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Short-Term Event-Driven Analysis of the South-East Asia Financial Crisis: A Stock Market Approach

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Abstract: A systematic short-term event review of the major events in the South-East Asia Financial crisis is presented in this article. This analysis adds to the existing literature by focusing on the equity market, rather than on the foreign exchange market where there is already abundant literature, as well as going to a granular level with the hope that the analysis of the short-term market reactions can help policy-maker make appropriate decisions understanding the likely implications on the stock market. Short-term movements in the equity market might have very substantial economic impacts on investors and on the broad economy. The existing literature tends to focus on longer time horizons but from an equity investor point of view short-term fluctuations might be equally important or even more. When analyzing longer time horizons these short-term fluctuations, which might cause investors to fully unwind their positions or even bankruptcies, might be average out, underestimating the potential impact on the investor. Given these practical considerations it seems important to carry out a short-term event driven analysis of this crisis.

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1. Introduction

The South-East Asia financial crisis of the late twentieth century was an unexpected (Krugman 1999) development that saw a rapid deterioration of the economies (Suryahadi et al. 2012) and financial markets (Choudhry et al. 2007; Click and Plummer 2005; Khan et al. 2009) of several South-East Asian countries. Several of the countries directly impacted by the crisis had experienced significant economic growth in the years previous to the crisis (Huang and Xu 1999). There were several major events during the crisis, such as Thailand floating the currency as well as political changes such as the high profile replacement in Malaysia of the finance minister, creating a very complex economic and financial situation. External factors, such as the IMF intervention, have been also frequently cited as detrimental (Bello 1999) further adding complexity to the crisis with some authors, such as Pilbeam (2001), suggesting that some of the programs introduced by the IMF were too harsh. In fact, Miller (1998) considers that it is more precise describing the situation as multiple crisis occurring simultaneously rather than a single crisis.

Akyuz (1998) mentioned the substantial differences in the economies of the countries involved in the crisis. Some of the countries/regions more heavily impacted by this crisis were Thailand, where the crisis arguably started, Malaysia, Indonesia, South Korea, and the Philippines.Some authors, such as Dickinson and Mullineux (2001), have mentioned that one major factor behind the crisis was the ineffective financial regulation in some of the countries impacted. Singapore and Hong Kong were also involved in the financial crisis but they were significantly less impacted (Jin 2000), arguably due to a combination of stronger (pre-crisis) financial oversight and regulations as well as relatively high foreign exchange reserves. To put it into context, the Singaporean economy contracted in 1998 only 2.2%. Of the countries directly involved in the South-East Asia financial crisis, only the Philippines experienced a smaller contraction in 1998. Indonesia for instance had a GDP contraction in 1998 of 13.1%. Authors such as Tee (2003) mentioned that the credibility of the Singaporean

dollar exchange rate and the sound economic situation of Singapore before the South-East Asia financial crisis were among the major factors protecting the currency during this period; nevertheless, Singapore was clearly also impacted. The capital markets as well as the currencies of most of the above mentioned countries and jurisdictions were impacted to various degrees (Goldstein 1998). Notably, not all the Asian currency pegs were broken during the crisis with for instance Hong Kong managing to successfully defend the Hong Kong dollar from multiple speculative assaults. One factor facilitating maintaining the peg was the large reserves of foreign capital held by Hong Kong, second only in the region of those of Mainland China (Chirathivat 2007). Hong Kong strongly defended the currency peg with the Monetary Authority of Hong Kong, the de facto central bank of Hong Kong, using its reserves to support the Hong Kong dollar. For instance, it was reported that the HKMA spent in two hours on 24 July 1997 one billion U.S. dollars supporting the Hong Kong dollar (Kearney and Hutson 1999). Some authors, such as Bennett (1994), have mentioned the importance of the different types of peg. Bennett (1994) compares the case of Hong Kong with a hard peg and Singapore with adjustable peg.

While Hong Kong overcame the South-East Asia financial crisis better than most of its regional neighbours and was able to maintain the peg with the U.S dollar, it was also clearly affected by the crisis. According to data from the IMF, the Hong Kong economy managed to grow in 1997, with GDP up 5.1%, but contracting in 1998 by approximately 5.5%. Economic growth remained positive in the following years. The performance of the Hong Kong economy during this period considerably lagged that of Mainland China. Remarkably, Mainland China did not have during this period a single year of negative growth with GDP increasing 9.3% and 7.8% in 1997 and 1998, respectively. GDP growth in the post-crisis period in Hong Kong remained positive but volatile with oscillations such as a GDP increase of 10.0% in 2000 followed by a GDP increase of only 0.6% in 2001. The stock market in Hong Kong was also impacted by the crisis with the Hang Seng Index down approximately 46% from the peak in 7 August 1997 of 16,673 to the bottom of 28 October 1997 of 9059.

The 1997 South-East Asia financial crisis brought to an abrupt stop (Miller (1998)) the remarkable rates of economic growth experienced by several of the countries in the region. Some authors, such as Corsetti et al. (1999), suggest that the South-East Asia financial crisis of 1997–1998 was the culmination of a series of long standing pre-existing structural imbalances rather than a single major event precipitating the crisis but this remains an area of debate. The degree of development and sizes of these economies involved were remarkably different. As previously mentioned, one of the most visible and first events during this financial crisis was the collapse of the Thai currency (baht) adding pressure on Thai companies that have borrowed on U.S. dollars. This is in fact the start of the crisis according to authors such as Leightner (2007). The situation in Thailand rapidly spread to other countries (Jomo 1998).

Most of the existing literature in the South-East Asia financial crisis focuses on the impact on the real economy as well as in the fluctuations in the foreign exchange market (Woo et al. 2000). This is perhaps due to some very high profile developments in the foreign exchange market such as the well-known bet of George Soros against the baht. There are also some interesting research, such as Beaverstock and Doel (2001), mentioning the role played by the baking sector, of both domestic institutions as well as of the international investment banks.

There is however relatively less literature covering the impact on the stock market, particularly from a short-term event driven angle. Short-term fluctuations in the equity market might have a very substantial impact on investors, particularly if their investments are leveraged or it they are forced to unwind their trades due to margin calls or risk management considerations. Unwinding these positions, during unfavorable market movements, might negate the benefits of a future recovery in the market. There is ample literature suggesting that there are volatility clusters in several equity markets (Cont 2007; Lux and Marchesi 2000) and such clusters might potentially be related to a major event.

An example of such an event could be Thailand letting its currency to free float during the South-East Asia financial crisis on 2 July 1997. Until that moment, most South-East Asian countries have defended their currencies, many of them pegged to the U.S. dollar. A related factor frequently mentioned in the existing literature (Radelet and Sachs 1998) is the spread of financial panic. In this paper, we carry out a short-term event driven Granger causality analysis using some important events cited in the existing literature. Granger causality tests are a frequently used technique to analyze dependencies between financial variables (Ibrahim 2000). The analysis focuses on the impact on the equity markets rather than the impact on the foreign exchange market.

One of the assumptions underlying this paper is that some events, such as, for instance, the end of a currency peg, can trigger significant movements in the local equity market. Furthermore, the impact on those events can also spread to other markets, particularly regional, also impacting their performance. It seems also reasonable to assume that in principle this market fluctuations can be short lived, averaging out over long periods of time, but having substantial impact in the short term. In order to analyze these events, it is necessary to have the appropriate mathematical and statistical tools. Note that the focus on this paper is on trying to determine the changes in interdepenedencies of stock markets rather that on trying to forecast the stock prices themsleves. In recent years, there has been a focus on using machine learning techniques generating interesting results, such as, for instance, neural networks (Cervello and Guijarro 2020; Garcia et al. 2018). However, the analysis in this paper focus on changes in the dynamics of the market with actual forecasting outside of the scope. An underlying assumption in this analysis is that the Granger causality test can detect some causality relationships. This is a common assumption in multiple articles such as Hoffmann et al. (2005); Akinboade and Braimoh (2010), and Lopez and Weber (2017). It is not assumed that the Granger causality test fully accurately reflects underlying causality relationships, but it is rather used as a quantitative indication of their existence. In other words, the Granger causality test reflects Granger causality rather than true underlying causality. Nevertheless, it is important to have a quantitative test that can be applied objectively to the data to try to minimize as much as possible the potential for biases in the analysis.

2. Some Major Events during the South-East Asia Financial Crisis

It is a challenging task to identify the major events during any financial crisis and the South-East Asia financial crisis is no exception and even more complex to determine the factors that might impact the equity market. For instance, besides objective financial conditions there is some existing research on the impact of investors sentiment (Guijarro et al. 2019) on the equity market. This could be a particularly important factor to be taken into consideration during financial crisis. It is also acknowledged that there is some degree of subjectivity and that there are some other events that could potentially be considered. Nevertheless, it is necessary when attempting to carry out an event driven analysis, to identify a list of such events that are significant enough to have had a large impact on the stock market. In this case of the South-East Asia financial crisis, seven events (Table 1) were identified as substantial enough to potentially having the capacity to impact the stock market. These events range from 2 July 1997 (Jansen 2001) that saw the end of the Thai baht peg (event 1) to 3 September 1998 with the replacement of the finance minister in Malaysia (event 7). Some authors such as Jansen (2001) consider that the start of the South-East Asia financial crisis was July 1997, coinciding with the end of the Thai baht peg. Krongkaew (1999), more explicitly, mentions that the start of the economic crisis occurs in Thailand with the flotation of its currency. Thus, this event should be one of those analyzed.

Table 1. List of some major events during the South-East Asia financial crisis.

