

Assessing Financial Stress in China, Japan, Korea and ASEAN-5 Economies

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Abstract

Given the increased global and regional interconnectedness, it is important to measure the level of financial stress in regional economies and detect the areas within the financial system that drive the stress levels. Pre-emptive policy measures could be taken in a more timely manner once signs of escalating financial stress levels are spotted. This study seeks to construct a Financial Stress Index (FSI) that can be used as a surveillance tool to assess signs of financial stress for regional economies with sufficient high-frequency financial sector data, as well as an aggregated FSI for the region. In the construction of the FSI, a number of indicators that proxy different areas of stress in the financial sector, i.e. the stock market, sovereign and corporate debt market, money and interbank market, and the foreign exchange market are evaluated for China, Hong Kong (China), Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand. The results from the study suggest that the FSI for each economy is able to identify stress originating from global, regional and domestic events well. The FSIs at the country and regional levels are able to capture the high stress level during the Global Financial Crisis (GFC), post-GFC, such as the Euro Crisis, the taper tantrum, FX pressure from changes in China's central parity mechanism, and more recently, growing risk aversion in emerging markets.

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Executive Summary

For the last two decades, ASEAN+3 economies have encountered two major financial crises, namely the Asian Financial Crisis (AFC) in 1997-98 and the Global Financial Crisis (GFC) in 2008-09 and witnessed different degrees of impairment to the functioning of financial markets with negative effects on the real economy. Given the increased global and regional interconnectedness, it is important to measure the level of financial stress in regional economies and detect the areas within the financial system that drive the stress levels. Pre-emptive policy measures could be taken in a more timely manner once signs of escalating financial stress levels are spotted.

An episode of financial stress is defined as a period when the financial system is under strain and its ability to intermediate is impaired. Financial stress can be thought of as an interruption to the normal functioning of financial markets. It tends to be associated with at least four fundamental characteristics; large swings in asset prices, an abrupt increase in risk and/or uncertainty, liquidity droughts, and concerns about the health of the banking system.

The purpose of this study is to construct a Financial Stress Index (FSI) that can be used as a surveillance tool to assess signs of financial stress for regional economies with sufficient high-frequency financial sector data, as well as an aggregated FSI for the region. Recent research works show that financial stress can help anticipate recessions and financial crisis. In the construction of the FSI, a number of indicators that proxy different areas of stress in the financial sector, i.e. the stock market, sovereign and corporate debt market, money and interbank market, and the foreign exchange market are evaluated for China, Hong Kong, China³, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand. These are then used as inputs to construct an aggregated regional and an ASEAN-4 FSI.

(1) Index Construction

The study examines nine daily financial market indicators from January 2005 onwards. The indicators are daily market-based data, capturing signs of stress in stock, sovereign debt, corporate bond, interbank/money as well as foreign exchange markets. These indicators are GARCH of stock market returns (for stock market), 5Y sovereign CDS spread and yield difference between 10Y local currency sovereign bonds and 10Y U.S. Treasury (for sovereign debt market), USD-denominated corporate bond spread (for corporate debt market), TED spread (for Japan, Korea and Hong Kong only) and inverted term spread (for interbank/money market), and implied FX volatility, 1Y cross currency basis swaps, and exchange market pressure index (EMPI) for the foreign exchange market.

The study adopts a combination of statistical techniques namely principal component analysis (PCA) and simple econometric tool namely constrained regression, as well as staff's judgements. After some data transformations, the first few principal components are derived from the PCA analysis. These are then considered as a proxy for each economy's FSI. In order to determine the contributions (or weights) of the above nine explanatory variables, a constrained least square regression is then employed to estimate the fitted FSI for each economy.

³ For brevity, hereafter referred to as Hong Kong.

The individual economy's FSIs are then pooled together to compute the aggregated regional and sub-regional FSIs, after assigning weights for each economy's FSI. We considered GDP and intra-regional cross-border investment as alternatives for the weights but found that the following mixture would represent the overall regional and sub-regional stress level better. Financial centers (Singapore and Hong Kong) have relatively lower GDP but high cross-border investments in the region and we arbitrarily assign a weight of 8% to each of them. For the rest of the economies, we derive the weights according to their GDPs.

(2) Assessment of Financial Stress in ASEAN+3

The results from the study suggest that the FSI for each economy is able to identify stress originating from global, regional and domestic events well. The FSIs are able to capture the high stress level during the GFC, post GFC, such as the Euro crisis, the taper tantrum, as well as the 2015 China shock.

The regional and individual economy's FSI levels are the highest during the GFC. During that period, the FSI levels were high for all economies, although the level is relatively low for China. For the entire region as well as ASEAN-4 sub-region, all indicators suggested stress, with FX volatility, sovereign CDS and corporate yield spreads contributing most to the regional FSI. For the Euro crisis and the taper tantrum, stress readings were also significant, but limited to a smaller number of indicators. The stress indicators in the Euro crisis were in fact quite similar to GFC. During the taper tantrum in 2013, Indonesia saw relatively higher level of stress, driven largely by FX pressure and wider sovereign spreads, as compared to other economies.

A shock originating from within the region such as changes to China's central parity exchange rate mechanism in August 2015 (which saw the RMB being devalued), had a impact comparable to the Euro Crisis. The areas of stress were escalating stock market volatility and rising EMPI due to either selling pressure on foreign reserves and/or exchange rate depreciation.

Stress indicators have begun to rise in early 2018, reflecting a confluence of global factors (such as escalation of global trade tensions and U.S. Fed Policy), as well as country-specific vulnerabilities in some EMs outside the region (such as growing macroeconomic imbalances in Argentina and Turkey). Stress indicators such as stock market volatility and EMPI have increased, while sovereign CDS spreads have widened. In ASEAN-4, the pressure on EMPI was particularly visible, as currencies have depreciated alongside drawdowns on foreign reserves. Indonesia and the Philippines are the two major contributors to the higher aggregate stress level in ASEAN-4, partly reflecting the structural vulnerabilities. However, so far, the level of stress in the region has not been as high as compared to the level experienced during the August 2015 China shock.

At the country level, the individual economy's FSIs are also able to capture domestic market-driven stress relatively well. For instance, the high stress level in China in August 2015 as a result of pressures in the FX markets and the higher level of stress in Malaysia in late 2016 and early 2017, which coincided with rising pressure in the offshore NDF market.

1. Introduction

1. In the last two decades, the world experienced two significant periods of financial turmoil, namely the 1997-98 Asian Financial Crisis (AFC) and the Global Financial Crisis of 2008-09 (GFC), with far-reaching effects. During such crisis periods, financial stresses tend to be associated with at least four fundamental characteristics: large swings in asset prices, an abrupt increase in risk and/or uncertainty, liquidity droughts, and concerns about the health of the banking system (Hakkio and Keeton, 2009). These will go down in history as classic examples of financial crises, where exchange rates depreciated, stock markets fell, bank lending was scaled back, sovereign and corporate debt spreads widened and there were capital outflows in most, if not, all of the countries that were affected by the crises.

2. A recession that is linked to a financial crisis is substantially more severe than those that are not. This region has experienced two severe recessions, and both were preceded by financial crisis: the Asian Financial Crisis and the Global Financial Crisis. Globally, a study by Cardarelli, Elekdag and Lall (2009) found that episodes of financial turmoil characterized by banking distress are more likely to be associated with severe and protracted downturns compared with episodes of stress mainly in securities or foreign exchange market. As economies in this region continue to develop and strengthen banking and financial linkages with the rest of the world, they will become increasingly exposed and vulnerable to shocks emanating from financial stress abroad.

3. Given the severe contagion effect from the GFC and the European sovereign debt crisis, it is crucial that financial stress levels within ASEAN+3 be closely monitored so that pre-emptive measures can be considered once any hint of financial stress is detected. Policies can then be taken to avert a further escalation of stress. In this regard, a financial stress index (FSI) tailored specifically for regional economies and the region as a whole, can be a helpful tool in quantifying developments in the financial markets and measuring levels of financial stress.

4. The purpose of this study is to construct an FSI that can be used as a surveillance tool to monitor developments in financial stress for nine regional economies (with enough high frequency data), as well as for the region. In the construction of the FSI, a small number of indicators that are proxies for sector-specific stress, i.e. the stock market, sovereign and corporate debt market, money and interbank market, and the foreign exchange market are evaluated for China, Hong Kong (China), Indonesia, Japan, Korea, Malaysia, the

Philippines, Singapore and Thailand. These are then used as inputs to construct an aggregated regional FSI. The study aims to answer the following questions:

- What are the areas of the financial sector that have witnessed stress in each of the nine regional economies? How do they differ across different crisis/stress periods?
- Looking at the bigger picture, which economies and which areas of the financial sector tend to contribute more to the regional stress level? How would the assessment differ when we look at just ASEAN-4 (Indonesia, Malaysia, the Philippines and Thailand) as a group of emerging economies in the region?

5. To answer these questions, the paper is organized into several sections as follows.

After this introduction, Section 2 provides a review of the literature on financial stress (overview, definition and measurement of financial stress). Section 3 discusses the construction of the nine individual economy FSI, a regional FSI (including a sub-regional FSI for ASEAN-4 economies). This section is divided into 4 sub-sections. In sub-section 3.1, the proposed FSI indicators are presented, including the rationale for the chosen indicators, as well as the data source. In sub-section 3.2, data transformation is explained, and sub-section 3.3 discusses the methodology whereby principal component analysis is combined with constrained least square regression, while sub-section 3.4 derives the weighting schemes for the construction of regional FSIs from country FSIs. Section 4 discusses the findings of the FSI, including the index performance in comparison with other indicators in the market. The final Section 5 concludes with some discussion on further research.

2. Overview

2.1 Defining Financial Stress

6. Defining financial stress can be challenging as the global financial market is a dynamic web of inter-linkages. No two episodes of financial stress have been completely alike. Hence while various definitions to the concept of financial stress have been offered, there is still no formally accepted definition. Earlier definitions of stress/crises have typically focused on specific sectors of financial markets (such as the banking sector and the foreign exchange market).

7. A review of the literature suggests that financial stress is typically associated with the following (based on the seminal work by Illing and Liu (2003)):

- **Banking stress/crises:**

Demirgüç-Kunt and Detragiache (1998) define a banking crisis as a situation where at least one of the following conditions holds: (i) the ratio of non-performing assets to total assets is greater than 10 percent (ii) the cost of the rescue operation is at least 2 percent of GDP, (iii) banking problems result in the large-scale nationalization of banks, and (iv) extensive bank runs lead to emergency measures.

- **Foreign exchange stress/crises:**

Frankel and Rose (1996) define a currency crisis as a nominal depreciation of at least 25 percent that exceeds the previous year's change by a margin of at least 10 percentage points. Kaminsky, Lizondo and Reinhart (1998) and Caramazza, Ricci and Salgado (2000) take a weighted average of exchange rate changes and foreign reserve losses to account for effects of foreign exchange intervention in the event of a speculative attack, while Eichengreen, Rose and Wyplos (1996) and Hawkins and Klau (2000) include hikes in interest rates.

- **Debt stress/crises:**

Bordo and Schwartz (2000) define a debt crisis as the inability of a sovereign or the private sector to service its foreign debts.

- **Equity stress/crises:**

Equity crises have mostly been defined as a sharp decline in the overall market index.

8. A more comprehensive definition of financial stress is used by Iling and Liu (2006), Hakkio and Keeton (2009) and Balakrishnan and others (2009) by pooling the four elements mentioned above into one composite measure. Hakkio and Keeton (2009) define financial stress as a period that displays at least one of the following five phenomena: increased uncertainty about the fundamental value of assets, increased uncertainty over other investors behavior, increased asymmetry of information, decreased willingness to hold risky assets (flight to quality) and decreased willingness to hold illiquid assets (flight to liquidity). The element of increased uncertainty common across all five phenomena typically results in greater volatility in financial asset prices, be it for stocks, bonds or loans. In general terms, financial stress can be thought of as a period where financial system is under strain and its ability to intermediate is impaired.

2.2 Measuring Financial Stress

9. Earlier studies and econometric works often used binary variables to represent either a crisis or no-crisis event. However, such variables do not provide a measure of the intensity of stress and often overlook periods of stress that never evolve into a full-blown crisis, but which could not be ignored either. With further study and refinement, financial stress has come to be recognized as a continuous variable with a spectrum of values and where extreme values are called a crisis.

10. From binary variables, the concept of financial stress has evolved, leading to the development of financial stress indices to quantify and measure varying levels of financial stress in a system. Iling and Liu (2006) constructed an index for financial stress for the Canadian financial system (Canadian-FSI) and their work was influential in the development of subsequent financial stress indices, such as the FSI for Kansas City's financial system by Hakkio and Keeton (2009), FSI for advanced economies by Cardarelli, Elekdag and Lall (2009), FSI for emerging economies by Balakrishnan and others (2009) and Park and Mercado (2013), and FSI for the Hong Kong economy by Yiu, Ho and Jin (2010).

11. The EM-FSI contains two important refinements: the inclusion of an exchange market pressure index to capture exchange market pressures and the inclusion of sovereign debt spread. These are the two more common sources of stress in emerging economies on top of those for advanced economies in the Canadian FSI, Kansas City FSI and the advanced economies FSI. The emerging markets FSI hence forms the basis of our FSI for regional economies.

