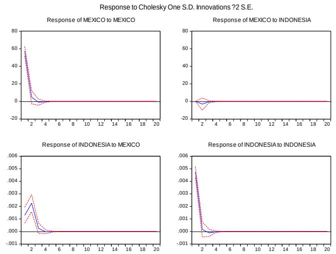
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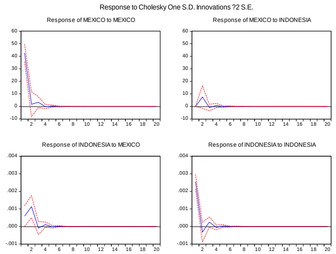
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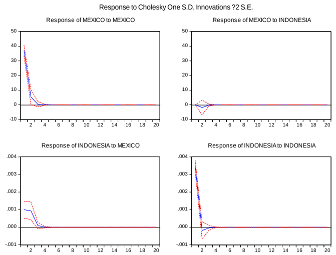
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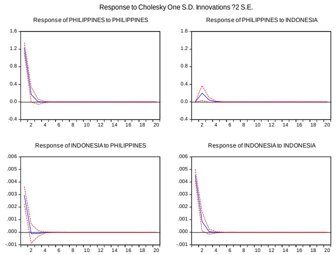
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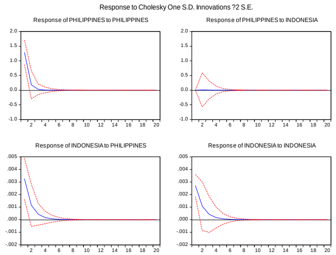
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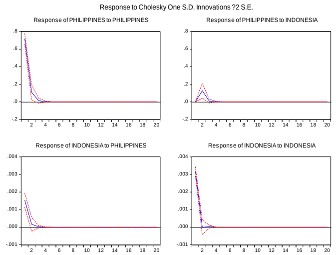
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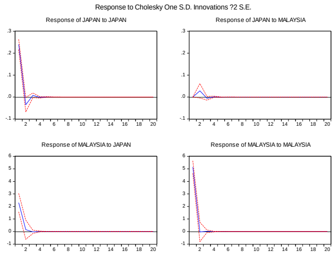
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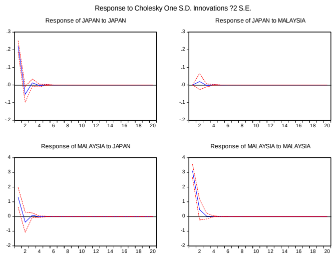
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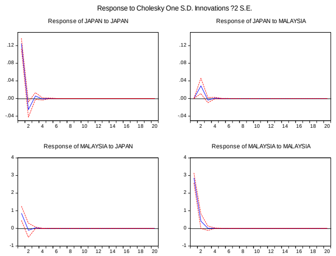
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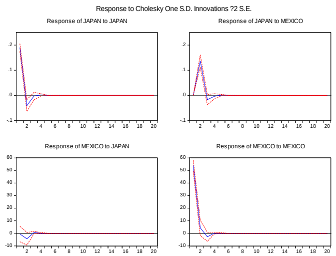
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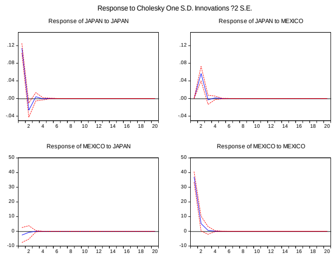
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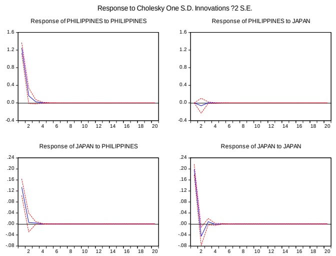
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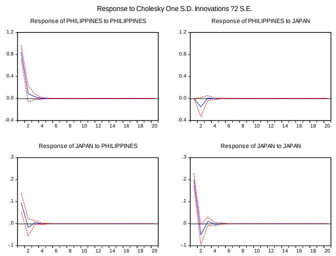
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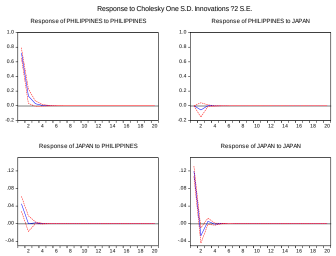
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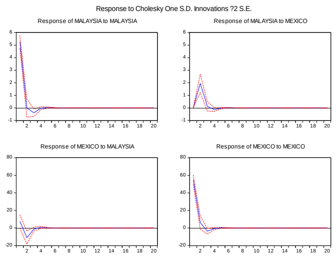
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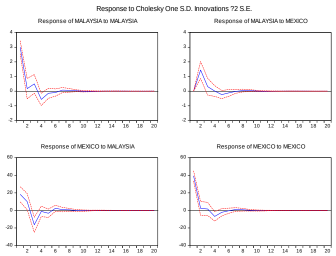
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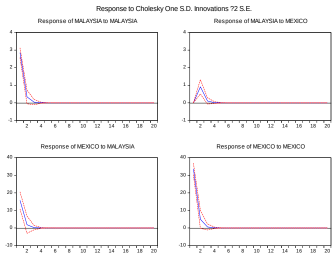
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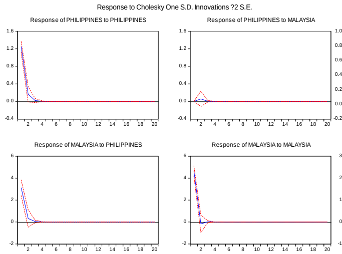
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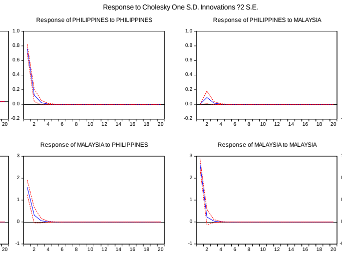
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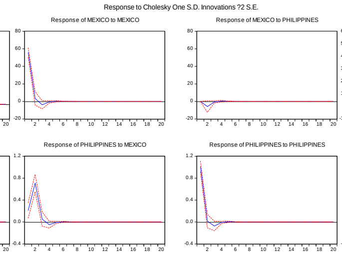
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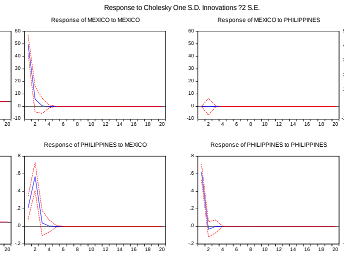
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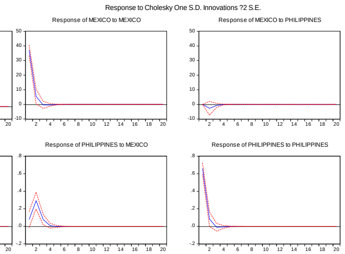
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