Event	Date	Description
1	2 July 1997	End of the Thai baht peg
2	14 August 1997	Indonesia let the currency to free float
3	14 October 1997	Restructuring package announced by Thailand
4	12 January 1998	Collapse of Peregrine investment
5	31 March 1998	Thai guideline of definition of non-performing loans
6	11 May 1998	Joseph Estrada wins general elections in the Philippines
7	3 September 1998	Finance minister of Malaysia replaced

Pressure had been building on the Thai economy since early 1997 and was becoming evident with the default of Somprasong Land (Lauridsen 1998; Wong 2001), a property developer, adding concerns about the health of property developers. However, this event by itself did not appear to have caused an impact on the broad financial market or economy. Another factor to take into account was the increasing pressure from hedge funds Robins (2000) on the baht. Perhaps some of the best known hedge funds to bet against the baht during this period are the Quantum Fund and Tiger Fund with a reportedly one and three billion U.S. dollars short positions on the currency, respectively. Note that the actual impact that the hedge funds had on the South-East Asia financial crisis remains a disputed topic with authors such as Brown et al. (2000) not founding empirical evidence that hedge funds caused the financial crisis in Thailand. Regardless of the actual impact of hedge funds, the situation in the currency front eventually became unsustainable and Thailand had to float its currency. After the flotation of the Thai baht there was an almost immediate overnight depreciation compared to the U.S. dollar (Punyaratabandhu 1998) putting substantial pressure on Thai companies that had borrowed in U.S. dollar terms. The deterioration in returns combined with large amounts of borrowings in foreign currency plus a significant devaluation of the baht proved to be a combination that hurt a large amount of Thai companies that were unable to repay their borrowings. Jansen (2001) and several other scholars have mentioned that financial institutions as well as companies got used to have a stable currency pegged to the U.S. dollar creating a false sense of security and causing poor risk management. According to these authors, the possibility of a sudden change in the exchange rate of the baht was regarded as a rather remote possibility and this perception was based on many years of stable foreign exchange values and growing economy. While there were financial tools for hedging currency exposure the borrowing from Thai domestic companies was predominantly not hedged (Takayasu 1998) and thus companies had to absorb loan repayments denominated in U.S. dollar while the local currency was rapidly depreciating.

Another event considered (event 2) was Indonesia letting its currency to free float in 14 August 1997 (Pratomo and Warokka 2013). This was arguably unavoidable after Thailand ended its peg a few weeks earlier with the Indonesian currency reserves coming under increasing pressure during those weeks. In the initial stages of the financial crisis Indonesia showed some signs of resilience. This situation quickly changed with the local currency slumping and a run on the banking sector putting the national finances under considerable stress. One of the first clear signs of stress in Indonesian economy appeared in the currency market with the Indonesian rupiah slumping against the U.S. dollar from July 1997 to January 1998. Indonesia had started a process of liberalizing the exchange rate system (James 2005) in the previous decades and by 1997 the Indonesia rupiah traded within a relatively narrow band relatively to the U.S. dollar. Given the increasing pressure on the currency and the cost of defending it, Indonesia decided on 14 August 1997 to float the currency. The regime shift added significant amount of volatility to the exchange rate and increased economic pressure. Some authors, such as, for instance, Pratomo and Warokka (2013), have argued that the Indonesian rupiah was not a stable currency even before the South-East Asia financial crisis and that if more efforts were have

done to stabilize it in the years before the crisis the rupiah should have hold substantially better during the crisis period.

After a turbulent summer of 1997, several of the countries engulfed in the crisis developed economic plans to tackle the crisis, such as for instance the restructuring package introduced by the Thai government in 14 October 1997 (event 3). This restructuring initiative received the praise of the IMF with IMF managing director, Mr. Michel Camdemssus, stating "The Thai government has made a significant announcement today about its detailed strategy to restructure Thailand's troubled financial sector." An important development of this initiative was the creation in Thailand of the Financial Sector Restructuring Authority commonly known as FRA (Hawkins 1997). FRA was one of the main agencies in charge of assessing the economic situation and handling troubled financial assets and had a wide range of powers including the ability to request troubled financial companies to recapitalize or to arrange acquisitions by third parties.

An event that attracted substantial attention during the South-East Asia financial crisis was the collapse or Peregrine Investments in early 1998 (event 4). Peregrine Investments went into liquidation in January 1998 in Hong Kong. At the core of the collapse of Peregrine Investments was a 269 million U.S. dollar loan to a taxi company in Indonesia called PT Steady Safe. Several attempts to restructure the loan were unsuccessful with the company going into liquidation relatively quickly after the start of the South-East Asia financial crisis. Note that Peregrine Investments was a very well-regarded institution with diversified operations across Asia and to a lesser degree in Europe and the US. At the time of its collapse it was one of the largest independent investment bank in Asia. A few months later, in 1998, there was a subtle but important development with Thailand modifying the definition of non-performing bank loans (event 5). The objective of this measure was to make the definition of non-performing bank loans in Thailand in line with the international accepted guidelines (Takayasu 1998). While a positive development, this reclassification arguably added in the short term more pressure on the market as international standards at the time were more stringent.

Another event considered was the successful presidential campaign of Mr. Joseph Estrada in the Philippines (Claudio 2014; Ringuet and Estrada 2003), representing the political party PMP, becoming president after winning the elections in 11 May 1998 (event 6). Estrada won the election with a populist message (Hedman 2001), promising alleviating poverty. The Philippines was one of the very few Asian countries, at the time of the South-East Asia financial crisis to have a fund deposit insurance scheme (Kochhar et al. 1998), likely helping alleviating runs in the Philippines banks. Additionally the banking sector in the Philippines was less exposed to the real estate sector (Table 2) that most of its regional peers. This is not to say that the banking system of the Philippines had no significant exposure to the real estate sector. According to Bello (1999), the commercial bank loan exposure of the Philippines to the real estate sector was approximately 20% in the period just before the financial crisis, while the real estate exposure in Indonesia during the same period was approximately 25% (Bello 1999). Several authors, such as Krugman (1999), have mentioned that a major issue was that a large amount of the capital borrowed overseas was directed towards investment in real estates. In many occasions, foreign capital was cheaper than domestic one and companies borrowed in foreign currency increasing their foreign exchange risk.

Table 2. Banking system exposure to the real estate sector. Source: Bank of International Settlements.

Country	Country Exposure (%)
Indonesia	30
Malaysia	40
Philippines	20
Singapore	40
South Korea	25
Thailand	40

A lesser exposure of the banking sector to property developers was one of the factors allowing the Philippines to be relatively less impacted than its peers by the crisis with for instance, according to figures from the World Bank, having the smaller GDP correction in 1998 (Table 3).

Table 3. GDP (1998). Source: World Bank.

Country	Country Exposure (%)
Indonesia	−13.1
Malaysia	−7.4
Philippines	−0.6
Singapore	−2.2
South Korea	−5.5
Thailand	−7.6

This is not to say that the Philippines were untouched by the financial crisis. For instance, the Philippine peso experiencing a depreciation against the U.S. dollar of approximately 37% from June 1997 to September 1998, which is in line with most of the Asian neighbors such as Thailand, Malaysia, and South Korea. The last event considered was the abrupt replacement of the finance minister in Malaysia in 3 September 1998. Malaysia faced significant internal political turmoil during this period with public disagreement between the members of the Malaysian government regarding how to react to the crisis with on one hand the Prime Minister Mahathir Mohamad (Kelly 2001), against accepting the bailout offer from the IMF, and on the other hand, the finance minister that supported this idea and was an advocate of free markets. The finance minister was replaced (Sundaran 2006) and Malaysia continued its strategy of not requesting a bailout from the IMF (Sausmarez 2004).

Prime Mister Mahathir mentioned that the IMF would have requested too stringent economic reforms and that IMF will focus only on loan repayments rather than on economic growth which was according to Prime Minister Mahathir not an acceptable approach for the country. Malaysia initial response to the crisis has been described by some scholars as a "state of denial" (Ariff and Abubakar 1999) with the government downplaying the seriousness of the situation. One of the first clear indications of the severity of the financial crisis was the depreciation of the Malay ringgit. The central bank of Malaysia (Bank Negara Malaysia) tried to support the currency purchasing at the beginning of July 1997 in excess of one billion U.S. dollar. It has been highlighted by some scholars that despite refusing the intervention by the IMF the Malay government immediate response was roughly in line with the IMF suggestions, by substantially decreasing government spending and delaying major projects such as railways and the emblematic Bakun dam (Ariff and Abubakar 1999) and banning short term repatriation of capital (less than 12 months).

Nevertheless, the severity of the economic situation became self-evident rather quickly and the Malay government reacted by establishing, in the beginning on 1998, the National Economic Action Council, which could be described as a think-tank helping the government drafting policies to overcome the financial crisis. Eventually the government took two major decisions: (1) strict capital control and (2) peg of the currency to the U.S. dollar at a 3.8 rate. This meant that the offshore ringgit was no longer convertible, basically closing the offshore foreign exchange market and forcing some repatriations of ringgit into Malaysia. Furthermore, Malaysia went a step further by declaring the Malay ringgit illegal tender outside Malaysia and by freezing non-resident bank accounts holding deposits denominated in Malay ringgit. Despite all these measures, the depreciation of the Malaysian ringgit compared to the U.S. dollar during the South-East Asia financial crisis was in line with most of its Asian neighbors, such as Thailand, Philippines, and South Korea.