3. FSI Construction: Methodology

3.1 Proposed Indicators and Data Sources

12. In the construction of the FSI, a number of stress indicators that proxy sector-specific stress in each of the nine regional economies are evaluated. The chosen indicators are daily market-based data that are considered important by market participants. The data in the study is from January 2005 onwards except the EMPI, which is available on a monthly basis. The proposed stress indicators represent the four important key sectors, namely the (1) stock market, (2) sovereign and corporate debt markets, (3) interbank/money markets, and (4) foreign exchange market. These indicators are chosen to capture market volatility, cost of funding (liquidity conditions), as well as country risk premia (credit risk), which together, tend to precede episodes of financial stress. A description of the proposed indicators, and the data source are set out in Table 1.

13. The proposed indicators aim to capture financial stress emanating from both external and internal shocks. Considering that several regional economies have high degree of trade and financial openness, the proposed indicators are intended to incorporate the transmission of stress originating from systemic countries both outside and inside the region as well as country specific shocks. Table 1 shows the rationale for the proposed indicators, and supporting literature. A detailed comparison of the variables used in our studies and the others are summarized in Appendix I.

Table 1. Description and Rationale of Proposed Indicators

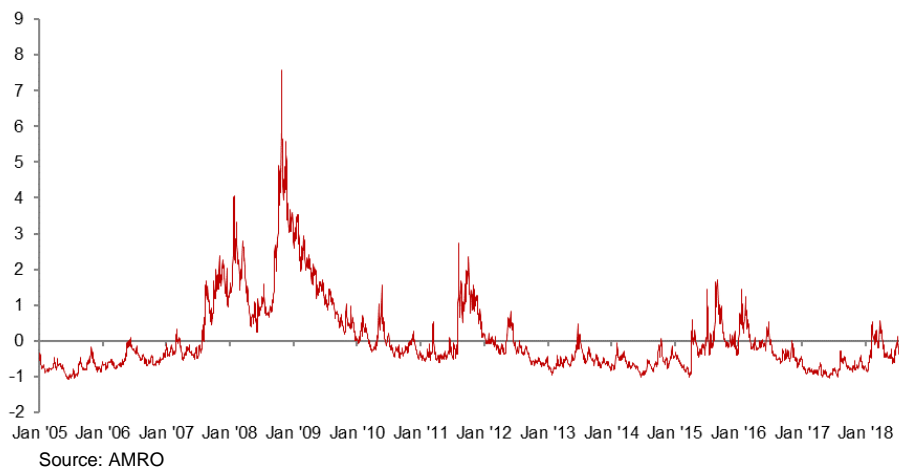
Sectors	Description of Proposed Indicator	Data Source	Explanation of Indicator	Example of Study
Stock Market	Conditional Variance of Stock Market Returns (GARCH)	Bloomberg & AMRO	Time-varying volatility of daily stock market returns indicates potential financial stress in the equity market	(Illing and Liu, 2003), (Hakkio and Keeton, 2009), (Cardarelli, Elekdag and Lall, 2009), (Balakrishnan and others, 2009), (Park and Mercado, 2013) (MAS, 2017)
Sovereign Debt	5Y Sovereign CDS Spread (CDS Spread)	JP Morgan	Credit Default Swap (CDS) shows the cost of insuring a 5Y sovereign bonds in events of default	(Stolbov and Shchepeleva, 2016), (MAS, 2017)
	Yield Difference between 10Y Local Currency Sovereign Bond & 10Y U.S. Treasury (Yield Spread) E.g. 10Y MGS – 10Y UST (Malaysia)	Reuters	The spread between LCY and FCY (USD) denominated yields indicates the country risk premium w.r.t to the “risk-free” UST	(Balakrishnan and others, 2009), (Yiu, Ho and Jin, 2010), (Park and Mercado, 2013)
Corporate Debt	USD-denominated Corporate Bond Spread (Corporate Spread)		Dollar-for-dollar spread indicates local corporate risk premium w.r.t U.S. corporate rate	(Illing and Liu, 2003)
Inter-Bank & Money Market	TED Spread Yield difference between 3M Local Interbank Rate & 3M Government Treasury (E.g. 3M Hibor – 3M Treasury) for Japan, Korea and Hong Kong	Bloomberg & Reuters	TED spread measures funding liquidity risk of interbank lending.	(Hakkio and Keeton, 2009), (Cardarelli, Elekdag and Lall, 2009), (Yiu, Ho and Jin, 2010), (Yiu, Ho and Choi, 2010), (MAS, 2017)
	Inverted Term Spread Yield difference between 3M Sovereign Note & 10Y Sovereign Bond (E.g. 3M KLIBOR – 10Y MGS)		The Inverted Term Spread indicates a shortage of short term liquidity in the banking sector. A positive inverted term spread occurs at a time when the short-term interest rate rises above the 10Y yield.	
FX Market	3M at-the-money Option Implied Volatility (FX Implied Volatility)	JP Morgan	3M at-the-money option implied volatility reflects the option price-derived market volatility measure of FX.	(Yiu, Ho and Jin, 2010),
	1Y Cross Currency Basis Swap Spread (against USD) (CCBS Spread)	Bloomberg & AMRO	CCBS indicates the premium paid to borrow USD in exchange for local currency in the future; an important gauge of USD funding conditions in Japan and some other major markets after the GFC	(Balakrishnan and others, 2009), (Park and Mercado, 2013), (Borio and others, 2016), (Avdjiev and others, 2017)
	Exchange Market Pressure Index (EMPI) The sum of variance adjusted FX depreciation and variance adjusted reduction in foreign reserves		EMPI shows the degree of stress in the overall FX market.	

Notes: Since there is no pricing of risk for Singapore sovereign debt, the sovereign CDS spread for Singapore is proxied by the CDS spread of Singtel. For the stock market, conditional variance is estimated using IGARCH(1,1), and we use the parameters given by the Riskmetrics. That is, . For China and ASEAN, we notice that their TED spreads are not responsive to our perceived stress, as the 3m interbank rates tend to move slowly, so we include this indicator for Japan, Korea and Hong Kong only.
Source: AMRO

3.2 Data Transformation

14. Before applying the methodology to construct the FSI, some data transformation is required in order to normalize the scales of different indicators. First, the daily raw data (5-day work week), are normalized to arrive at the Z-scores over the period from 2 January 2005 to end of 2017 (Figure 1). The data normalization is needed to ensure that indicators for each country can be compared in terms of magnitude and that they are treated equally when the Principal Component Analysis is employed.

Figure 1. Normalized Z-Scores of Stock Market Volatility in Hong Kong



The normalized Z-scores for each indicator across the sample period has a mean of zero ($\mu = 0$), a standard deviation of one ($\sigma = 1$), and higher value always indicates greater stress. For example, as shown in Figure 1, when the normalized Z-score (Stock Market Volatility in Hong Kong) takes a value greater than zero (positive reading), it implies that the stress level is higher than the historical average which is represented by the horizontal zero line. Likewise, when the Z-score reading is less than zero (negative reading), it implies that the stress level is lower than the historical average. Such interpretation is important, as a negative reading does not necessarily mean that the stress index is negative in absolute term. For any indicators, higher Z-score indicates higher stress relative to the average. For example, as a lower original value of Cross Currency Basis Swap (CCBS) indicates higher stress, we multiply all original values by (-1) during the normalization process. A compilation of normalized Z-scores for all indicators across the nine regional economies is tabulated in Appendix II.

Second, for Exchange Market Pressure Index (EMPI) data⁴, we adjusted the traditional formula from month-on-month change to the change of each month from the average of the

⁴ The EMPI captures exchange rate depreciations and declines in international reserves, and is defined for country i in month t as:

$$EMPI_{i,t} = \frac{(\Delta e_{i,t} - \mu_{i,\Delta e})}{\sigma_{i,\Delta e}} - \frac{(\Delta RES_{i,t} - \mu_{\Delta RES})}{\sigma_{i,\Delta RES}}$$

previous six months to better capture the sustained pressures over time. A counterfactual analysis shows that the adjusted EMPI formula improves the information content in the FSI. Monthly EMPI data are then re-estimated to derive the equivalent daily data.⁵

3.3 Construction of Individual Economies' FSI

3.3.1 Principal Component Analysis

15. In constructing the FSI for each individual economy, we first adopt the PCA approach as it has the advantage of extracting the main variance factors from all nine indicators, thereby serving as a proxy for the country FSI.⁶ Given that multiple financial variables tend to exhibit similar patterns of responses that are associated with a latent variable that is unobservable, the PCA has the advantage of extracting the main variance factors from all nine indicators – which fits our intention. PCA seeks linear combinations of variables, called factors that represent underlying fundamental quantities of which the observed variables are expressions. In essence, the PCA is able to quantify the most important factor in describing the variability of a dataset.

16. We select the first few principal components for each regional economy to describe the degree of financial stress over time. Cumulatively, for each economy, the first to the third principal components (PC1 to PC3) cover about 76 percent to 85 percent of the total variance of the variables. Therefore, for some economies (CN, HK), we use the sum of first PC1 to PC3 as a proxy to model the FSI. However, for other economies, when including PC2 or PC3, the factor loadings for some variables have the wrong sign, and in this case, we use only PC1 (CN, KR, ID, TH) or sum of PC1 and PC2 (JP, MY, SG and PH). The PCA FSI output is shown in Figure 2.

where $\Delta e_{i,t}$ denotes the change of exchange rate in month t from the average of the previous six months ($t-1$ to $t-6$), that is, $\Delta e_{i,t} = \log(\text{Exchange}_{i,t}) - \log(\sum_{k=1}^{k=6} \text{Exchange}_{i,t-k}/6)$, and similarly, ΔRES denotes the change of reserves in month t from the average of the previous six months.

⁵ This is done using a Python program.

⁶ The PCA is a statistical technique used to examine the interrelations among a set of variables in order to identify the underlying structure of those variables. It is a non-parametric analysis and the answer is unique and independent of any hypothesis about data distribution.