3. Methodology

A systematic approach was followed in this paper including in the analysis not only South-East Asian countries but also emerging and non-emerging countries in order to

make the comparisons more reliable as well as in order to determine base line pre-existing relationships. An underlying assumption is that financial crisis can cause contagion among the equity markets of different countries (Kernourgios et al. 2011). A short-term event driven Granger causality test was performed among all the 23 countries/regions analysed (Table 4). Granger causality tests have been applied to the stock market in several paper such as Hiemstra and Jones (1994). A set of events, previously identified in Table 1, were used as critical dates representing significant developments such as for instance Thailand floating the baht. This differs from most of the analysis in the existing literature that tend to segment the analysis into the pre, post, and crisis periods (Jang and Sul 2002) rather than going to a more granular level during the actual financial crisis. For each event a time period, including ten days before and ten days after the events, was analyzed. This period of time was chosen to avoid overlap between the different events which can make the interpretation of the results more difficult. Following the standard notation the variables can be described as (Equation (1))

$$y_{i,t} = \alpha_{0,i} + \alpha_{1,i}y_{i,t-1} + \alpha_{2,i}y_{i,t-2} + \ldots + \alpha_{j,i}y_{i,t-j} + \beta_{1,i}x_{i,t-1} + \beta_{2,i}x_{i,t-2} + \ldots + \beta_{j,i}x_{i,t-j} \quad (1)$$

The inputs for the Granger causality test were the daily returns on the indexes of all countries/regions analyzed for the previously mentioned periods (Equation (2)).

$$R_{t+1} = \frac{P_{t+1}}{P_t} - 1 \quad (2)$$

The Granger causality test was carried out using 2, 3, and 4 days lag. The data for all the stock equity indexes were obtained from Bloomberg.

Table 4. GDP (1998). Indexes included in the Granger causality test.

Country/Region	Stock Index	Country/Region	Stock Index
Argentina	Argentine MERVAL	Netherlands	Netherlands AEX
Australia	S&P ASX 200 Australia	New Zealand	NSZE
Austria	ATX Austria	Pakistan	Pakistan KSE
Belgium	Belgium BEL 20	Peru	S&P BVL Peru
Canada	S&P TSX 60 Canada	Philippines	Philippine PCOMP
France	France CAC 40	Portugal	Portugal PSI 20
Germany	Germany DAX	South Africa	FTSE JSE
Hong Kong	Hang Seng Index	South Korea	Kospi
Indonesia	Indonesia Jakarta Composite	Spain	IBEX 35
Japan	Nikkei 225	Thailand	Thai SET
Malaysia	FTSE Malay KLCI	United States	Dow Jones Industrial
Mexico	S&P BMC Mexico		

This type of analysis aims to analyze events in isolation. It is acknowledged that events do not occur in isolation and that there are other moving parts. Nevertheless, the events described in Table 1 are likely significant enough to have, by themselves, an impact on the stock market. A total of 23 countries/jurisdictions were included in the analysis. The Granger causality tests were carried out including all the pairs of stock indexes analyzed. The Singaporean stock market was not included in the analysis. This is due to data availability during the time period analyzed. Given the number of data points, using more than a four-day lag does not appear to be advisable. It is also acknowledged that a Granger causality tests does not necessarily infer real causality relationships between to events, but it is nevertheless an empirically objective test that can add some support to the existence of real underlying causality relationships between the variables analyzed. Given that the Granger causality test of 23 countries are analyzed in pairs, for seven different major events an including three different lag terms the number of tests is clearly rather large.

Another important factor that needs to be taken into account is that there could be structural, pre-existing relationships between the countries/regions analyzed and that these pre-existing relationships need to be taken into account during the analysis. For instance, it would be likely that the stock market of a country would have an impact on the performance of the stock market in its region. In order to account for those relationships a base line Granger causality relationships was established using the index returns before the crisis. More specifically, the returns of the indexes were calculated for the 1996 calendar year and the related Granger causality tests calculated. Existing causality relationship before the crisis period were excluded from the list of Granger causalities relationships for each of the seven events analyzed. In this way it was obtained a list of filtered Granger causality results.

The adjusted volatility for each of the seven periods analyzed was also estimated. The first step consisted in calculating the daily standard deviations (Schwert 1990) for all the seven periods analyzed (σ_p). This volatility by itself is difficult to interpret so it was scaled by dividing it by the average volatility of a reference period (σ_{Ref}) before the financial crisis (1996). The resulting number ($\sigma_{Adjusted}$) is dimensionless as it represents the ratio between two standard deviations (Equation (3)).

$$\sigma_{Adjusted} = \frac{\sigma_p}{\sigma_{Ref}} \tag{3}$$

The larger the number is the more volatile the market was, compared to the base line level, during the event analyzed. A formal F-test comparing the volatility for each indexes in each event with the base line volatility was also carried out. The null hypothesis is that the volatility of the two distributions (base line and during the event) are the same.

4. Results

The results suggest that there are three distinct phases, from a stock market volatility point of view. Initially, the crisis was mostly regional in nature (event 1), mostly impacting emerging markets in South-East Asia. Volatility started to spread to other markets, such as for instance Japan (Figure 1a) and even developed markets as different as Australia (Figure 1b). This process reached its peak approximately at event 4. After that initial phase of increasing volatility (from event 1 to 4), volatility started to gradually return more normal historical levels. Volatility then experienced another spike during event 7. The results illustrated graphically with the adjusted volatility values were formally tested using F-tests. As previously mentioned the volatility for each event and each index was compared to the volatility during the base line period (1996). The result of the graphical approach and the formal statistical test are consistent with all the markets analyzed having statistically higher volatility during events 3, 4 and 7 compared to their base line levels.

In order to estimate a base line the pre-existing (1996), Granger relationships were analyzed. During this period, the stock market of the countries in the region did not appear, according to the Granger analysis, to be a major driver of other markets. For example, Indonesia was only driver (Granger causality) of the Hong Kong and Portugal markets (using 2 day lag) and the Philippines was only a driver of the Thai market. Hong Kong was a driver of Argentina, Indonesia, and the Netherlands, and Japan of Austria, Indonesia, and the Netherlands. Some of these Granger relationships might be the result of spurious data relationships not based on strong underlying economic reasons however some of those relationships seem consistent with expectations, such as for instance, Philippines and Thailand. Similar results were obtained when the analysis was carried out with 2 and 3 days lag. Overall, there were less than expected pre-existing relationship (Granger causality) among countries in the South-East Asia region. In the following sections the results for each event are presented.
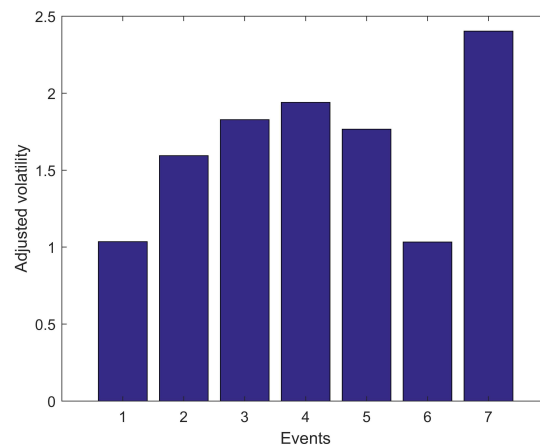
(**a**) Adjusted volatility for Japan during all the considered events
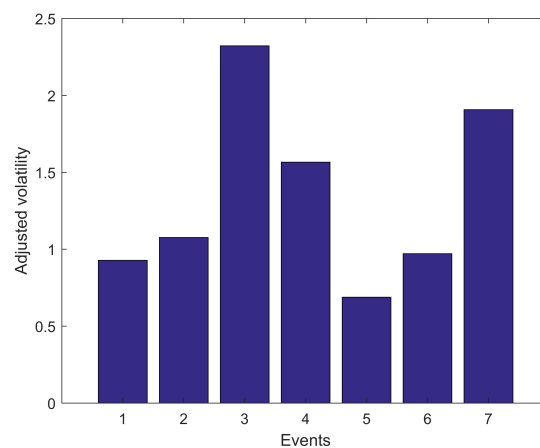
(**b**) Adjusted volatility for Australia during all the considered events

Figure 1. Examples of adjusted volatility.

4.1. Event 1—2 July 1997

Thailand letting the Thai baht to freely float is arguably one of the most important event during the South-East Asia financial crisis. The results from the F-tests (Appendix A Table A17) comparing the volatility of the stock markets suggest that at this stage the South-East Asia financial crisis was mostly a regional event. The volatility during this event was statistically higher than in the baseline period (1996) only in 6 out of the 24 countries analyzed, most of these countries where the volatility was significantly higher were countries directly related to the crisis such as Thailand and the Philippines. As illustrated in Figure 2a, Thailand, since event 1, started having high adjusted volatility levels of almost twice its base line levels. This is a reasonable result considering that letting the Thai baht to float, after a long period of stable exchange rates, likely substantially impacted the performance of the Thai stock exchange. In Figure 2b it is shown the results from the Granger causality tests (adjusted for baseline effects) using three different time lags (1, 2, and 3 days). The number of statistically significant Granger causality relationships was relatively low. Using 1 and 2 days lag there were only 14 statistically significant Granger causality relationships while 15 relationships were found when using 3 days lag. Interestingly during this first event, the Thai stock market, according to the Granger causality test, did not substantially impact other markets after adjusting for base line relationships. Perhaps this is related to investors, at that initial stage, considering that it was mostly a local issue. The stock market of Malaysia seems to have impacted, during this period, the stock market of Thailand (1-day lag) and Japan (2- and 3-day lag).
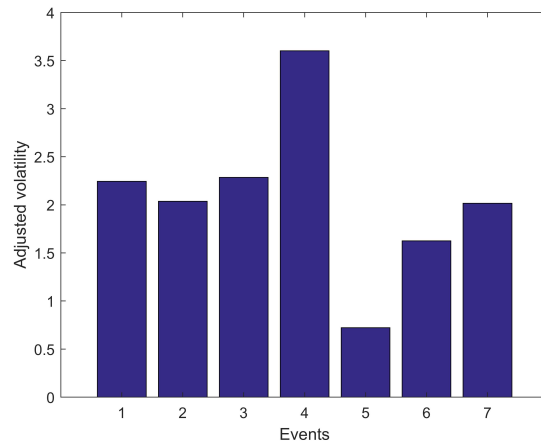
(**a**) Adjusted volatility for Thailand during all the considered
events.
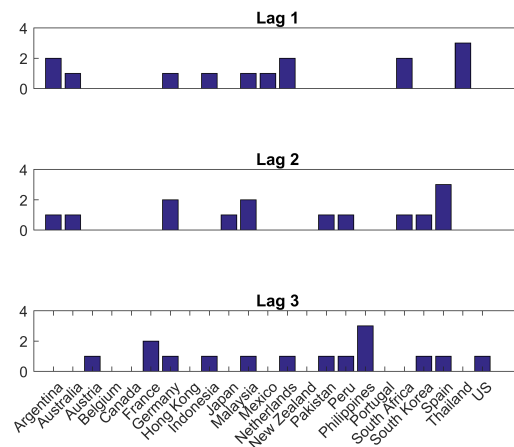
(**b**) Results of the Granger causality tests after filtering for
event 1

Figure 2. Adjusted volatility for Thailand and Granger analysis of event 1.

4.2. Event 2—14 August 1997

After several attempts to defend its currency on 14 August 1997, Indonesia decided to float its currency. The Indonesian Central Bank tried robustly to defend its currency but pressure was gradually increasing and foreign reserves were not large enough. Indonesia was initially not too severely affected. In fact, at the beginning of the financial crisis it was considered a success story. However, that rapidly changed with volatility doubling compared to its baseline level during the event 2 period. In the Indonesian case, volatility remained elevated for prolonged periods of time. The stock market experienced the same phases as previously mentioned with an initial phase of sustained volatility increases, peaking in event 4, followed by a phase of lower volatility, around event 6. The main difference in the Indonesian case compared to some other markets is that this phase of lower volatility was shorter with a volatility spike during event 6. Volatility remained high during event 7. The number of Granger causality relationships remained low during this period at 11, 14 and 10 for lags of 1, 2 and 3 days, respectively (Figure 3).
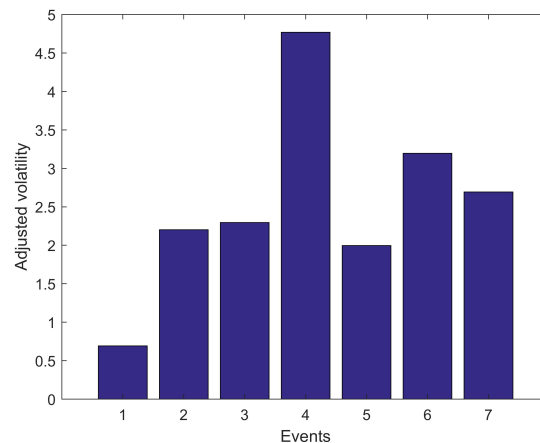
(**a**) Adjusted volatility for Indonesia during all the considered events
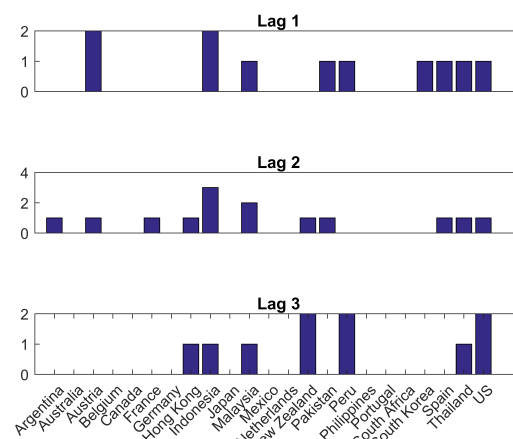
(**b**) Results of the Granger causality tests after filtering for event 2

Figure 3. Adjusted volatility for Indonesia and Granger analysis of event 2.

4.3. Event 3—14 October 1997

In 14 October 1997, Thailand announced a restructuring package in another of the major events during the South-East Asia financial crisis. In this event volatility remained high compared to historical levels. In fact, from event 1 to 3 volatility was roughly twice the base line levels volatility of 1996. The number of statistically significant Granger causality relationships was one of the lowest during this period with only 10, 10, and 17 relationships identified when using 1-, 2-, and 3-day lag, respectively. A bidirectional relationship between the stock markets of South Korea and Indonesia was identified when using the Granger test (3-day lag).

4.4. Event 4—12 January 1998

Another important event during the financial crisis was the collapse of Peregrine investment on 12 January 1998. The investment company was based in Hong Kong but it failed due to losses for a transaction in Indonesia. As it can be seen in Figure 4a volatility in the Hong Kong stock market was significantly higher than the base line levels during events 3 and 4. Note that Hong Kong did manage to successfully defend its peg to the U.S. dollar but clearly its stock market was substantially impacted by the crisis. The same phases as in other markets can be identified in Hong Kong with a primary spike in volatility around event 3 and 4 and a secondary spike around event 7. As shown in Figure 4b, the Indonesian market experienced a drastic increase in volatility in event 4 passing from

approximately twice its baseline level in event three to more than four times during event 4. The number of Granger causality relationships identified as statistically significant (adjusted for base line level) remained relatively moderate during the event 4 period with 19, 14 and 18 relationships using 1-, 2-, and 3-day lags.
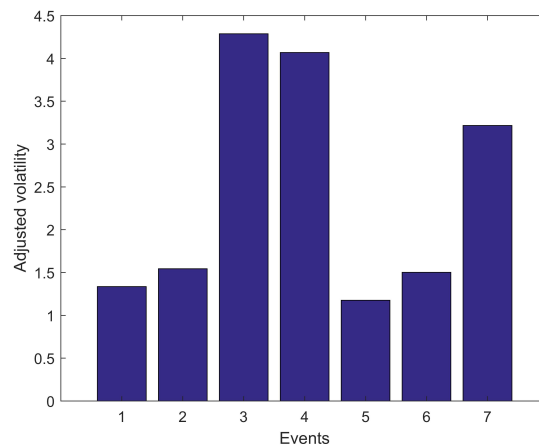
(**a**) Adjusted volatility for Hong Kong during all the considered events
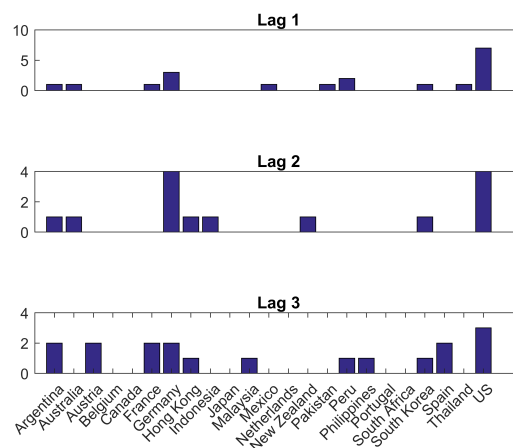
(**b**) Results of the Granger causality tests after filtering for event 4

Figure 4. Adjusted volatility for Hong Kong and Granger analysis of event 4.

4.5. Event 5—31 March 1998

On 31 March 1998, another major development in the South-East Asia financial crisis happened with Thailand releasing new guidelines for the definition of nonperforming loans. Event 5 coincides with one of the lowest adjusted volatility periods for the markets analyzed. By event 5 there started to be clear, statistically significant signs of contagion among different stock markets with Granger causality relationships, adjusted by base line effects, increasing regardless of the lag used. The Granger causality relationship found using 1, 2 and 3 days lags were 34, 47, and 30, respectively (Figure 5).
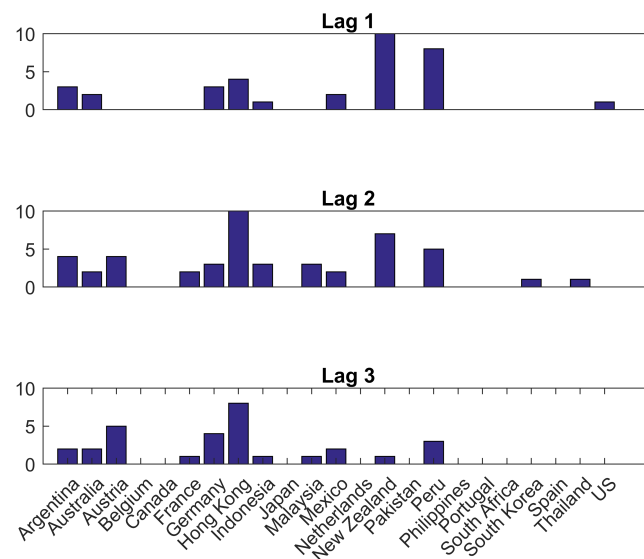
Figure 5. Results of the Granger causality tests after filtering for event 5.

4.6. Event 6—11 May 1998

On 11 May 1998 Joseph Estrada won the general elections in the Philippines in another major development during the South-East Asia financial crisis. During this event volatility started to increase again compared to the previous events for most of the markets analyzed. The Granger causality tests identified 13 causality relationships among the countries, using a one-day lag period. When using 2 and 3 days lag there were 17 and 25 Granger causality relationships respectively (Figure 6). A bidirectional relationships was found between the US and Canadian markets (3-day lag).
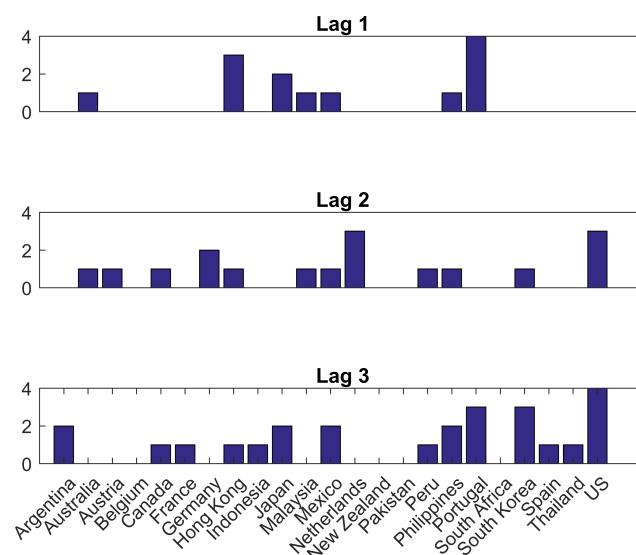
Figure 6. Results of the Granger causality tests after filtering for event 6.