Figure 2. FSI PCA for Each Individual Economy

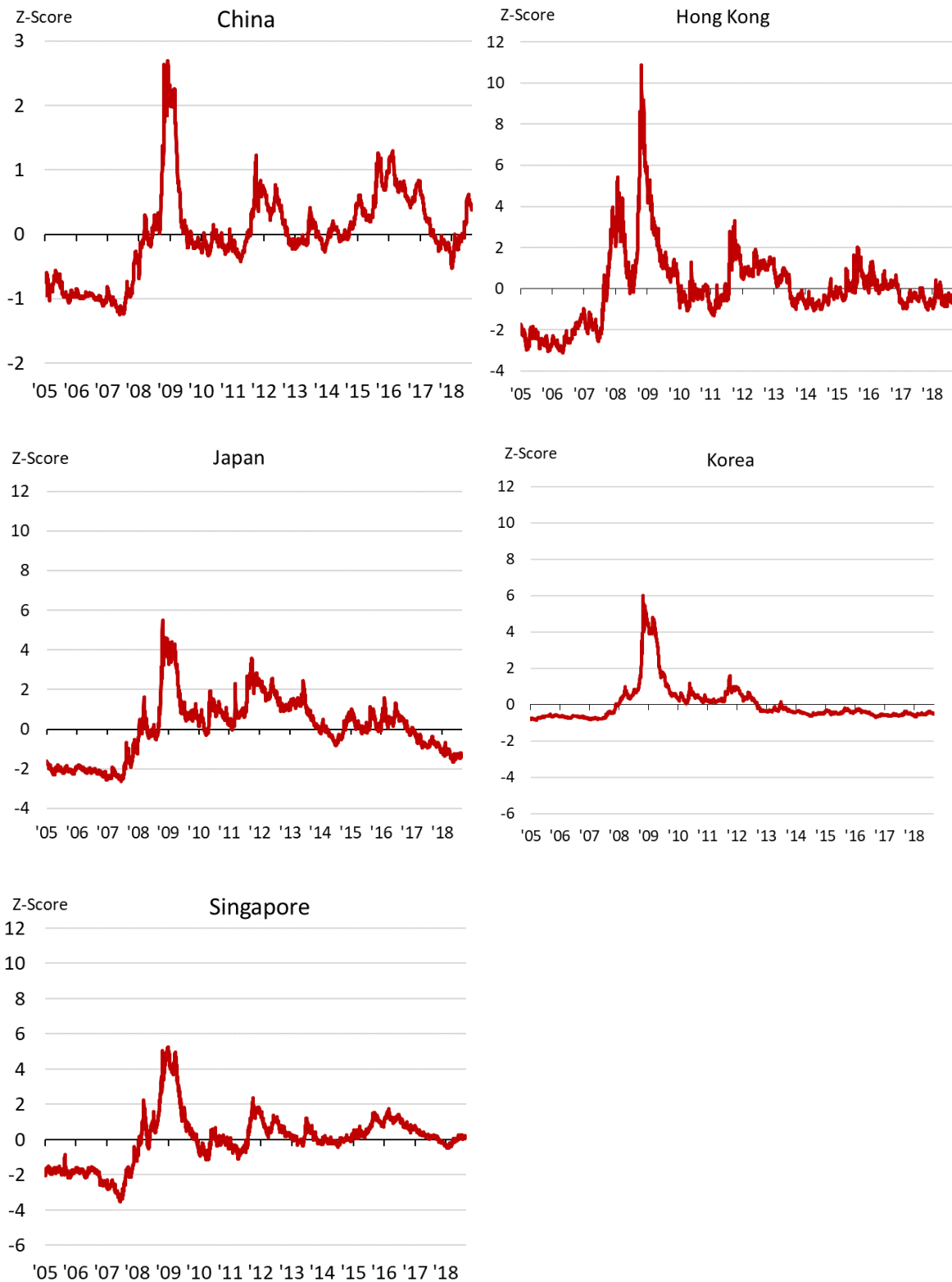
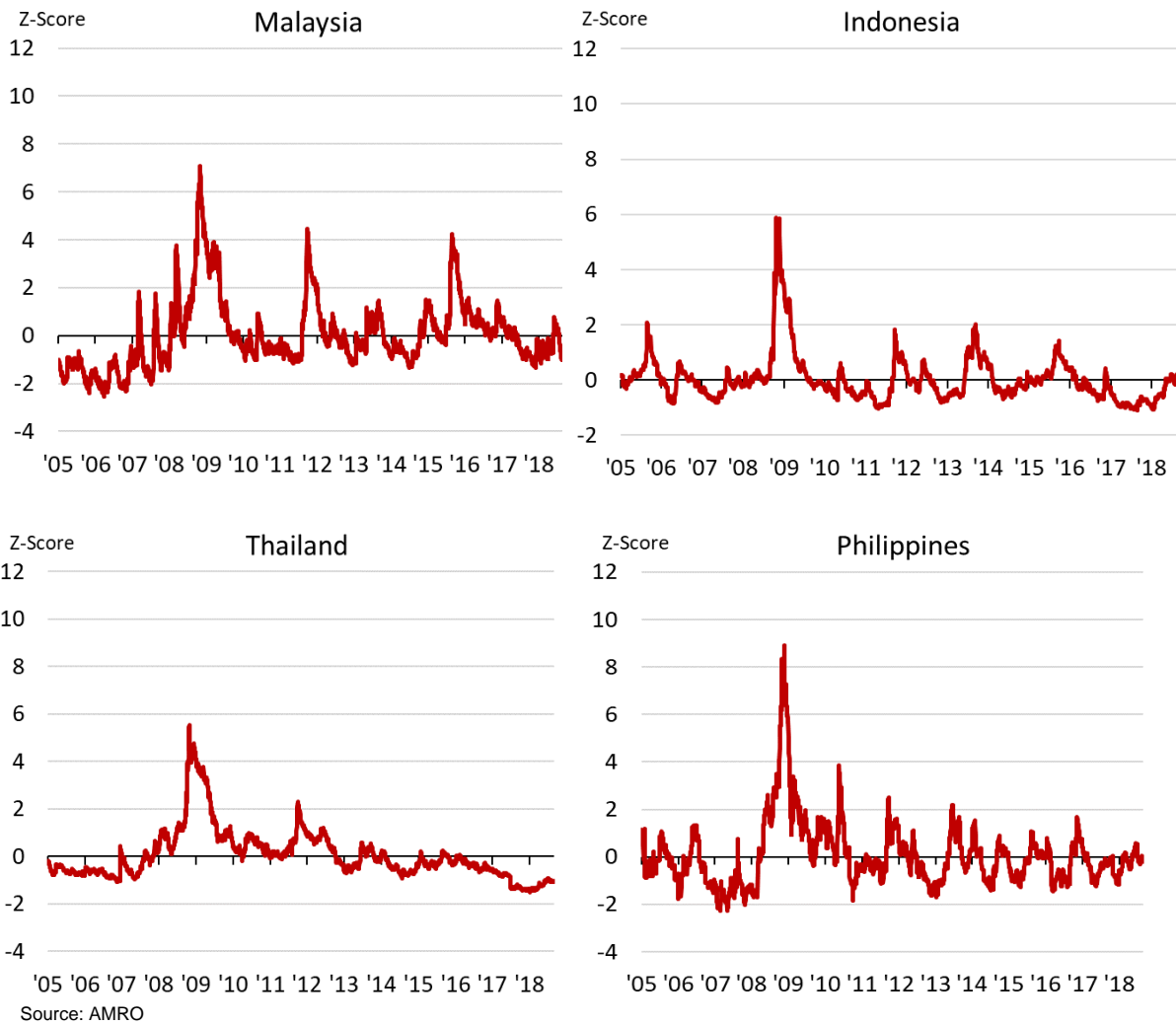


Figure 2. FSI for Each Individual Economy, Continued



3.3.2 Constrained Regressions

17. Although the above PCA results demonstrate the stress periods and levels appropriately, this technique sometimes does not identify the main contributing indicators satisfactorily.⁷ To better ascertain the relative importance of the indicators, we propose the following constrained regression method:

$$FSI_{PCA} = \beta_0 \sum_{k=1}^n \beta_k X_k + \varepsilon \quad (1)$$

subject to: $\sum_{k=1}^n \beta_k = 1$ and $\beta_k > 0$ for any β_k , and β_0 is a scalar (there are effectively n number of parameters, due to an equality constraint). As economists may also prefer to

⁷ In practice, when using all variables to conduct the PCA analysis, we find that sometimes the sign of the factor loading is incorrect and the value is significant. Hence, we exclude some variables from the PCA analysis for some economies, such that the factor loadings eventually have the correct signs, or have the wrong sign but the value are close to zero. For example, the sovereign CDS for ASEAN-4 economies reflects the overall risk so well, such that when CDS is included in the analysis, it drives almost all the variance of the FSI. In this case, the factor loading of CDS is positive and very large, and the factor loadings on all other variables become negative. Therefore, we drop this variable when for PCA analysis for ASEAN-4. However, also because it is able to reflect the overall risk so well, it will be included at a later stage. Similarly, we drop the implied FX volatility for PCA analysis for the case of Japan.

impose weights such as minimum/maximum weights on certain variables based on knowledge of the financial markets, this regression method can also allow for such imposition of judgement.

18. When assigning weights, we seek a balance between an empirically-driven approach and expert judgment. In the literature, when assigning weights on variables, there are two approaches: equal weights (Cardarelli, Elekdag, and Lall, 2011) or empirically-driven such as PCA (Park and Mercado, 2013). However, an equal weight approach is not desirable, as apparently, some variables are more informative than others for certain economies. For example, in Hong Kong, stock market implied volatility is more informative than government yield spread with the U.S. At the same time, empirically-driven PCA FSI is also not the most desirable, as it could give too much weights for certain variables, against economists and market analysts' perception. To strike a balance, we use a least square as well as judgement to impose minimum/maximum weight on each variables for each country FSI.

In doing so, we use a straight forward constrained regression (1) to allocate the weights for China, Hong Kong, Korea and Singapore.

For ASEAN-4, the sovereign CDS seems to capture the overall risk very well, so that when it is included in the PCA analysis, the factor loadings of other variables become large and negative. Therefore, we acknowledge that sovereign CDS is important and allocate a high weight (25 percent), but the sovereign CDS is not used in the PCA analysis, and it will be excluded in the regression. The regression is:

$$FSI_{PCA} = \beta_0 \sum_{k=1}^n \beta_k X_k + \varepsilon \quad (2)$$

subject to: $\sum_{k=1}^n \beta_k = 75\%$ (as CDS has a 25% weight) and $\beta_k > 0$ for any β_k , β_0 is a scalar, and X_k does not include sovereign CDS.

We then include the sovereign CDS and assign a weight of 25 percent later. Similarly, for Japan, the FX implied volatility is not used for PCA analysis, we exclude it from the regression and include it later with a weight of 0.25.

19. To obtain a well-behaved⁸ sets of weights, the key is to set reasonable minimum/maximum weights. The weights in Equation (1) are intuitive and the goal is to make the weights well-behaved. The PCA FSI estimates can be used as the reference series, and employed as regressors (i.e. left-hand side variable) in equation (1). We also impose weights constraints, as shown in Table 2. The minimum weights on corporate bond yield (in USD) and

⁸ All weight should be greater than zero. No weight should be too dominant.

equity market volatility are 8 percent,⁹ as we believe these markets contain important information. For Singapore, the maximum weight on the “sovereign CDS” is 10 percent,¹⁰ lower than other economies, as we use the CDS for Singtel as a proxy, and the lower weight reflects this data limitation. For countries other than Japan, we also impose a constraint that the total weights on the FX market (including FX implied volatility, CCBS and EMPI) does not exceed 35 percent.¹¹

Table 2. Weight Constraints on Variables
Panel A: Minimum Weight

	FX Implied Volatility	Sovereign CDS	Sovereign Yield Spread with the U.S.	Corporate USD Bond Spread	Inverted Sovereign Term Spread	TED Spread	Equity Market Volatility	CCBS	EMPI
China	8.0%	3.0%	3.0%	8.0%	3.0%	NA*	8.0%	3.0%	3.0%
Hong Kong	3.0%	3.0%	3.0%	8.0%	3.0%	3.0%	12.0%	3.0%	3.0%
Japan	NA*	3.0%	3.0%	8.0%	3.0%	3.0%	8.0%	3.0%	3.0%
Korea	8.0%	3.0%	3.0%	8.0%	3.0%	3.0%	8.0%	3.0%	3.0%
Malaysia	8.0%	NA*	3.0%	8.0%	3.0%	NA*	8.0%	3.0%	8.0%
Thailand	8.0%	NA*	3.0%	8.0%	3.0%	NA*	8.0%	3.0%	8.0%
Singapore	8.0%	3.0%	3.0%	8.0%	3.0%	NA*	12.0%	3.0%	8.0%
Indonesia	8.0%	NA*	3.0%	8.0%	3.0%	NA*	8.0%	NA*	8.0%
Philippines	8.0%	NA*	3.0%	8.0%	3.0%	NA*	8.0%	NA*	8.0%

Notes: TED spread data are not available for China, Malaysia, Thailand, Indonesia and the Philippines. The weight of variables with “NA” will be assigned a weight of 25 percent in a later step.

Panel B: Maximum Weight

	FX Implied Volatility	Sovereign CDS	Sovereign Yield Spread with the U.S.	Corporate USD Bond Spread	Inverted Sovereign Term Spread	TED Spread	Equity Market Volatility	CCBS	EMPI
China	25.0%	25.0%	15.0%	25.0%	15.0%	NA*	25.0%	15.0%	25.0%
Hong Kong	25.0%	25.0%	15.0%	25.0%	15.0%	25.0%	25.0%	25.0%	25.0%
Japan	NA*	25.0%	5.0%	5.0%	15.0%	25.0%	25.0%	25.0%	25.0%
Korea	25.0%	25.0%	15.0%	25.0%	15.0%	25.0%	25.0%	25.0%	25.0%
Malaysia	25.0%	NA*	15.0%	25.0%	15.0%	NA*	25.0%	25.0%	25.0%
Thailand	25.0%	NA*	15.0%	25.0%	15.0%	NA*	25.0%	25.0%	25.0%
Singapore	25.0%	10.0%	15.0%	25.0%	15.0%	NA*	25.0%	25.0%	25.0%
Indonesia	25.0%	NA*	15.0%	25.0%	15.0%	NA*	25.0%	NA*	25.0%
Philippines	25.0%	NA*	15.0%	25.0%	15.0%	NA*	25.0%	NA*	25.0%

Notes: TED spread data are not available for China, Malaysia, Thailand, Indonesia and the Philippines. The weight of variables with “NA” will be assigned a weight of 25 percent in a later step.

20. The results of the regressions are in general consistent with our desk economists’ views about the importance of different indicators for each economy. As shown in Table 3, after imposing the weight constraints, we find the results in general satisfactory. For China, the FX market has the highest weight. Equity, bond markets signals and inverted term spread are important for Hong Kong. CCBS is critical for Japan but not for other economies. For ASEAN, the FX market, the corporate yield spread and equity market volatility are the most important.

⁹ The “8 percent” floor is higher than “3 percent” floor for other variables. It is set arbitrarily, and we consider equity and bond market stress important for each economies.

¹⁰ The “10 percent” cap here is arbitrary. As this is based on CDS of a single company only, we would let the weight be much lower than other economies’ cap of “25 percent”.

¹¹ There are indicators from 5 sectors, and we consider 35 percent a high weight for a single sector.