4.7. Event 7—3 September 1998

Event 7 was a rather important event with the replacement of the Malaysian finance minister. This event lead to a decades long feud among the Malaysian elites. As previously mentioned, Malaysia followed a rather unique direction during the crisis compared to its regional neighbors by refusing the bailout offered by the IMF. During event 7 most of the markets analyzed experienced a significant increase in volatility (Figure 7a). The case of Malaysia is particularly remarkable with volatility increasing to 12 times the base line levels.

This increase in adjusted volatility was much large in the case of Malaysia than in the case of its regional neighbors. Using one- and two-day lag there were 21 statistically significant Granger causality relationships while 25 relationships were found when using 3 days lag (Figure 7b). The Indonesian stock market during this period seemed to impact several other markets such as for instance Japan and the Philippines (using a lag of 1 day). The adjusted volatility for all the countries/jurisdictions and for all the seven events considered can be seen in Table A1. The main statistics for the indexes in 1996, which was used as a reference period to estimate the pre-existing (base) volatility of the indexes can be seen in Table A2. The main statistics for the indexes for all the events can be seen in Tables A3–A9 and the results form the Granger tests can be seen in Tables A10–A16. The null hypothesis in the Granger tests is that $Index_A$ does not Granger cause $Index_B$.
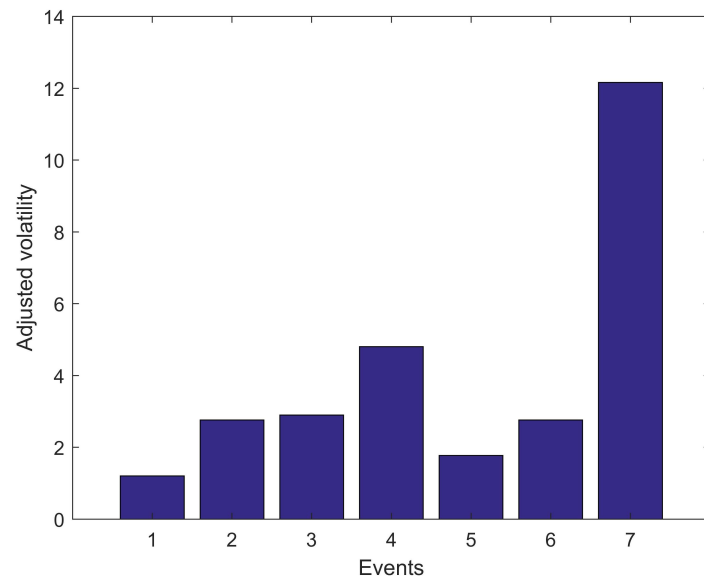
(**a**) Adjusted volatility for Malaysia during all the considered events
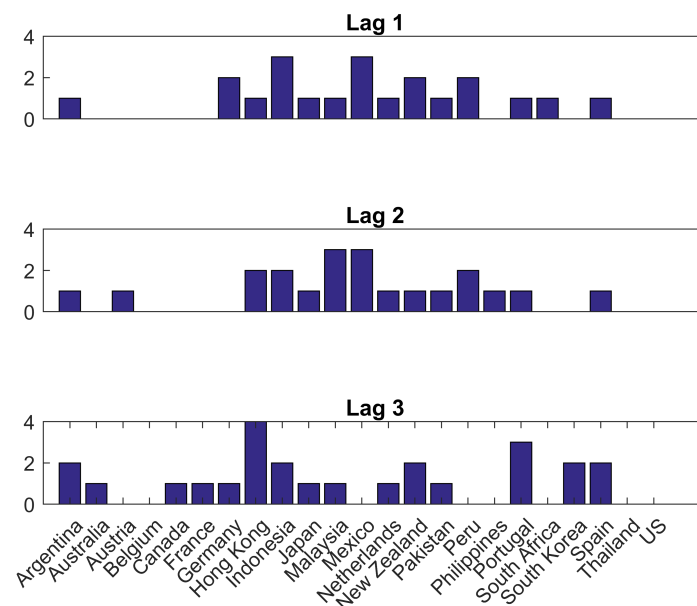
(**b**) Results of the Granger causality tests after filtering for event 7

**Figure 7.** Adjusted volatility for Malaysia and Granger analysis of event 7.

5. Discussion

When analyzing financial crises there is a tendency to consider the long term impacts on the economy with less attention to the short-term impacts on the equity market that are among the principal concerns for equity investors. Even if the equity market fully recovers after a financial crisis, the loss to equity investors might be very substantial. Equity investors might be forced to unwind the positions because risk management concerns or margin calls, even if they believe that the market is going to recover. This type of short-term fluctuations are sometimes neglected in the literature even if they might have very substantial economic impacts on investors.

While there is clearly some level of subjectivity, from a stock market point of view the South-East Asia financial market can be divided, according to the short-term event driven carried out, into three main phases. A first phase in which the crisis initially appears to be a local issue to then rapidly spread to other stock markets even outside Asia. This phase goes approximately from the decision of Thailand to float the baht on 2 July 1997 (event 1) to the collapse of Peregrine investments on 12 January 1998 (event 4). During this phase there is an increasing level of volatility, adjusted for base line effects, across stock markets. The number of statistically significant Granger causality relationships, adjusted for base line effects, also gradually increases. A second phase, of lower volatility across multiple stock markets happened during event 5 which was the release by Thailand of the new guidelines for non-performing bank loans on 31 March 1998. While volatility decreased during this period there are indications of contagion with the number of statistically significant Granger relationships increasing. This was a period of lower volatility that for some markets expanded to event 6. Event 6 was the victory of Joseph Estrada in the general elections of the Philippines on 11 May 1998. The final phase was another spike in volatility on 3 September 1998 when the Malaysian finance ministered was replaced triggering a spike in volatility across markets.

The results from F-test comparing the volatilities for each market during each event with its baseline levels of 1996 are consistent with above mentioned results. This analysis suggests that there were two differentiated peaks in stock market volatility one centered around the collapse of Peregrine investments (event 4) and another centered around the period when the finance minister in Malaysia was replaced (event 7). This second peak in volatility was, at least for some countries, even more intense that during the first phase of the crisis. During the period in which that Thai government released the new guidelines for non-performing loans classification (event 5) there were indications of contagion effects even outside Asia. There are, however, no statistically significant indications of a single country in South-East Asia having consistently driven (tested using Granger causality) the stock market of several other countries consistently during the entire crisis period.

It would be interesting, as a line of future research, to use machine learning techniques to model the stock prices during the Southeast Asia financial crisis. It remains unclear if machine learning techniques can handle black swan events such as the Southeast Asia financial crisis. Machine learning techniques use historical data to train the chosen algorithm, such as neural networks. If the behavior of the market during a financial crisis is new, i.e., the market has not experienced similar conditions in the past, the neural network might have problems generating accurate forecasts.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. Adjusted volatility per jurisdiction in each event.

Event/Jurisdiction	Symbol	1	2	3	4	5	6	7
Argentina	X_1	0.853	0.728	2.485	1.700	0.960	1.114	4.063
Australia	X_2	0.928	1.076	2.322	1.566	0.689	0.972	1.908
Austria	X_3	1.120	2.120	2.849	1.802	1.240	1.043	3.653
Belgium	X_4	1.106	1.674	1.767	1.486	0.984	1.721	2.641
Canada	X_5	1.310	1.147	2.685	2.201	1.134	1.088	3.747
France	X_6	1.424	1.628	2.053	1.533	1.404	1.908	3.257
Germany	X_7	1.145	2.037	3.202	1.811	1.091	1.535	3.694
Hong Kong	X_8	1.337	1.543	4.288	4.069	1.176	1.502	3.217
Indonesia	X_9	0.691	2.202	2.295	4.769	1.997	3.195	2.692
Japan	X_{10}	1.036	1.594	1.827	1.940	1.766	1.033	2.403
Malaysia	X_{11}	1.207	2.759	2.899	4.803	1.771	2.761	12.159
Mexico	X_{12}	0.920	1.062	3.500	1.709	0.777	1.133	3.926
Netherlands	X_{13}	1.211	2.959	2.690	1.578	1.321	2.597	2.930
New Zealand	X_{14}	1.321	1.220	3.663	1.546	1.253	1.154	3.013
Pakistan	X_{15}	1.274	1.184	1.393	0.873	0.675	3.880	1.353
Peru	X_{16}	1.577	0.972	1.637	0.852	0.920	1.089	2.619
Philippines	X_{17}	2.814	3.162	1.984	4.135	0.901	1.708	3.860
Portugal	X_{18}	2.115	4.035	2.127	2.693	4.475	3.824	6.560
South Africa	X_{19}	0.496	1.158	3.591	2.531	1.015	2.573	4.145
South Korea	X_{20}	0.735	0.794	3.457	3.089	2.162	2.233	1.973
Spain	X_{21}	1.593	1.392	1.836	1.164	2.011	1.909	4.930
Thailand	X_{22}	2.244	2.037	2.286	3.601	0.722	1.625	2.016
United States	X_{23}	1.198	1.601	2.902	1.382	1.245	1.456	2.669

Table A2. Main descriptive statistics of the indexes in 1996 (used to calculate per-existing base volatility). Including the daily standard deviation σ, return, and average daily return.

Jurisdiction	Return	Daily σ	Avg. Daily Ret.
Argentina	0.2250	0.0150	0.0009
Australia	0.1015	0.0075	0.0004
Austria	0.1693	0.0076	0.0006
Belgium	0.1949	0.0069	0.0007
Canada	0.2547	0.0061	0.0010
France	0.2205	0.0077	0.0008
Germany	0.2464	0.0079	0.0009
Hong Kong	0.3032	0.0103	0.0012
Indonesia	0.2300	0.0097	0.0009
Japan	−0.0125	0.0092	−0.0000
Malaysia	0.2262	0.0078	0.0009
Mexico	0.2089	0.0120	0.0008
Netherlands	0.2756	0.0073	0.0011
New Zealand	0.1092	0.0061	0.0004
Pakistan	−0.0118	0.0127	−0.0000
Peru	0.1525	0.0100	0.0006
Philippines	0.1809	0.0093	0.0007
Portugal	0.3100	0.0043	0.0012
South Africa	0.0060	0.0068	0.0000
South Korea	−0.1780	0.0126	−0.0007
Spain	0.3823	0.0077	0.0015
Thailand	−0.4924	0.0129	−0.0019
United States	−0.2910	0.0068	−0.0011

Table A3. Main descriptive statistics of the index (event 1). Including the standard deviation daily σ, return, and average daily return.

Jurisdiction	Return	Daily σ	Avg. Daily Ret.
Argentina	0.0128	0.0329	0.0016
Australia	0.0069	−0.0116	−0.0006
Austria	0.0085	0.0769	0.0037
Belgium	0.0077	0.0707	0.0034
Canada	0.0080	0.0391	0.0019
France	0.0110	0.0798	0.008
Germany	0.0090	0.1170	0.0056
Hong Kong	0.0138	0.0786	0.0037
Indonesia	0.0067	0.0263	0.0013
Japan	0.0096	−0.0106	−0.0005
Malaysia	0.0094	−0.0690	−0.0033
Mexico	0.0110	0.1143	0.0054
Netherlands	0.0089	0.1317	0.0063
New Zealand	0.0081	0.0446	0.0021
Pakistan	0.0162	0.1624	0.0077
Peru	0.0158	−0.0143	−0.0007
Philippines	0.0261	−0.0329	−0.0016
Portugal	0.0091	0.0454	0.0022
South Africa	0.0034	0.0063	0.0003
South Korea	0.0093	−0.0572	−0.0027
Spain	0.0123	−0.0623	−0.0030
Thailand	0.0289	0.0618	0.0029
United States	0.0081	0.0378	0.0018

Table A4. Main descriptive statistics of the index (event 2). Including the standard deviation daily σ, return, and average daily return.

Jurisdiction	Return	Daily σ	Avg. Daily Ret.
Argentina	0.0109	0.0223	0.0011
Australia	0.0080	−0.0411	−0.0020
Austria	0.0160	−0.0823	−0.0039
Belgium	0.0116	−0.1129	−0.0054
Canada	0.0070	−0.0418	−0.0020
France	0.0125	−0.0800	−0.0038
Germany	0.0161	−0.1040	−0.0050
Hong Kong	0.0159	−0.0691	−0.0033
Indonesia	0.0214	−0.3015	−0.0144
Japan	0.0147	−0.0888	−0.0042
Malaysia	0.0214	−0.2266	−0.0108
Mexico	0.0127	−0.0362	−0.0017
Netherlands	0.0217	−0.1009	−0.0048
New Zealand	0.0075	−0.0310	−0.0015
Pakistan	0.0151	−0.0219	−0.0010
Peru	0.0097	−0.0576	−0.0027
Philippines	0.0293	−0.1292	−0.0062
Portugal	0.0174	0.0342	0.0016
South Africa	0.0079	−0.0400	−0.0019
South Korea	0.0100	−0.0710	−0.0034
Spain	0.0107	0.0153	0.0007
Thailand	0.0262	−0.1447	−0.0069
United States	0.0109	0.0060	0.0003

Table A5. Main descriptive statistics of the index (event 3). Including the standard deviation daily σ, return, and average daily return.

Jurisdiction	Return	Daily σ	Avg. Daily Ret.
Argentina	0.0373	−0.1225	−0.0058
Australia	0.0173	−0.1784	−0.0085
Austria	0.0215	−0.1280	−0.0061
Belgium	0.0122	−0.0861	−0.0041
Canada	0.0163	−0.0406	−0.0019
France	0.0158	−0.1170	−0.0056
Germany	0.0253	−0.1332	−0.0063
Hong Kong	0.0441	−0.4689	−0.0223
Indonesia	0.0223	−0.1922	−0.0092
Japan	0.0169	−0.0946	−0.0045
Malaysia	0.0225	−0.2167	−0.0103
Mexico	0.0419	−0.0831	−0.0040
Netherlands	0.0197	−0.0755	−0.0036
New Zealand	0.0224	−0.1586	−0.0076
Pakistan	0.0178	−0.0896	−0.0043
Peru	0.0164	−0.0733	−0.0035
Philippines	0.0184	−0.1195	−0.0057
Portugal	0.0092	−0.0711	−0.0034
South Africa	0.0245	−0.1210	−0.0058
South Korea	0.0436	−0.1327	−0.0063
Spain	0.0142	−0.0772	−0.0037
Thailand	0.0294	−0.1565	−0.0075
United States	0.0197	−0.0694	−0.0033

Table A6. Main descriptive statistics of the index (event 4). Including the standard deviation daily σ, return, and average daily return.

Jurisdiction	Return	Daily σ	Avg. Daily Ret.
Argentina	0.0255	−0.0430	−0.0020
Australia	0.0117	0.0187	0.0009
Austria	0.0136	0.0241	0.0011
Belgium	0.0103	0.0601	0.0029
Canada	0.0134	0.0107	0.0005
France	0.0118	0.0450	0.0021
Germany	0.0143	0.0131	0.0006
Hong Kong	0.0419	−0.1315	−0.0063
Indonesia	0.0464	0.1985	0.0095
Japan	0.0179	0.1132	0.0054
Malaysia	0.0373	0.0382	0.0018
Mexico	0.0205	−0.0937	−0.0045
Netherlands	0.0116	0.0485	0.0023
New Zealand	0.0094	−0.0016	−0.0001
Pakistan	0.0111	0.1198	0.0057
Peru	0.0085	−0.0751	−0.0036
Philippines	0.0383	0.3920	0.0187
Portugal	0.0116	0.1235	0.0059
South Africa	0.0172	0.1566	0.0075
South Korea	0.0389	0.1813	0.0086
Spain	0.0090	0.0952	0.0045
Thailand	0.0464	0.4370	0.0208
United States	0.0094	0.0891	0.0042

Table A7. Main descriptive statistics of the index (event 5). Including the standard deviation daily σ, return, and average daily return.

Jurisdiction	Return	Daily σ	Avg. Daily Ret.
Argentina	0.0144	0.0023	0.0001
Australia	0.0051	0.0428	0.0020
Austria	0.0094	0.0708	0.0034
Belgium	0.0068	0.0654	0.0031
Canada	0.0069	0.0492	0.0023
France	0.0108	0.0735	0.0035
Germany	0.0086	0.0967	0.0046
Hong Kong	0.0121	0.0226	0.0011
Indonesia	0.0194	0.0141	0.0007
Japan	0.0163	−0.0325	−0.0015
Malaysia	0.0137	−0.0547	−0.0026
Mexico	0.0093	0.0500	0.0024
Netherlands	0.0097	0.0516	0.0025
New Zealand	0.0077	0.0025	0.0001
Pakistan	0.0086	0.0244	0.0012
Peru	0.0092	0.0905	0.0043
Philippines	0.0083	−0.0121	−0.0006
Portugal	0.0193	0.0385	0.0018
South Africa	0.0069	0.0693	0.0033
South Korea	0.0272	−0.0981	−0.0047
Spain	0.0155	−0.0296	−0.0014
Thailand	0.0093	−0.1013	−0.0048
United States	0.0084	0.0225	0.0011

Table A8. Main descriptive statistics of the index (event 6). Including the standard deviation daily σ, return, and average daily return.

Jurisdiction	Return	Daily σ	Avg. Daily Ret.
Argentina	0.0167	−0.1341	−0.0064
Australia	0.0073	−0.0488	−0.0023
Austria	0.0079	0.0310	0.0015
Belgium	0.0119	0.0438	0.0021
Canada	0.0066	0.0219	0.0010
France	0.0147	0.0848	0.0040
Germany	0.0121	0.0821	0.0039
Hong Kong	0.0155	−0.1281	−0.0061
Indonesia	0.0311	−0.0997	−0.0047
Japan	0.0095	−0.0134	−0.0006
Malaysia	0.0214	−0.1023	−0.0049
Mexico	0.0136	−0.0957	−0.0046
Netherlands	0.0190	0.0482	0.0023
New Zealand	0.0070	−0.0439	−0.0021
Pakistan	0.0495	−0.3572	0.0170
Peru	0.0109	−0.0330	−0.0016
Philippines	0.0158	−0.1701	−0.0081
Portugal	0.0165	−0.0105	−0.0005
South Africa	0.0175	0.1465	−0.0070
South Korea	0.0281	−0.0871	−0.0041
Spain	0.0147	−0.0018	−0.0001
Thailand	0.0209	−0.2713	−0.0129
United States	0.0099	−0.0303	−0.0014

Table A9. Main descriptive statistics of the index (event 7). Including the standard deviation daily σ, return, and average daily return.

Jurisdiction	Return	Daily σ	Avg. Daily Ret.
Argentina	0.0609	−0.2590	−0.0123
Australia	0.0142	−0.0441	−0.0021
Austria	0.0276	−0.2257	−0.0107
Belgium	0.0183	−0.1001	−0.0048
Canada	0.0228	−0.1235	−0.0059
France	0.0251	−0.1503	−0.0072
Germany	0.0291	−0.1717	−0.0082
Hong Kong	0.0331	0.0049	0.0002
Indonesia	0.0262	−0.3419	−0.0163
Japan	0.0222	−0.1006	−0.0048
Malaysia	0.0943	0.2068	0.0098
Mexico	0.0470	−0.0378	−0.0018
Netherlands	0.0215	−0.1893	−0.0090
New Zealand	0.0184	−0.1063	−0.0051
Pakistan	0.0173	0.1179	0.0056
Peru	0.0262	−0.2354	−0.0112
Philippines	0.0358	0.0189	0.0009
Portugal	0.0283	−0.2537	−0.0121
South Africa	0.0282	0.0518	0.0025
South Korea	0.0249	−0.0180	−0.0009
Spain	0.0381	−0.1394	−0.0066
Thailand	0.0260	0.1795	0.0085
United States	0.0181	0.0145	0.0007

Table A10. Granger test results—Event 1. Only combinations with *p*-value less than 5% shown.