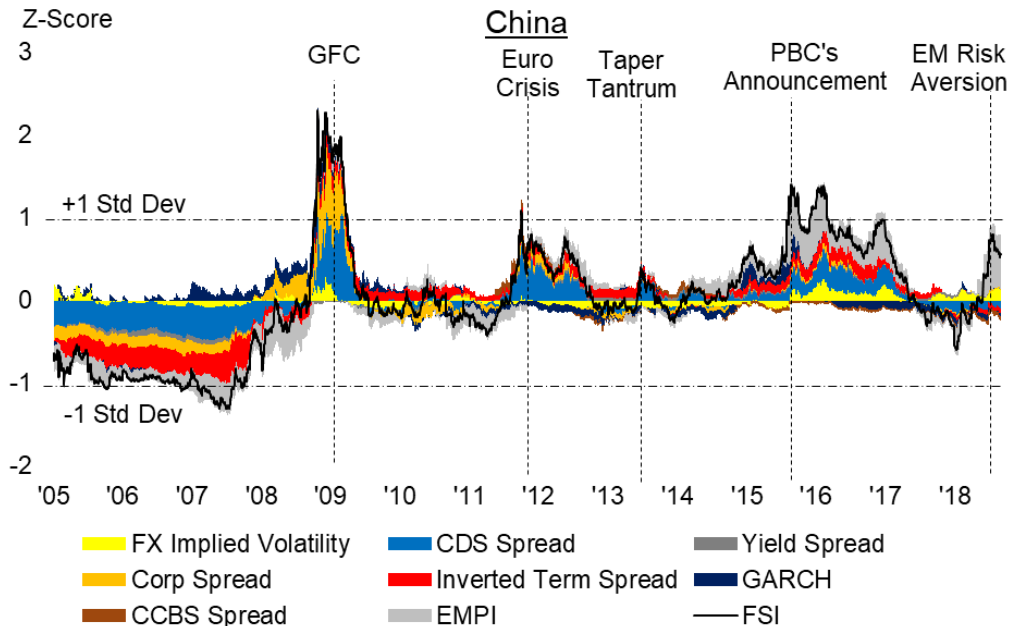
Table 3. Final Weights on Variables

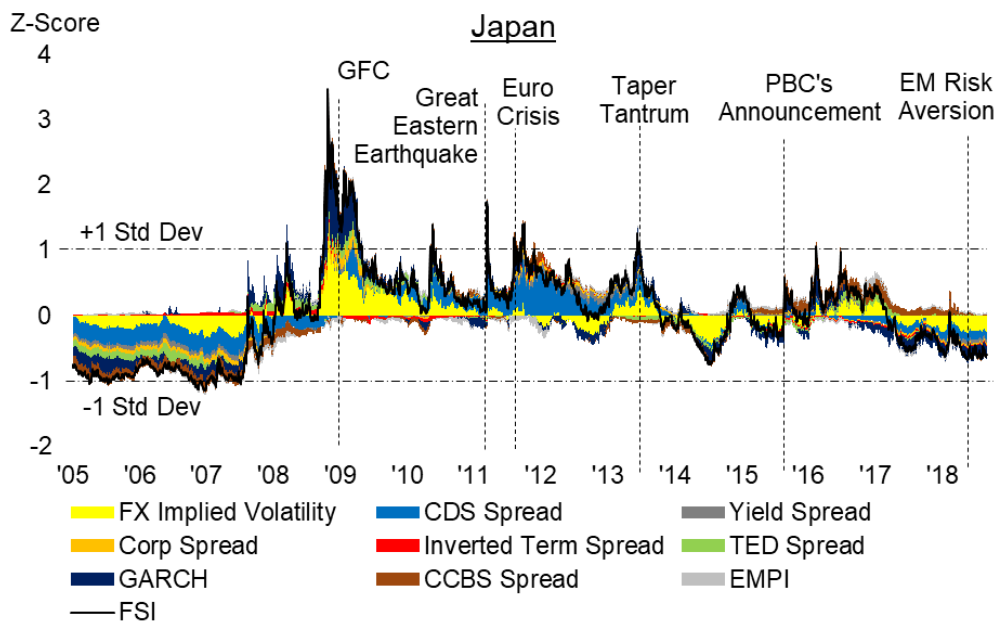
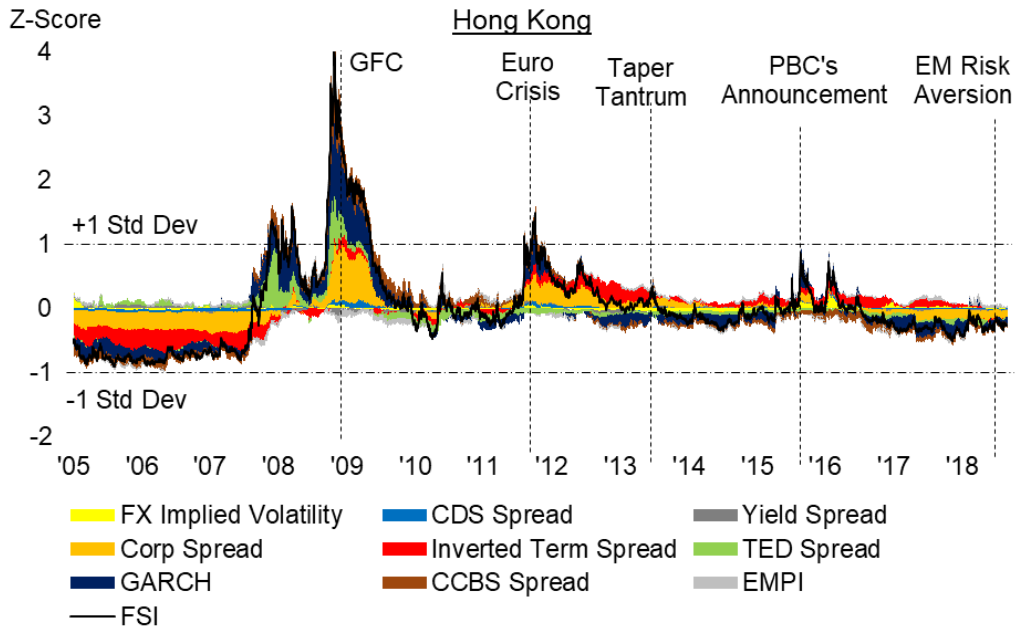
	FX Implied Volatility	Soverign CDS	Soverign Yield Spread with the U.S.	Corporate USD Bond Spread	Inverted Soverign Term Spread	TED Spread	Equity Market Volatility	CCBS	EMPI	Sum
China	8.0%	25.0%	3.0%	14.0%	15.0%	NA*	8.0%	3.0%	24.0%	100%
HK	3.7%	3.0%	3.0%	22.7%	15.0%	14.7%	25.0%	9.9%	3.0%	100%
Japan	25.0%	22.3%	5.0%	5.0%	3.0%	7.0%	19.7%	10.0%	3.0%	100%
Korea	15.8%	25.0%	11.8%	25.0%	3.6%	4.7%	8.0%	3.0%	3.0%	100%
Malaysia	11.7%	25.0%	3.4%	13.4%	3.3%	NA*	20.0%	15.3%	8.1%	100%
Thailand	14.2%	25.0%	3.0%	19.3%	3.0%	NA*	14.7%	12.8%	8.0%	100%
Singapore	17.9%	10.0%	15.0%	25.0%	3.0%	NA*	12.0%	5.5%	11.6%	100%
Indonesia	13.3%	25.0%	10.4%	12.4%	3.0%	NA*	14.2%	NA*	21.7%	100%
Philippines	15.7%	25.0%	9.6%	12.3%	3.0%	NA*	15.1%	NA*	19.3%	100%

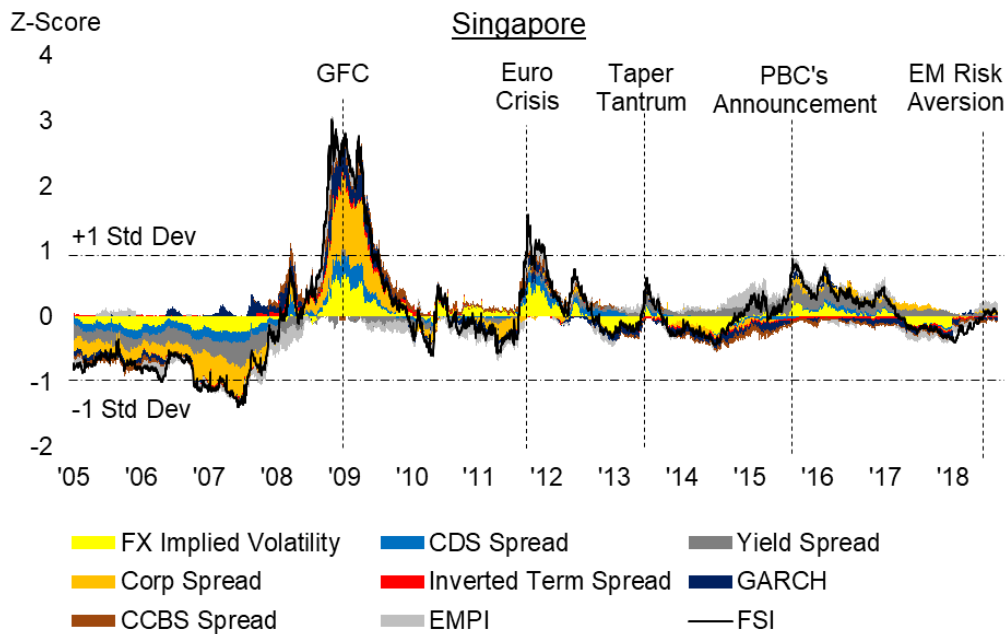
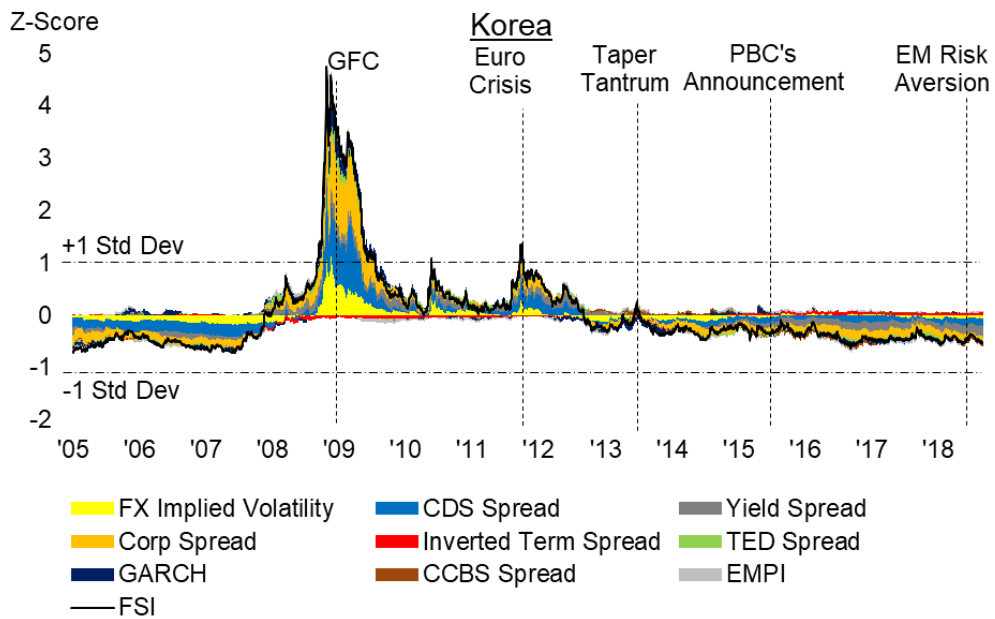
Note: * the weight of variables in dark cells (e.g. Japan FX implied volatility) is not determined by the regression but it is assigned based on our judgement at a later stage. We give the variables in dark cells a high weight of 25 percent, because if we were to include them in the previous PCA analysis, these variables would be the only primary driver of the overall FSI variation for these economies.

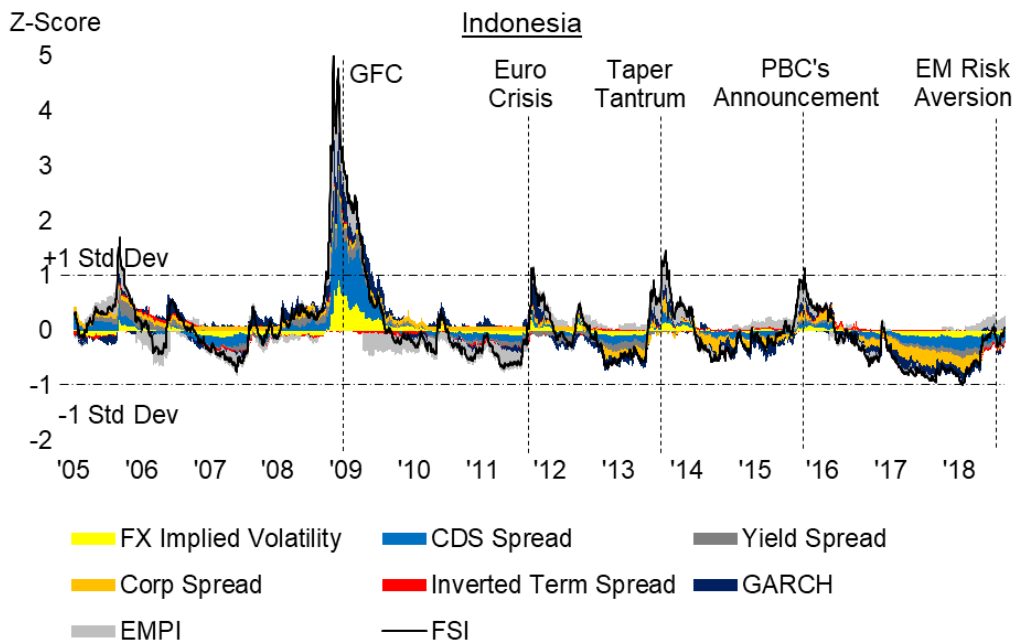
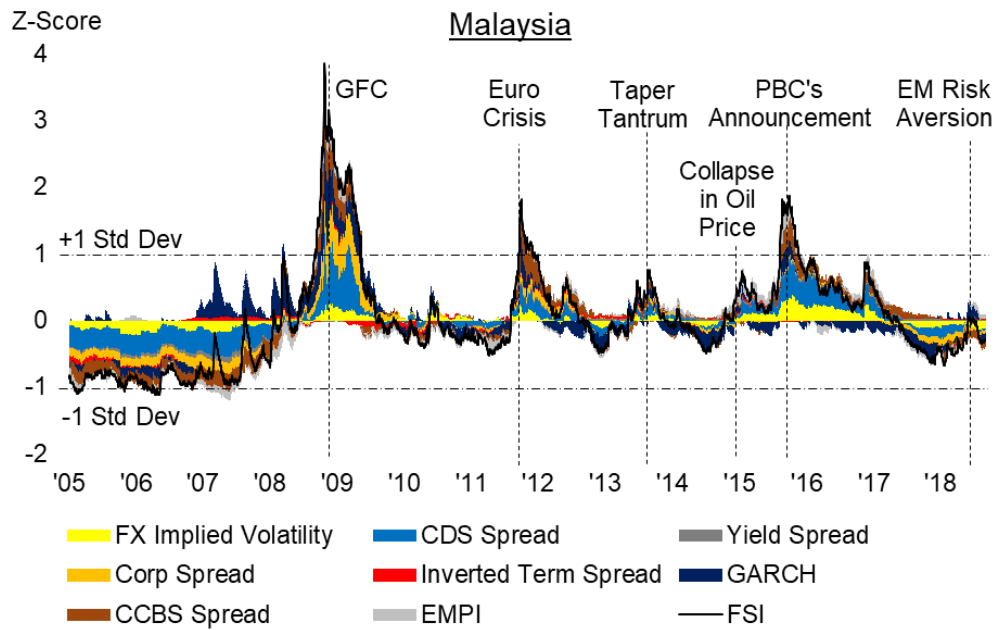
21. The final FSI successfully flags all stress events. As shown in Figure 3, the GFC is an important event for all economies and all indicators contribute to the overall stress level. The Euro crisis is also important for ASEAN economies and Hong Kong. The Taper Tantrum caused stress in a few ASEAN economies, especially Indonesia, and largely due to stress in the FX market. The PBC’s announcement in reformulating USD/RMB pricing mechanism also led to stress in China and ASEAN (excluding Philippines), and the stress was also largely in the FX market.