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_1	X_{10}	0.0306		
X_1	X_{14}	0.0078		
X_2	X_{14}	0.0055		
X_7	X_{14}	0.0050		
X_9	X_3	0.0386		
X_{11}	X_{22}	0.0296		
X_{12}	X_6	0.0445		
X_{13}	X_1	0.0392		
X_{13}	X_{14}	0.0442		
X_{19}	X_{11}	0.0343		
X_{19}	X_{17}	0.0133		
X_{21}	X_{11}	0.0191		
X_{21}	X_{20}	0.0241		
X_{21}	X_{22}	0.0206		
X_1	X_{14}		0.0332	
X_2	X_{14}		0.0142	
X_7	X_{14}		0.0349	
X_7	X_{16}		0.0426	
X_{10}	X_{15}		0.0377	
X_{11}	X_3		0.0234	
X_{11}	X_{10}		0.0180	
X_{15}	X_5		0.0110	
X_{16}	X_9		0.0157	
X_{19}	X_{17}		0.0386	
X_{20}	X_{10}		0.0129	
X_{21}	X_{11}		0.0422	
X_{21}	X_{20}		0.0162	
X_{21}	X_{22}		0.0443	

Table A10. *Cont.*

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_3	X_{20}			0.0338
X_6	X_{14}			0.0457
X_6	X_{16}			0.0466
X_7	X_{16}			0.0347
X_9	X_{20}			0.0069
X_{11}	X_{10}			0.0295
X_{13}	X_1			0.0429
X_{15}	X_6			0.0409
X_{16}	X_9			0.0296
X_{17}	X_2			0.0244
X_{17}	X_{11}			0.0059
X_{17}	X_{15}			0.0373
X_{20}	X_{10}			0.0448
X_{21}	X_{20}			0.0119
X_{23}	X_{17}			0.0372

Table A11. Granger test results—Event 2. Only combinations with p-value less than than 5% shown.

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_3	X_2	0.0373		
X_3	X_{10}	0.0232		
X_9	X_5	0.0101		
X_9	X_{10}	0.0240		
X_{11}	X_{12}	0.0371		
X_{15}	X_{19}	0.0091		
X_{16}	X_8	0.0434		
X_{20}	X_{19}	0.0144		
X_{21}	X_{17}	0.0454		
X_{22}	X_8	0.0262		
X_{23}	X_{16}	0.0007		
X_1	X_{10}		0.0334	
X_6	X_5		0.0155	
X_6	X_{11}		0.0207	
X_8	X_2		0.0352	
X_9	X_3		0.0375	
X_9	X_5		0.0460	
X_9	X_{10}		0.0089	
X_{11}	X_1		0.0268	
X_{11}	X_{12}		0.0168	
X_{14}	X_{22}		0.0377	
X_{15}	X_8		0.0244	
X_{21}	X_{16}		0.0368	
X_{22}	X_8		0.0408	
X_{23}	X_{16}		0.0070	
X_8	X_2			0.0259
X_9	X_{10}			0.0280
X_{11}	X_{12}			0.0153
X_{14}	X_8			0.0313
X_{14}	X_{22}			0.0289
X_{16}	X_{21}			0.0272
X_{16}	X_{22}			0.0203
X_{22}	X_6			0.0139
X_{23}	X_{15}			0.0281
X_{23}	X_{16}			0.0299

Table A12. Granger test results—Event 3. Only combinations with *p*-value less than than 5% shown.

$Index_A$	$Index_B$	Lag-1 *p*-Val.	Lag-2 *p*-Val.	Lag-3 *p*-Val.
X_2	X_7	0.0151		
X_8	X_{12}	0.0206		
X_9	X_{12}	0.0191		
X_9	X_{14}	0.0309		
X_9	X_{15}	0.0257		
X_{11}	X_1	0.0064		
X_{11}	X_{12}	0.0011		
X_{12}	X_6	0.0434		
X_{18}	X_5	0.0443		
X_{19}	X_{15}	0.0107		
X_2	X_8		0.0478	
X_3	X_{15}		0.0035	
X_8	X_1		0.0264	
X_8	X_{23}		0.0391	
X_9	X_{15}		0.0201	
X_{10}	X_{14}		0.0054	
X_{11}	X_1		0.0005	
X_{11}	X_{12}		0.0040	
X_{13}	X_{15}		0.0178	
X_{19}	X_{15}		0.0012	
X_1	X_{16}			0.0325
X_2	X_7			0.0377
X_3	X_{14}			0.0292
X_3	X_{15}			0.0249
X_3	X_{23}			0.0189
X_7	X_{21}			0.0226
X_8	X_{23}			0.0360
X_9	X_{20}			0.0362
X_{11}	X_1			0.0029
X_{11}	X_6			0.0334
X_{11}	X_{12}			0.0160
X_{12}	X_{20}			0.0378
X_{14}	X_{22}			0.0161
X_{19}	X_{15}			0.0145
X_{20}	X_2			0.0296
X_{20}	X_9			0.0129
X_{21}	X_8			0.0151

Table A13. Granger test results—Event 4. Only combinations with *p*-value less than than 5% shown.

$Index_A$	$Index_B$	Lag-1 *p*-Val.	Lag-2 *p*-Val.	Lag-3 *p*-Val.
X_1	X_{14}	0.0067		
X_2	X_{19}	0.0331		
X_6	X_3	0.0139		
X_7	X_1	0.0233		
X_7	X_3	0.0377		
X_7	X_{11}	0.0488		
X_{12}	X_6	0.0152		
X_{15}	X_{20}	0.0377		
X_{16}	X_3	0.0397		
X_{16}	X_{14}	0.0141		
X_{20}	X_{21}	0.0410		
X_{22}	X_{20}	0.0157		
X_{23}	X_2	0.0387		
X_{23}	X_6	0.0414		
X_{23}	X_8	0.0022		
X_{23}	X_9	0.0337		

Table A13. *Cont.*

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_{23}	X_{11}	0.0122		
X_{23}	X_{14}	0.0007		
X_{23}	X_{16}	0.0069		
X_1	X_{14}		0.0054	
X_2	X_{19}		0.0196	
X_7	X_1		0.0134	
X_7	X_3		0.0376	
X_7	X_8		0.0019	
X_7	X_{12}		0.0210	
X_8	X_{19}		0.0418	
X_9	X_{14}		0.0244	
X_{14}	X_1		0.0216	
X_{20}	X_{15}		0.0243	
X_{23}	X_8		0.0039	
X_{23}	X_9		0.0046	
X_{23}	X_{14}		0.0034	
X_{23}	X_{16}		0.0199	
X_1	X_{12}			0.0006
X_1	X_{14}			0.0070
X_3	X_2			0.0371
X_3	X_{16}			0.0168
X_6	X_1			0.0350
X_6	X_3			0.0267
X_7	X_8			0.0088
X_7	X_{17}			0.0393
X_8	X_{11}			0.0483
X_{11}	X_8			0.0473
X_{16}	X_3			0.0286
X_{17}	X_3			0.0426
X_{20}	X_2			0.0216
X_{21}	X_{12}			0.0214
X_{21}	X_{18}			0.0059
X_{23}	X_8			0.0216
X_{23}	X_9			0.0065
X_{23}	X_{14}			0.0406

Table A14. Granger test results—Event 5. Only combinations with p-value less than than 5% shown.

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_1	X_{10}	0.0094		
X_1	X_{14}	0.0045		
X_1	X_{16}	0.0253		
X_2	X_3	0.0029		
X_2	X_7	0.0437		
X_3	X_2	0.0272		
X_3	X_5	0.0236		
X_7	X_{14}	0.0114		
X_8	X_5	0.0001		
X_8	X_{12}	<0.0001		
X_8	X_{14}	0.0234		
X_8	X_{16}	0.0069		
X_9	X_{15}	0.0039		
X_{12}	X_{10}	0.0131		
X_{12}	X_{16}	0.0010		

Table A14. *Cont.*

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_{14}	X_2	0.0489		
X_{14}	X_3	0.0007		
X_{14}	X_4	0.0022		
X_{14}	X_5	0.0113		
X_{14}	X_7	0.0038		
X_{14}	X_8	0.0056		
X_{14}	X_{10}	0.0195		
X_{14}	X_{11}	0.0103		
X_{14}	X_{12}	0.0108		
X_{14}	X_{16}	0.0063		
X_{16}	X_1	0.0106		
X_{16}	X_3	0.0044		
X_{16}	X_5	0.0085		
X_{16}	X_7	0.0407		
X_{16}	X_9	0.0436		
X_{16}	X_{10}	0.0451		
X_{16}	X_{12}	0.0175		
X_{16}	X_{20}	0.0020		
X_{23}	X_{15}	0.0471		
X_1	X_{10}		0.0258	
X_1	X_{12}		0.0360	
X_1	X_{14}		0.0141	
X_1	X_{16}		0.0055	
X_2	X_3		0.0145	
X_2	X_{16}		0.0490	
X_3	X_2		0.0361	
X_3	X_5		0.0213	
X_3	X_9		0.0119	
X_3	X_{10}		0.0403	
X_6	X_{10}		0.0006	
X_6	X_{11}		0.0279	
X_7	X_8		0.0248	
X_7	X_9		0.0483	
X_7	X_{12}		0.0328	
X_8	X_7		0.0023	
X_8	X_6		0.0406	
X_8	X_5		0.0011	
X_8	X_3		0.0405	
X_8	X_2		0.0041	
X_8	X_1		0.0001	
X_8	X_{16}		0.0075	
X_8	X_{14}		0.0017	
X_8	X_{12}		0.0001	
X_8	X_{10}		0.0187	
X_9	X_3		0.0154	
X_9	X_6		0.0320	
X_9	X_{15}		0.0252	
X_{11}	X_1		0.0316	
X_{11}	X_6		0.0149	
X_{11}	X_{13}		0.0278	
X_{12}	X_{10}		0.0159	
X_{12}	X_{16}		0.0071	
X_{14}	X_3		0.0208	
X_{14}	X_5		0.0335	
X_{14}	X_7		0.0253	
X_{14}	X_8		0.0069	
X_{14}	X_{10}		0.0392	
X_{14}	X_{11}		0.0225	
X_{14}	X_{16}		0.0130	