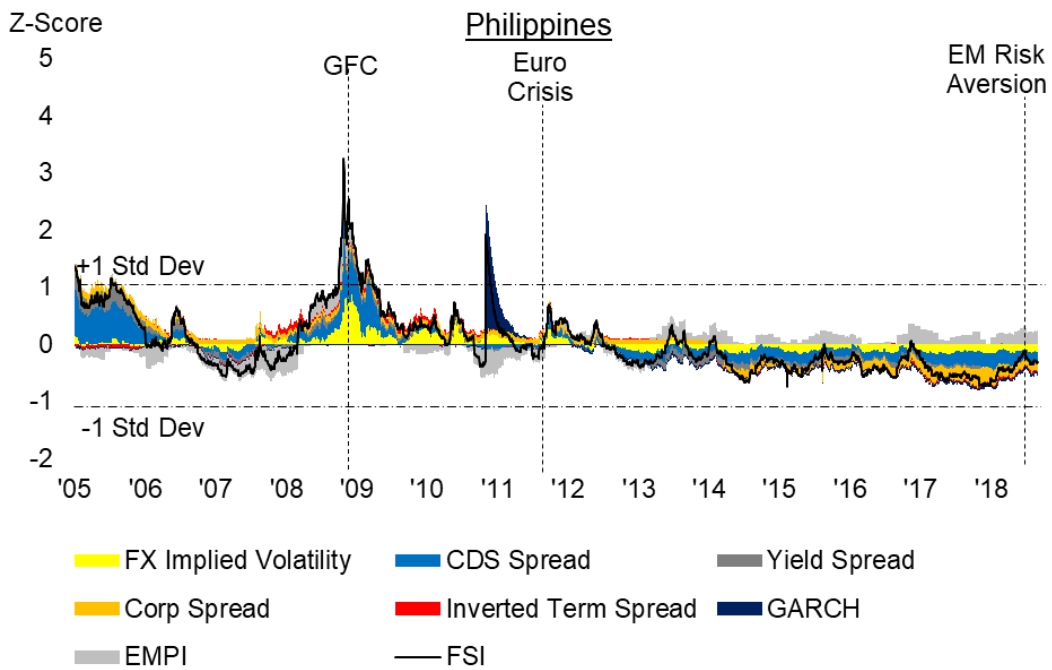
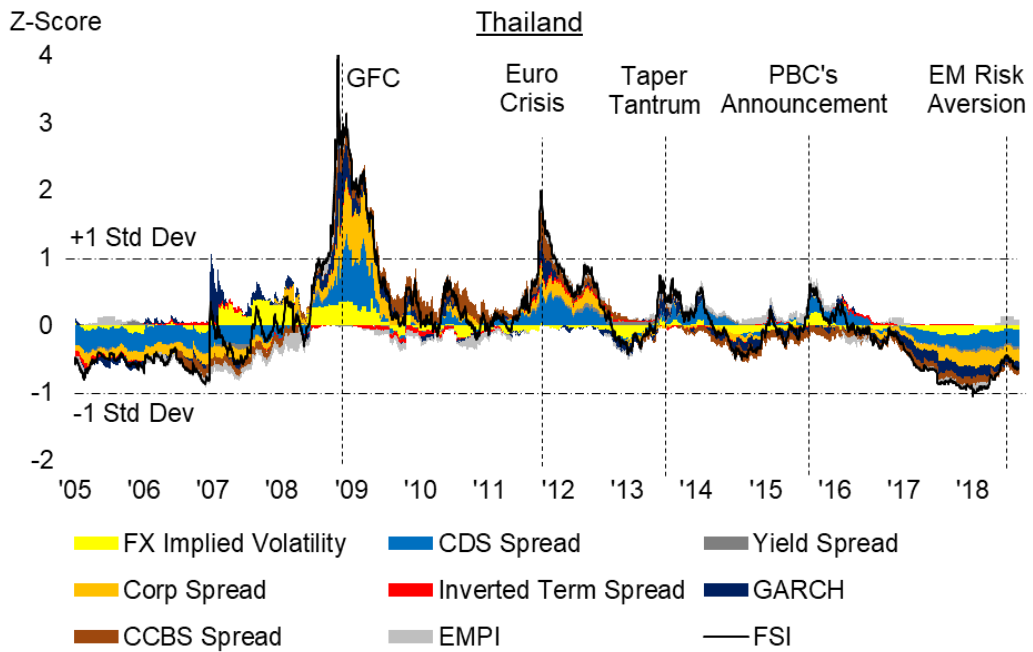
Figure 3. Contribution of Each Explanatory Variable to Country FSI











3.4 Construction of Regional FSI

22. After obtaining the country FSI and its weight of each variable for each economy, we can also construct the regional (or sub-regional) FSI by assigning a weight for each country. In doing so, the weight for each country should reflect its systemic importance in this region. A high weight should be assign to countries with large economy, large financial assets

and trading volumes, a number of systemically important financial institutions and high stock of cross border investments (FDI), especially investments to and from the region.

23. A good starting point is their GDP, but there are some limitations. The most straight forward and simple weighting scheme is using each economy's GDP in current price, as shown in Table 4, Panel A. However, the weights for financial centers (Singapore and Hong Kong) are too small, even though these two financial centers have large stocks of tradable equities, bond, high FX turnovers, and the bank and non-bank financial institutions holding sizable assets. In addition, in Panel A, the weight for Japan in 2005 (53.0 percent) seems very high and likewise for the weight for China (57.2 percent) in 2015. While Japan's GDP is large, its financial markets are mostly domestic and may not have a proportional large impact on the region. Likewise, while China's GDP is also large, its financial market is still in a gradual process of opening up, and its spillover to the region is relatively small except through market sentiments in certain turbulent periods.

24. We thus made adjustments to the GDP weights to construct the regional FSI. We impose a weight of 8 percent for Singapore and Hong Kong, as they are financial centers and their share of FDI and foreign portfolio investment exceeds 10 percent in this region (This will also be shown later). We view that 8 percent is a good balance between their smaller GDP and their importance in the financial market. For the other 7 economies, the weight is allocated according to their GDP^S . When S is equal to 0, all economies have the same weight, and when S=1, they are simply weighted by GDP. We impose that S is equal to 0.497, such that the maximum weight for any economy in any year is not higher than 30 percent¹² (China in 2015). Accordingly, the allocated weights are as shown in Table 4, Panel B. Such simple weight allocation will also help to facilitate regular updating of FSI.

Table 4. Weight for Each Economy
Panel A: By current GDP in USD (Will not be used)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
China	25.5%	29.0%	33.4%	37.5%	39.8%	40.9%	43.9%	46.5%	51.9%	54.4%	57.2%	55.7%
HK	2.0%	2.0%	2.0%	1.8%	1.7%	1.5%	1.4%	1.4%	1.5%	1.5%	1.6%	1.6%
Japan	53.0%	47.7%	42.4%	41.1%	40.7%	38.2%	35.7%	33.7%	27.6%	25.2%	22.8%	24.6%
Korea	10.0%	10.6%	10.6%	8.2%	7.0%	7.3%	7.0%	6.6%	7.0%	7.3%	7.2%	7.0%
Malaysia	1.6%	1.7%	1.8%	1.9%	1.6%	1.7%	1.7%	1.7%	1.7%	1.8%	1.5%	1.5%
Thailand	2.1%	2.3%	2.6%	2.4%	2.2%	2.3%	2.2%	2.2%	2.3%	2.1%	2.1%	2.0%
Singapore	1.4%	1.6%	1.7%	1.6%	1.5%	1.6%	1.6%	1.6%	1.6%	1.6%	1.5%	1.5%
Indonesia	3.2%	3.8%	4.1%	4.2%	4.2%	5.1%	5.2%	5.0%	4.9%	4.6%	4.5%	4.6%
Philippines	1.1%	1.3%	1.4%	1.4%	1.3%	1.3%	1.3%	1.4%	1.5%	1.5%	1.5%	1.5%
Sum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

¹² This "30 percent" cap on weight is imposed arbitrarily. Although China's current GDP is more than 50 percent of all the economies, as the financial market is relatively closed, hence, its impact on the regional financial markets will be less than "50 percent", but perhaps closer to "30 percent".

Panel B: Adjusted, with S=0.497 (Will be used)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
China	20.1%	21.0%	22.3%	23.8%	24.8%	24.9%	25.9%	26.7%	28.2%	29.0%	30.0%	29.6%
HK	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
Japan	28.9%	26.9%	25.1%	24.9%	25.1%	24.1%	23.3%	22.7%	20.6%	19.8%	19.0%	19.7%
Korea	12.6%	12.8%	12.6%	11.2%	10.5%	10.6%	10.4%	10.1%	10.4%	10.7%	10.7%	10.6%
Malaysia	5.1%	5.2%	5.3%	5.4%	5.0%	5.1%	5.2%	5.2%	5.2%	5.3%	5.0%	4.9%
Thailand	5.8%	6.0%	6.3%	6.1%	5.9%	5.9%	5.8%	5.8%	5.9%	5.8%	5.8%	5.7%
Singapore	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
Indonesia	7.2%	7.7%	7.8%	8.0%	8.1%	8.8%	8.9%	8.8%	8.7%	8.5%	8.5%	8.6%
Philippines	4.3%	4.5%	4.6%	4.7%	4.6%	4.5%	4.5%	4.6%	4.8%	4.8%	5.0%	4.9%
Sum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

25. Using investment stock will give financial centers very high weight and low weight for ASEAN-4, therefore, it is only used as a reference. Table 5 shows the degree of financial linkage as measured by the stocks of both FDI and portfolio investments in other regional economies. As of 2015, the weights for financial centers and China seem very high and the weights for ASEAN-4 are very low. Thus, this is used just as a reference. As financial centers are also hubs of regional FDI and portfolio investment, we assign a weight of 8 percent in Table 6, Panel B, for Hong Kong and Singapore, which is far above their shares of GDP.

Table 5. Weight Using Financial Linkage, 2015

USD mil	Reporting Economies									Sum	Weight
	China	HK	Japan	Korea	Malaysia	Thailand	Singapore	Indonesia	Philippines		
China	-	1,339,504	135,590	87,574	4,306	14,173	129,238	7,742	2,343	1,720,471	31%
HK	1,621,339	-	97,668	43,518	17,149	23,535	78,552	4,757	5,300	1,891,818	34%
Japan	179,246	94,841	-	88,787	25,696	75,276	83,337	28,691	2,469	585,946	11%
Korea	78,279	27,916	71,471	-	3,623	4,984	51,332	4,411	3,623	244,485	4%
Malaysia	8,922	12,586	22,756	6,280	-	6,757	81,871	14,036	856	154,064	3%
Thailand	11,504	36,447	59,177	41,95	5,048	-	16,383	1,233	359	134,346	2%
Singapore	214,821	97,507	81,796	63,85	88,891	41,139	-	67,843	10,741	666,562	12%
Indonesia	3,910	2,071	31,863	6,163	15,750	3,167	35,454	-	2,387	100,765	2%
Philippines	3,018	5,893	14,746	3,373	843	1,056	11,713	2,174	-	42,817	1%

Note: Measure of interconnectedness: E.g. Stock of Japan's Outward FDI to Korea (USD32,281 mil) + Stock of Japan's Inward FDI from Korea (USD3,190 mil) + Stock of Japan's Portfolio Assets in Korea (USD25,196 mil) + Stock of Japan's Portfolio Liabilities in Korea (USD 11,804 mil) = USD71,481 mil.