Table A14. *Cont.*

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_{16}	X_1		0.0319	
X_{16}	X_5		0.0466	
X_{16}	X_9		0.0364	
X_{16}	X_{17}		0.0347	
X_{16}	X_{20}		0.0107	
X_{20}	X_8		0.0483	
X_{22}	X_8		0.0209	
X_1	X_{14}			0.0114
X_1	X_{16}			0.0208
X_2	X_3			0.0299
X_2	X_{18}			0.0282
X_3	X_2			0.0366
X_3	X_9			0.0305
X_3	X_{10}			0.0085
X_3	X_{11}			0.0443
X_3	X_{14}			0.0342
X_6	X_9			0.0062
X_7	X_9			0.0435
X_7	X_{11}			0.0030
X_7	X_{12}			0.0005
X_7	X_{14}			0.0085
X_8	X_1			0.0004
X_8	X_2			0.0138
X_8	X_5			0.0008
X_8	X_7			0.0271
X_8	X_9			0.0167
X_8	X_{12}			0.0011
X_8	X_{14}			0.0304
X_8	X_{16}			0.0242
X_9	X_3			0.0164
X_{11}	X_9			0.0147
X_{12}	X_{16}			0.0011
X_{12}	X_{20}			0.0038
X_{16}	X_9			0.0172
X_{14}	X_{16}			0.0166
X_{16}	X_{17}			0.0481
X_{16}	X_{20}			0.0127

Table A15. Granger test results—Event 6. Only combinations with p-value less than than 5% shown.

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_2	X_{18}	0.0372		
X_8	X_7	0.0114		
X_8	X_{10}	0.0440		
X_8	X_{12}	0.0254		
X_{10}	X_{18}	0.0342		
X_{10}	X_{23}	0.0339		
X_{11}	X_3	0.0117		
X_{12}	X_2	0.0167		
X_{17}	X_{20}	0.0475		
X_{18}	X_5	0.0422		
X_{18}	X_6	0.0414		
X_{18}	X_8	0.0288		
X_{18}	X_{13}	0.0312		

Table A15. *Cont.*

$Index_A$	$Index_B$	Lag-1 *p*-Val.	Lag-2 *p*-Val.	Lag-3 *p*-Val.
X_2	X_{18}		0.0417	
X_3	X_{20}		0.0125	
X_5	X_{23}		0.0363	
X_7	X_1		0.0482	
X_7	X_{20}		0.0212	
X_8	X_5		0.0250	
X_{11}	X_5		0.0455	
X_{12}	X_{10}		0.0168	
X_{13}	X_1		0.0381	
X_{13}	X_{18}		0.0303	
X_{13}	X_{20}		0.0080	
X_{16}	X_{17}		0.0335	
X_{17}	X_{20}		0.0004	
X_{20}	X_{23}		0.0408	
X_{23}	X_6		0.0155	
X_{23}	X_{12}		0.0290	
X_{23}	X_{13}		0.0084	
X_1	X_{17}			0.0366
X_1	X_{19}			0.0364
X_5	X_{23}			0.0231
X_6	X_{20}			0.0463
X_8	X_5			0.0315
X_9	X_{15}			0.0116
X_{10}	X_{22}			0.0389
X_{10}	X_{23}			0.0003
X_{12}	X_{18}			0.0235
X_{12}	X_{23}			0.0354
X_{16}	X_{21}			0.0167
X_{17}	X_{20}			0.0035
X_{17}	X_{21}			0.0407
X_{18}	X_3			0.0122
X_{18}	X_6			0.0131
X_{18}	X_7			0.0351
X_{20}	X_3			0.0386
X_{20}	X_{19}			0.0431
X_{20}	X_{21}			0.0353
X_{21}	X_5			0.0121
X_{22}	X_9			0.0153
X_{23}	X_5			0.0459
X_{23}	X_6			0.0097
X_{23}	X_9			0.0267
X_{23}	X_{13}			0.0033

Table A16. Granger test results—Event 7. Only combinations with *p*-value less than than 5% shown.

$Index_A$	$Index_B$	Lag-1 *p*-Val.	Lag-2 *p*-Val.	Lag-3 *p*-Val.
X_1	X_{15}	0.0441		
X_7	X_1	0.0198		
X_7	X_3	0.0205		
X_8	X_{15}	0.0394		
X_9	X_1	0.0402		
X_9	X_{10}	0.0068		
X_9	X_{17}	0.0212		
X_{10}	X_1	0.0045		
X_{11}	X_9	0.0272		
X_{12}	X_{15}	0.0020		
X_{12}	X_{17}	0.0149		
X_{12}	X_{22}	0.0329		

Table A16. *Cont.*

$Index_A$	$Index_B$	Lag-1 p-Val.	Lag-2 p-Val.	Lag-3 p-Val.
X_{13}	X_3	0.0048		
X_{14}	X_{10}	0.0074		
X_{14}	X_{20}	0.0139		
X_{15}	X_{17}	0.0430		
X_{16}	X_8	0.0030		
X_{16}	X_{15}	0.0075		
X_{18}	X_{17}	0.0499		
X_{19}	X_{18}	0.0482		
X_{21}	X_{13}	0.0043		
X_1	X_3		0.0026	
X_3	X_{23}		0.0292	
X_8	X_{10}		0.0352	
X_8	X_{15}		0.0447	
X_9	X_1		0.0309	
X_9	X_{10}		0.0330	
X_{10}	X_1		0.0037	
X_{11}	X_1		0.0161	
X_{11}	X_8		0.0247	
X_{11}	X_{16}		0.0211	
X_{12}	X_{15}		0.0047	
X_{12}	X_{17}		0.0414	
X_{12}	X_{22}		0.0273	
X_{13}	X_3		0.0033	
X_{14}	X_{10}		0.0264	
X_{15}	X_{17}		0.0303	
X_{16}	X_9		0.0267	
X_{16}	X_{15}		0.0402	
X_{17}	X_{20}		0.0377	
X_{18}	X_{17}		0.0327	
X_{21}	X_{13}		0.0105	
X_1	X_3			0.0094
X_1	X_{15}			0.0456
X_2	X_{23}			0.0018
X_5	X_{23}			0.0173
X_6	X_{20}			0.0188
X_7	X_1			0.0480
X_8	X_6			0.0104
X_8	X_{10}			0.0050
X_8	X_{15}			0.0176
X_8	X_{16}			0.0334
X_9	X_1			0.0418
X_9	X_{10}			0.0292
X_{10}	X_1			0.0131
X_{11}	X_1			0.0121
X_{13}	X_3			0.0085
X_{14}	X_{20}			0.0449
X_{14}	X_{21}			0.0331
X_{15}	X_{17}			0.0043
X_{18}	X_9			0.0440
X_{18}	X_{15}			0.0111
X_{18}	X_{17}			0.0486
X_{20}	X_{21}			0.0380
X_{20}	X_{23}			0.0272
X_{21}	X_3			0.0477
X_{21}	X_{11}			0.0076

Table A17. Volatility F-test.

Index	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7
Argentina	0.40600	0.09510	0.00000	0.00012	0.88230	0.43960	0.00000
Australia	0.72540	0.58220	0.00000	0.00140	0.05150	0.93640	0.00000
Austria	0.42180	0.00000	0.00000	0.00001	0.13740	0.72650	0.00000
Belgium	0.46860	0.00019	0.00003	0.00520	0.99900	0.00008	0.00000
Canada	0.06200	0.33640	0.00000	0.00000	0.37470	0.53580	0.00000
France	0.13500	0.00046	0.00000	0.00250	0.01790	0.00000	0.00000
Germany	0.34240	0.00000	0.00000	0.00001	0.52620	0.00240	0.00000
H.K.	0.04450	0.00210	0.00000	0.00000	0.26050	0.00400	0.00000
Indonesia	0.05330	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Japan	0.75770	0.00085	0.00001	0.00000	0.00003	0.76890	0.00000
Malaysia	0.19300	0.00001	0.00001	0.00000	0.00003	0.00000	0.00000
Mexico	0.68820	0.00000	0.00000	0.00010	0.18160	0.37870	0.00000
Netherlands	0.18670	0.00000	0.00000	0.00110	0.05420	0.00000	0.00000
N.Z.	0.05430	0.16910	0.00000	0.00200	0.11970	0.31600	0.00000
Pakistan	0.09480	0.24230	0.02090	0.48380	0.04040	0.00000	0.03590
Peru	0.00120	0.94010	0.00039	0.40540	0.68790	0.53390	0.00000
Philippines	0.00000	0.00000	0.00000	0.00000	0.60080	0.00010	0.00000
Portugal	0.00000	0.00000	0.00000	0.00000	0.00000	0.00010	0.00000
S. Africa	0.00060	0.30700	0.00000	0.00000	0.85210	0.00010	0.00000
S. Korea	0.10500	0.22290	0.00000	0.00000	0.00000	0.00000	0.00000
Spain	0.00087	0.02110	0.00001	0.28990	0.00000	0.00000	0.00000
Thailand	0.00000	0.00000	0.00000	0.00000	0.08650	0.00048	0.00000
U.S.	0.21180	0.00075	0.00000	0.02440	0.13140	0.00830	0.00000

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