26. Based on the above weights for each economy and each variable, the regional FSI is constructed. Table 6 shows the weights for each economy and each variable in 2016 in this region. We also construct weights for each economy and each variable for ASEAN-4 based on the same proportions of their weights in the whole region. The regional FSI and ASEAN-4 FSI as well as the contributions by economies and by indicators are shown in Figures 4 to 5.

Table 6. Weight for Each Economy and Each variable, 2016.

	FX Implied Volatility	Sovereign CDS	Sovereign Yield Spread with the U.S.	Corporate USD Bond Spread	Inverted Sovereign Term Spread	TED Spread	Equity Market Volatility	CCBS	EMPI	Sum
China	2.4%	7.4%	0.9%	4.1%	4.4%	NA	2.4%	0.9%	7.1%	29.6%
HK	0.3%	0.2%	0.2%	1.8%	1.2%	1.2%	2.0%	0.8%	0.2%	8.0%
Japan	4.9%	4.4%	1.0%	1.0%	0.6%	1.4%	3.9%	2.0%	0.6%	19.7%
Korea	1.7%	2.6%	1.2%	2.6%	0.4%	0.5%	0.8%	0.3%	0.3%	10.6%
Malaysia	0.6%	1.2%	0.2%	0.7%	0.2%	NA	1.0%	0.7%	0.4%	4.9%
Thailand	0.8%	1.4%	0.2%	1.1%	0.2%	NA	0.8%	0.7%	0.5%	5.7%
Singapore	1.4%	0.8%	1.2%	2.0%	0.2%	NA	1.0%	0.4%	0.9%	8.0%
Indonesia	1.1%	2.2%	0.9%	1.1%	0.3%	NA	1.2%	NA	1.9%	8.6%
Philippines	0.8%	1.2%	0.5%	0.6%	0.1%	NA	0.7%	NA	1.0%	4.9%
Sum	14.0%	21.5%	6.3%	15.0%	7.6%	3.1%	13.8%	5.9%	12.8%	100%

Figure 4a. Regional FSI: Contributions by Economies

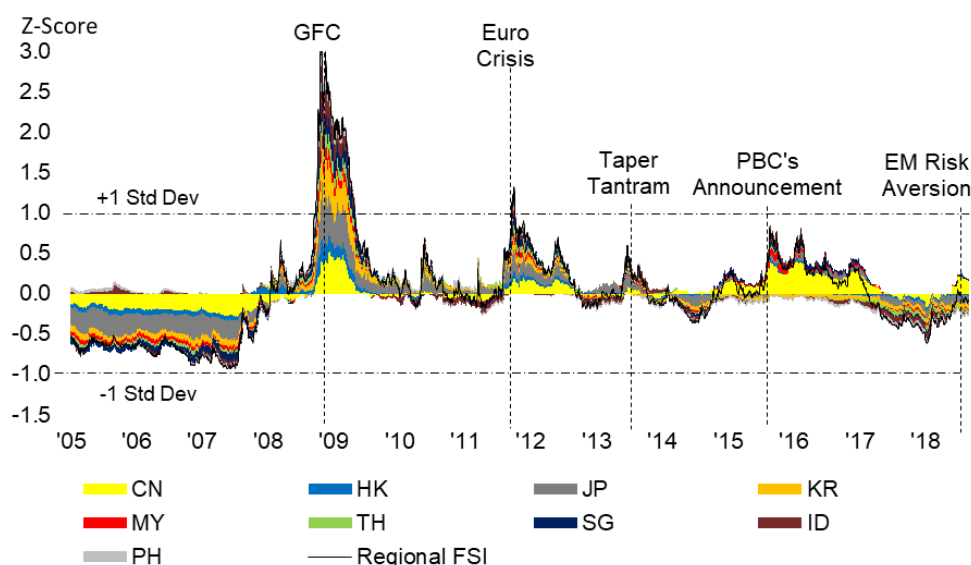


Figure 4b. Regional FSI: Contributions by Markets/Indicators

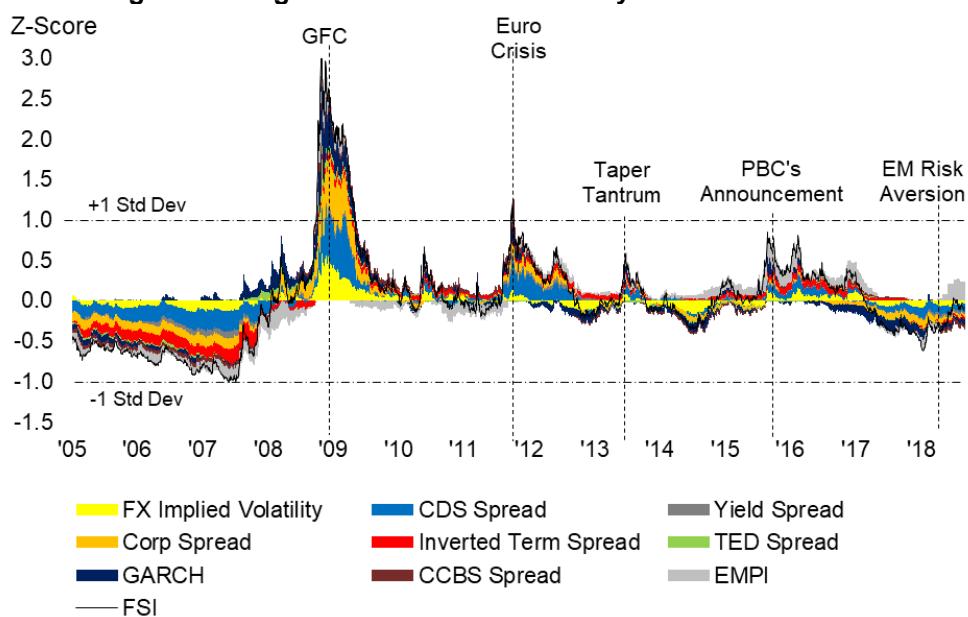


Figure 5a. ASEAN-4 FSI: Contributions by Economies

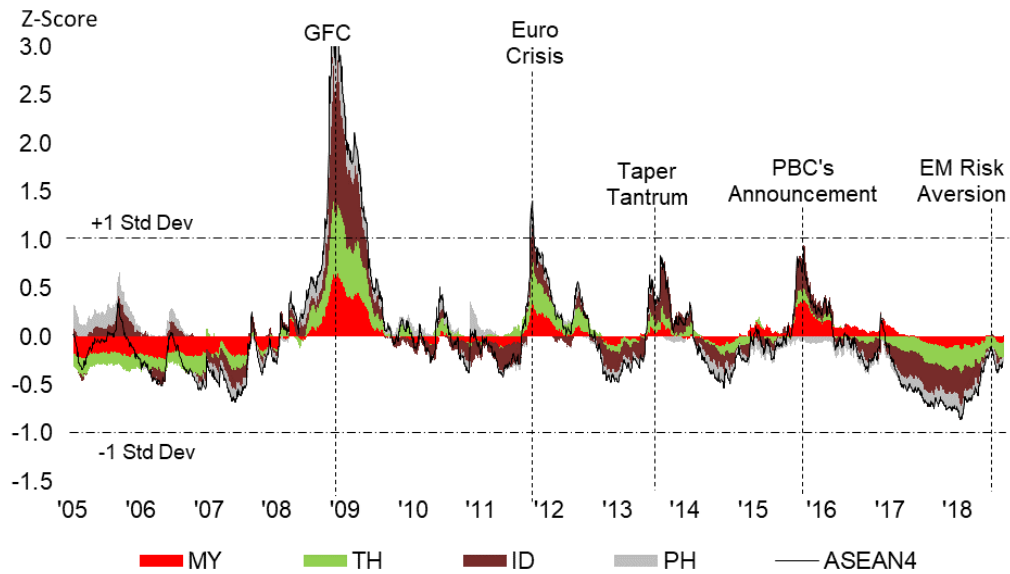
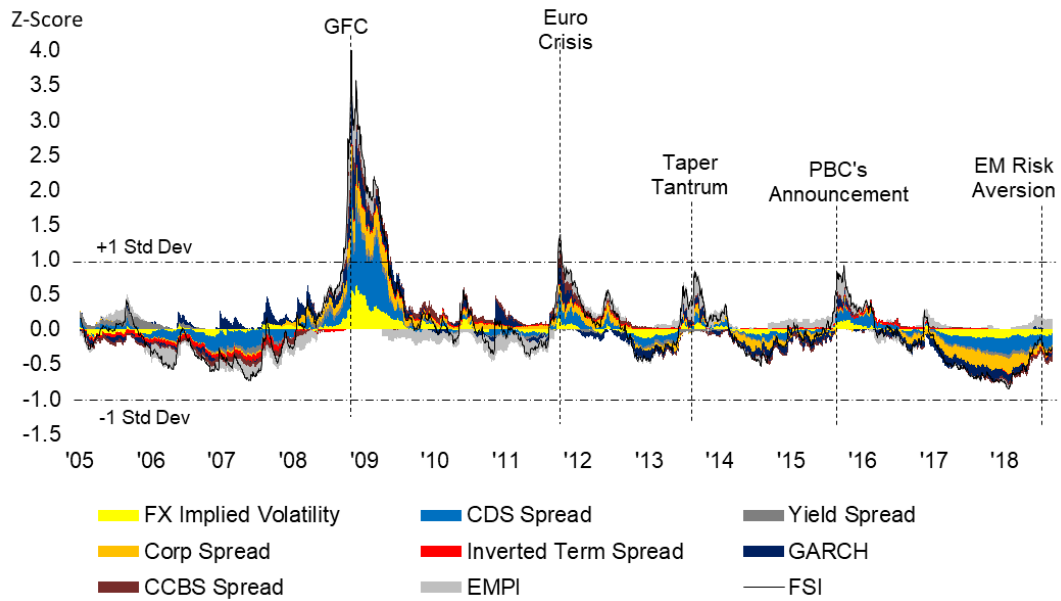


Figure 5b. ASEAN-4 FSI: Contributions by Markets/Indicators



4. Assessing Financial Stress in Regional Economies

27. To recap, FSI can be a helpful tool in quantifying levels of financial stress, as high level of financial strain could impair the normal functioning of the financial system and therefore pose challenges to macroeconomic and financial stability. This section discusses the areas of stress in each individual economy during the stress periods. And since each of the nine FSIs is comparable across time, a comparison of the relative magnitudes of the stress components across different periods of stress can also be made. Furthermore, we can infer how the stress level is differentiated across the region. Identification of financial stress is also useful for further discussion on the major channels through which economic activity is affected by stresses in the financial system.¹³

28. Given the increased global and regional interconnectedness, common global factors (such as rising risk aversion and herding behavior of investors) tend to be transmitted to regional economies quickly, mainly through the confidence channel. It is also acknowledged that the level of financial stress would also depend on country-specific linkages with the global economy, such as the relative degrees of capital market openness and trade exposure to a systemic country. In addition, domestic vulnerabilities and structural characteristics of individual economies could potentially amplify the level of financial stress (Balakrishnan and others, 2009). Although the definition of a critical level of the FSI – the threshold(s) at which financial stress is a serious concern is beyond the scope of the study, policymakers can still gain some insight into the severity of financial stress in recent times by comparing current FSI levels with past levels. The following sub-sections discuss the assessment of financial stress in regional economies based on the results from the preceding section.

4.1 Areas of Financial Stress in the Region

29. The level of financial stress associated with a large external shock such as the GFC was by far the highest in the region post-AFC. The stress readings at the regional level during the GFC exceeded 2 standard deviations from its long run average. During the GFC, stress was evidently driven by rising sovereign CDS spread (with the exceptions of Japan and Hong Kong), widening corporate spread, and increasing FX volatility. The relative significance of these indicators depend on the characteristics of individual economies. For example, our results show that sovereign CDS spread made a relatively greater contribution to rising

¹³ Although FSI on its own does not measure the direct impact on real economic activities, the FSI can be useful in assessing the degree in which economic indicators might be affected by movements in the index.

financial stress for emerging economies in the region such as China, Korea, Indonesia, Thailand, Malaysia and the Philippines. Corporate bond spread contributed significantly to the high stress level for advanced economies such as Japan, Hong Kong and Singapore.

30. During Euro crisis in late 2011 to 2012, stress readings in the region were also significant, surpassing +1-standard deviation from its long run average. The areas of stress were quite similar to the GFC, i.e. rising sovereign CDS spread (in China, Korea, and Thailand) and widening corporate spread (in Japan, Singapore and Hong Kong). In the case of Japan, the March 2011 earthquake led to the soaring sovereign CDS spread on worries over sovereign risks in Japan.

31. Unlike the GFC and the Euro crisis, the U.S. taper tantrum in May 2013 did not translate into severe financial stress in most regional economies. Indonesia saw a relatively higher stress level at slightly below +1 standard deviation, and to a lesser extent, the stress readings increased in the other ASEAN-4 economies and Singapore. The increased stress level in Indonesia was associated with the rising FX pressure as a result of market's concerns about its current account deficit at that time. The terms of trade shock from the collapse in oil prices in mid-2014 affected Malaysia badly.

32. Shocks originating from the region, particularly from China's adjustment of the exchange rate mechanism in August 2015 and subsequent episodes of large capital outflows until early 2017 led to more severe stress than that from the taper tantrum. The impact was significant on Hong Kong, Singapore, Malaysia, Indonesia, and to some extent, Thailand. In this period, financial stress was driven more by EMPI, with diminishing contributions from sovereign CDS, and was partially offset by lower corporate spread and lower stock market volatility. The terms of trade shock, coupled with the uncertainties over the pace of U.S. Fed rate hike (the USD index surged in late 2015 and again in early 2017), also likely contributed to higher EMPI.

33. Since the above periods, the performances of the region's financial markets have become more closely linked to developments in China's financial markets. For instance, regional currencies and stock markets in the region are more sensitive to movements in the RMB and China's stock markets than what direct financial linkages with China would suggest, underscoring the importance of confidence in the transmission of stress in China. However, in recent years, the lower stress levels in Japan and Korea were able to partially offset the stress originating from China.

34. In early 2018, stress indicators have begun to rise, reflecting a confluence of global factors (such as escalation of global trade tensions and U.S. Fed Policy), as well as country-specific vulnerabilities in some EMs outside the region (such as growing macroeconomic imbalances in Argentina and Turkey). Stress indicators such as stock market volatility and EMPI have increased, while sovereign CDS spreads, an indicator of sovereign risk perception have correspondingly widened. Across regional EMs (such as in ASEAN-4), the pressure on EMPI was particularly visible, as currencies have depreciated alongside selling pressures on foreign reserves. The elevated stress in the EMPI continued to be sustained going into Q3 2018. Indonesia and the Philippines are the two major contributors to the higher aggregate stress level in ASEAN-4, partly reflecting the structural vulnerabilities (e.g. widening current account deficits). However, so far, the level of financial stress in the region has not been as high as compared to the level experienced during the August 2015 shock, when China announced changes to its central parity exchange rate mechanism.

4.2 Performance of AMRO's FSI vs. Bloomberg's Asian Financial Conditions Index

35. Bloomberg provides a simple real time, Asia ex Japan Financial Conditions Index (FCI) and it is widely referred to by market participants. While there are many FSIs constructed by various institutions, few are available publicly on a real time basis. Bloomberg FCI tracks the overall level of financial stress in Asia (excluding Japan) money, bond, and equity markets to help assess the availability and cost of credit. In contrast to our FSI, it has fewer indicators. A positive value indicates accommodative financial conditions, while a negative value indicates tighter financial conditions relative to pre-crisis norms.

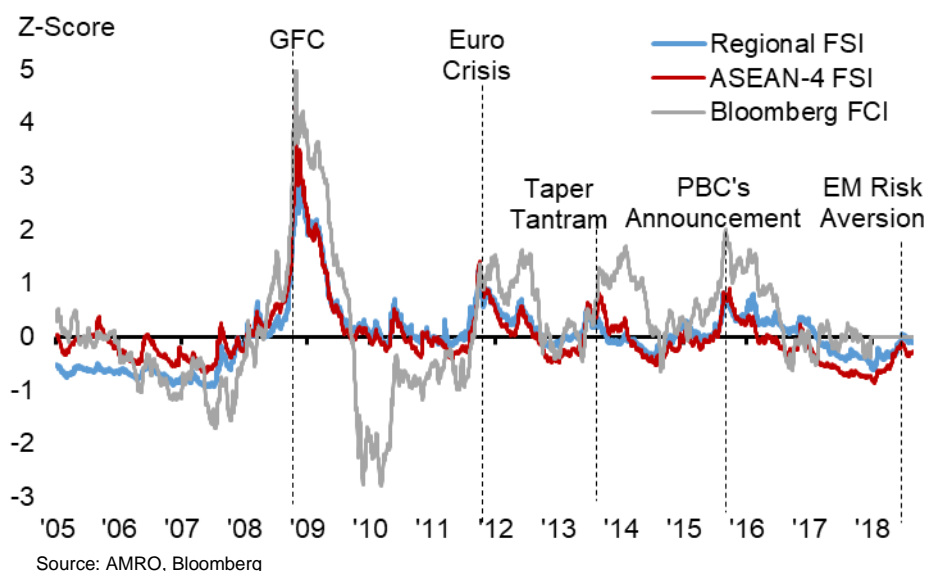
Table 7. Components and Weights of Indicator of Bloomberg FCI

	Start Date	Weight	
Money Market			
Singapore Libor/OIS Spread	11/7/2001	1.9%	
India Mibor/OIS Spread	4/19/2000	1.9%	
Hong Kong Libor/OIS Spread	8/8/2001	1.9%	
China Real 3-Mo Chibor Rate	9/22/1997	5.6%	
			11.1%
Bond Market			
JP Morgan EMBI + Asia Sovereign Spread Index (yoy %)	12/30/1998	11.1%	
China CDS Rate	1/24/2003	5.6%	
Korea CDS Rate	2/28/2002	5.6%	
			11.1%
Equity Market			
MSCI ASIA Index (yoy %)	12/24/1996	33.3%	
			33.3%
Capital Flow Proxy			
Asian Carry Trade (yoy %)	9/13/1995	33.3%	
			33.3%
Total			100%

Source: Bloomberg

36. A comparison with Bloomberg’s Financial Conditions Index for Asia ex-Japan with AMRO’s FSI (Figure 6) shows that they tend to be quite similar and were both able to capture the major stress periods well (GFC, Euro crisis, taper tantrum, 2015 China shock, and more recently, EM risk aversion). It is noted that Bloomberg’s Financial Conditions Index’s components include one or two indicators for each markets (e.g. equity and bond markets), and from a narrower list of countries (see Appendix III). In contrast, AMRO’s FSI captures the indicators from all markets across all economies, and therefore, able to better explain the contribution of each indicator (or by economy) to the region’s stress level. In addition, a comparison with MAS’ FSI for selected Asian economies (MAS, 2017) also showed broadly similar results capturing major stress periods, including the recent EM risk aversion episode.

Figure 6. Comparison of Bloomberg’s Financial Conditions Index vs. AMRO’s Regional FSI



4.3 Contributions and Some Caveats

37. This study has made the following contributions to macroeconomic and financial surveillance in the ASEAN+3 region and the work on FSI. First, we have developed a financial stress index that is able to monitor financial stress on a real time basis for surveillance purposes and for policy making. Second, our set of indicators is comprehensive and represents what market participants use to gauge stress in different areas of financial markets. Third, our approach attempts to strike a good balance between empirically-driven method and judgement in assigning the weights of different indicators for the FSI of each economy and takes into country-specific factors in assigning weights to different economies for the regional FSI. Fourth, our methodology also allows us to clearly show the contribution of each indicator to the stress level.

38. Notwithstanding the above contributions, there are some caveats that need to be borne in mind when interpreting the FSI:

- As the FSI of each economy reflects both common and country-specific factors, understanding of the conditions underlying each indicator is important to help interpret both regional and individual economy's FSIs.
- The estimated least square coefficients in this study are not time varying. Some studies considered time-varying parameters and find the results broadly consistent with approaches whose parameters are fixed. MAS (2017) considered a Time-Varying Parameter Factor-Augmented Vector Auto Regressive (TVP-FAVAR) model, and found that the results were broadly consistent with a PCA approach with fixed factor loadings. We view that our method with fixed parameter would be sufficient to capture financial stress and the parameters can be re-estimated from time to time, such as every few years, to incorporate new developments.
- As the mean and standard deviation of each regional economies' FSI could be different from one another, comparison of the FSIs across all nine economies in terms of the magnitude of stress cannot be done in a straightforward manner by considering the levels.

5. Conclusion and Potential Future works

39. To conclude, we use both statistical methods as well as desk economists' judgement to construct an FSI that is easy to understand and convenient to update on a real time basis. After studying various approaches and indicators, we select 9 indicators (8 indicators for emerging economies) from 5 sectors to capture financial stress in each economy. To derive the weight for each factor, we first use the traditional PCA analysis. The weights are then further derived by employing constrained regression, with constraints that take into account the expert views of our desk economists. Finally, we aggregate each economy's FSI by considering GDP size and financial linkages to obtain regional FSI and ASEAN-4 FSI.

40. The FSI will be used as a routine surveillance tool for monitoring financial stability in the region. As this study uses high-frequency (daily) data, it can be used to facilitate real-time decision making. Policymakers and AMRO will thus be able to assess rapidly evolving financial conditions in a more timely manner. However, in doing so, policy makers shall also keep in mind that high-frequency data tend to be volatile and may also yield some false signals (Kliesen, Owyang and Vermann, 2012).

41. Studies to explore the drivers behind rising financial stress and to examine spillover within the region and between different regions can be further conducted. As FSIs for regional economies have been constructed, a panel regression can be employed to investigate external and domestic factors behind rising financial stress in regional economies. As our methodology shows, contributions by different indicators to the stress level and common factors behind rising stress in different economies can be further studied. In addition, spillover among regional economies, can also be further examined. There are also some established FSIs for developed economies and other emerging market regions (e.g., Park and Mercado, 2013). Therefore, it will be useful to study the interactions between FSIs in different regions to better understand spillovers among them. These potential research works should further benefit policy making at the domestic, regional as well as the global levels.

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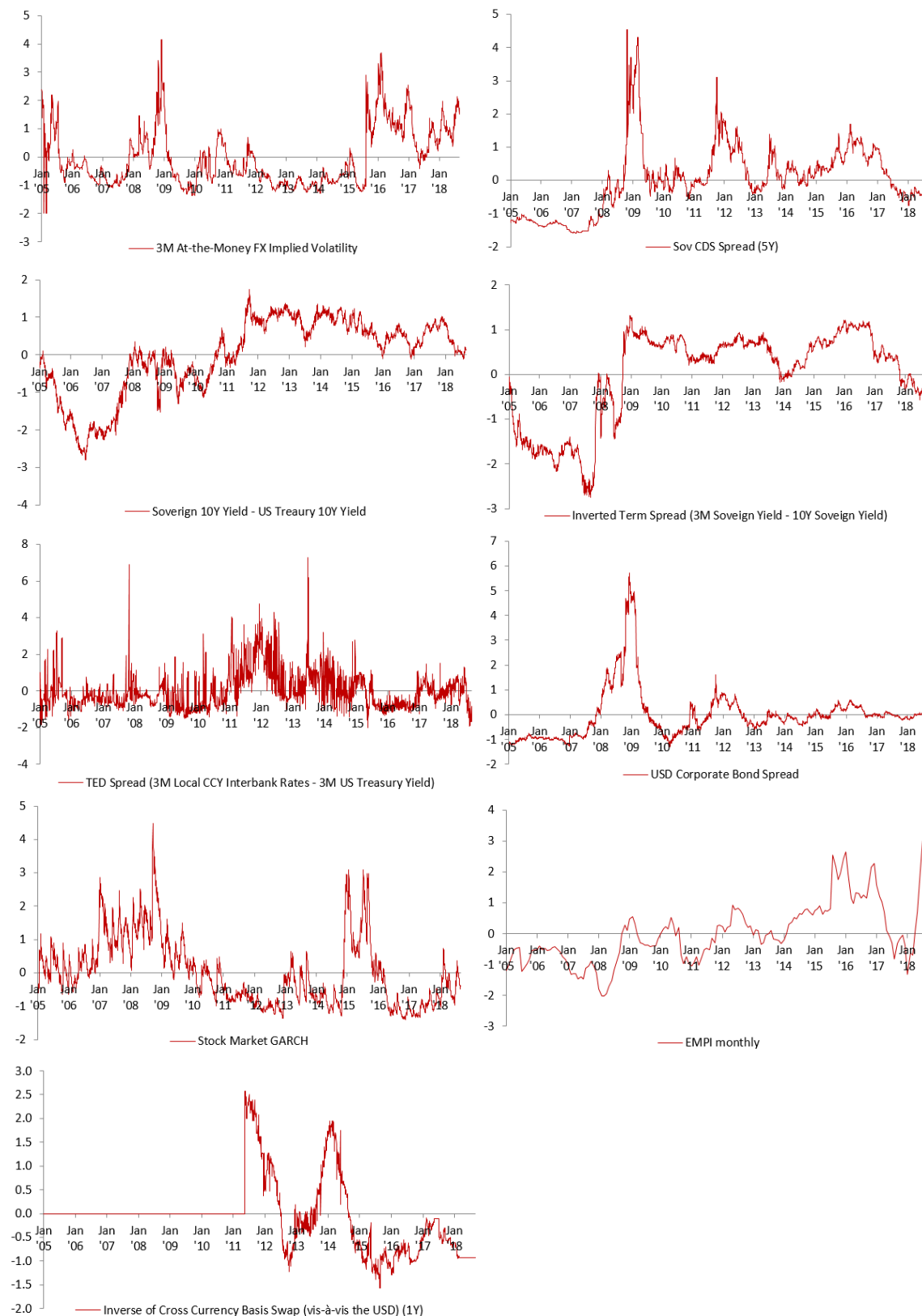
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Appendix I: Summary of Variables Used in Other Studies

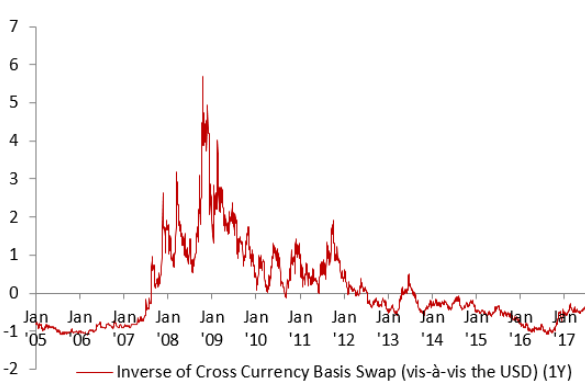
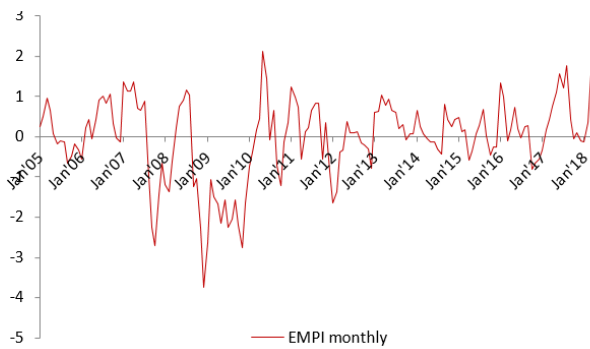
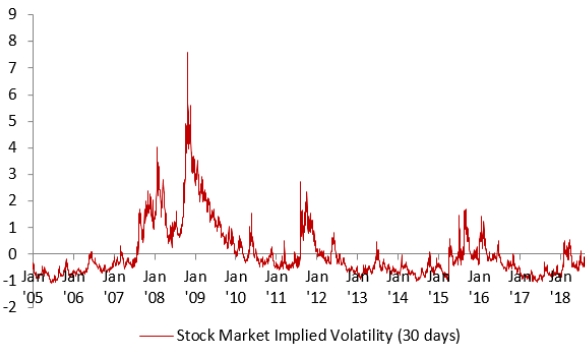
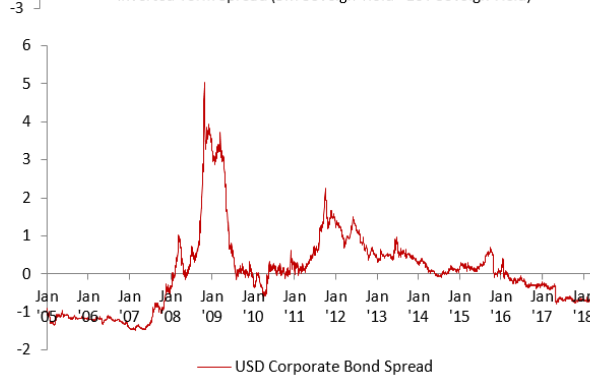
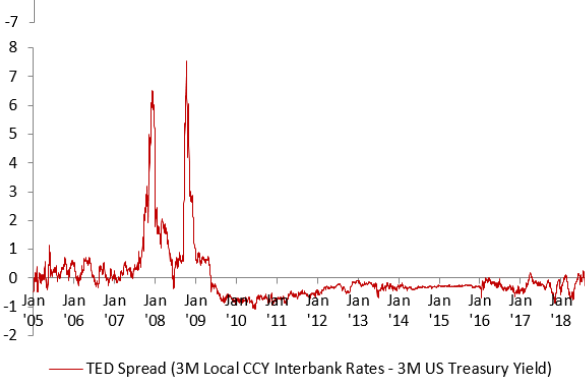
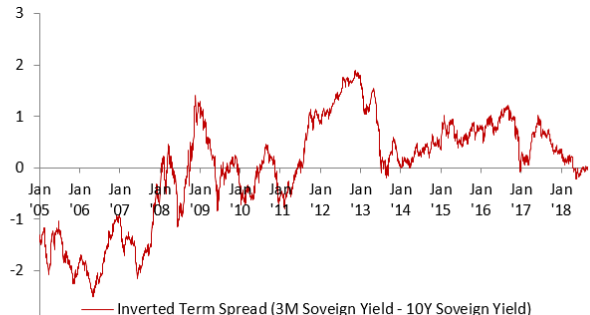
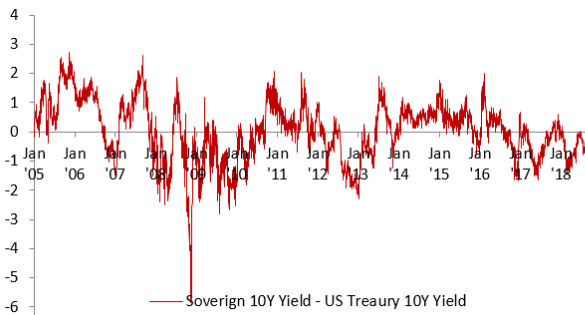
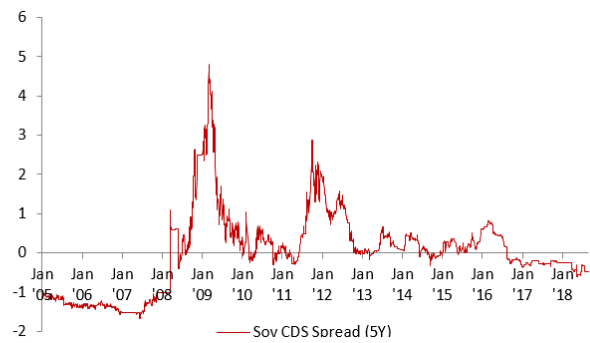
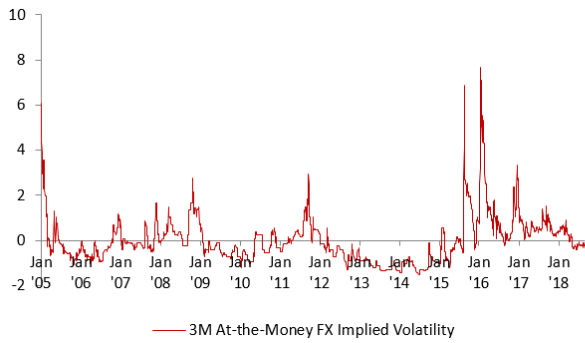
Sector	Variables	Illing and Liu (2006)	Hakkio and Keeton (2009)	Cardarelli et. al (2009)	Balakrishnan et. al (2009)	Park and Mercado (2013)
Banking Sector	TED spread		✓	✓		
	Rolling banking/financial sector beta			✓	✓	✓
	Volatility of bank stock prices		✓			
	Dispersion of bank stock returns		✓			
	Slope of the yield curve	✓		✓		
	2-year swap spread		✓			
	Off-the-run/on-the-run Treasury spread		✓			
	AAA/10-year Treasury spread		✓			
Debt Market	Baa/AAA spread		✓			
	High yield bond/Baa spread		✓			
	Consumer ABS/5-year Treasury spread		✓			
	Sovereign debt spread (yield differentials between long-term (10-year) local government bonds and U.S. Treasuries)				✓	✓
	Corporate bond spread	✓		✓		
	Commercial paper/T-bill spread	✓				
	Bid-ask spread on 90-day Government of Canada Treasury bills	✓				
	Covered interest differential with the U.S.	✓				
Equity Market	Stock market returns			✓	✓	
	Volatility of stock prices/returns	✓	✓	✓	✓	✓
	Correlation between stock and Treasury returns		✓			
Foreign Exchange Market	Exchange rate volatility			✓		
	Exchange market pressure index				✓	✓

Appendix II: Indicators of Financial Stress (Individual Economies)

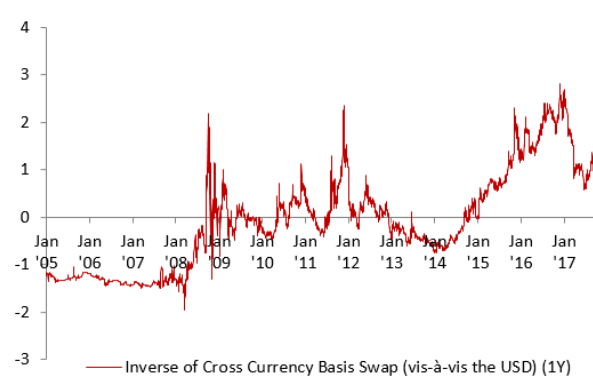
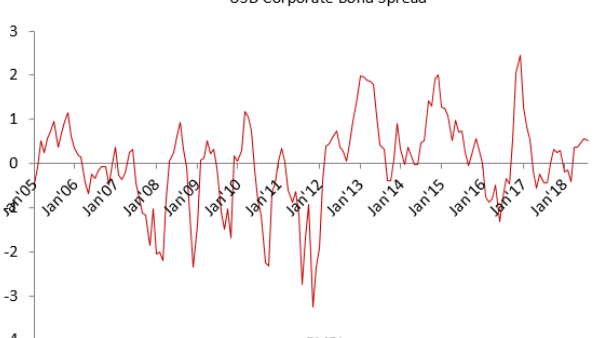
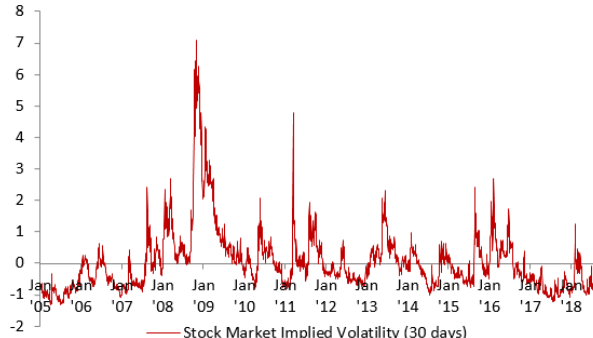
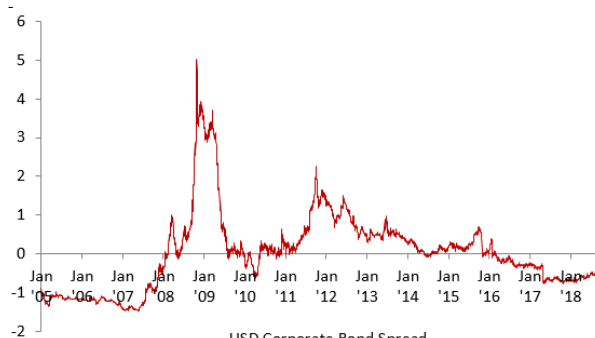
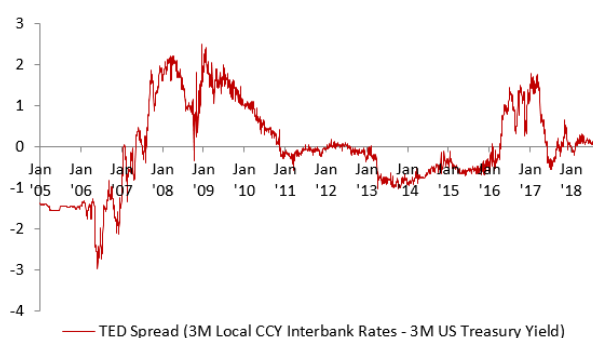
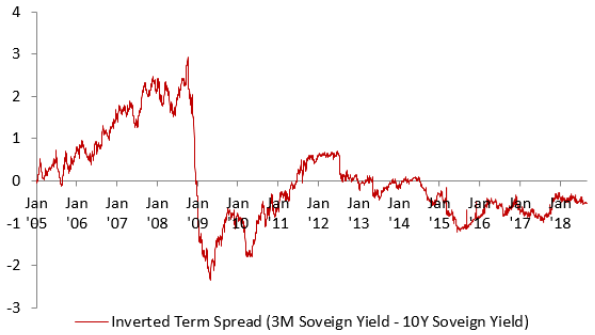
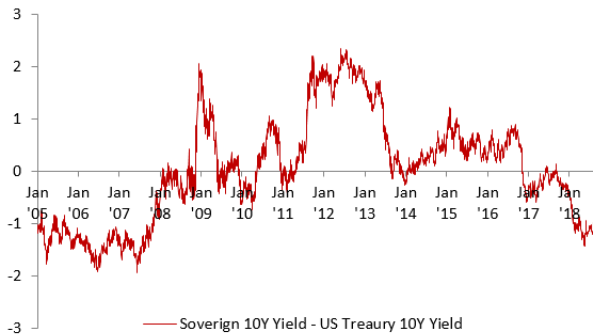
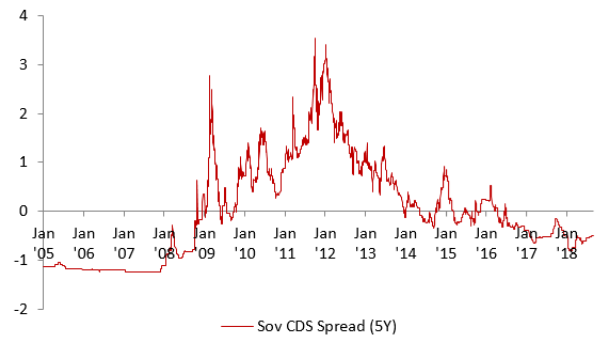
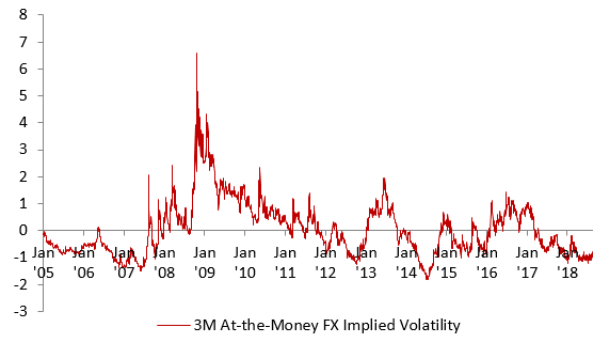
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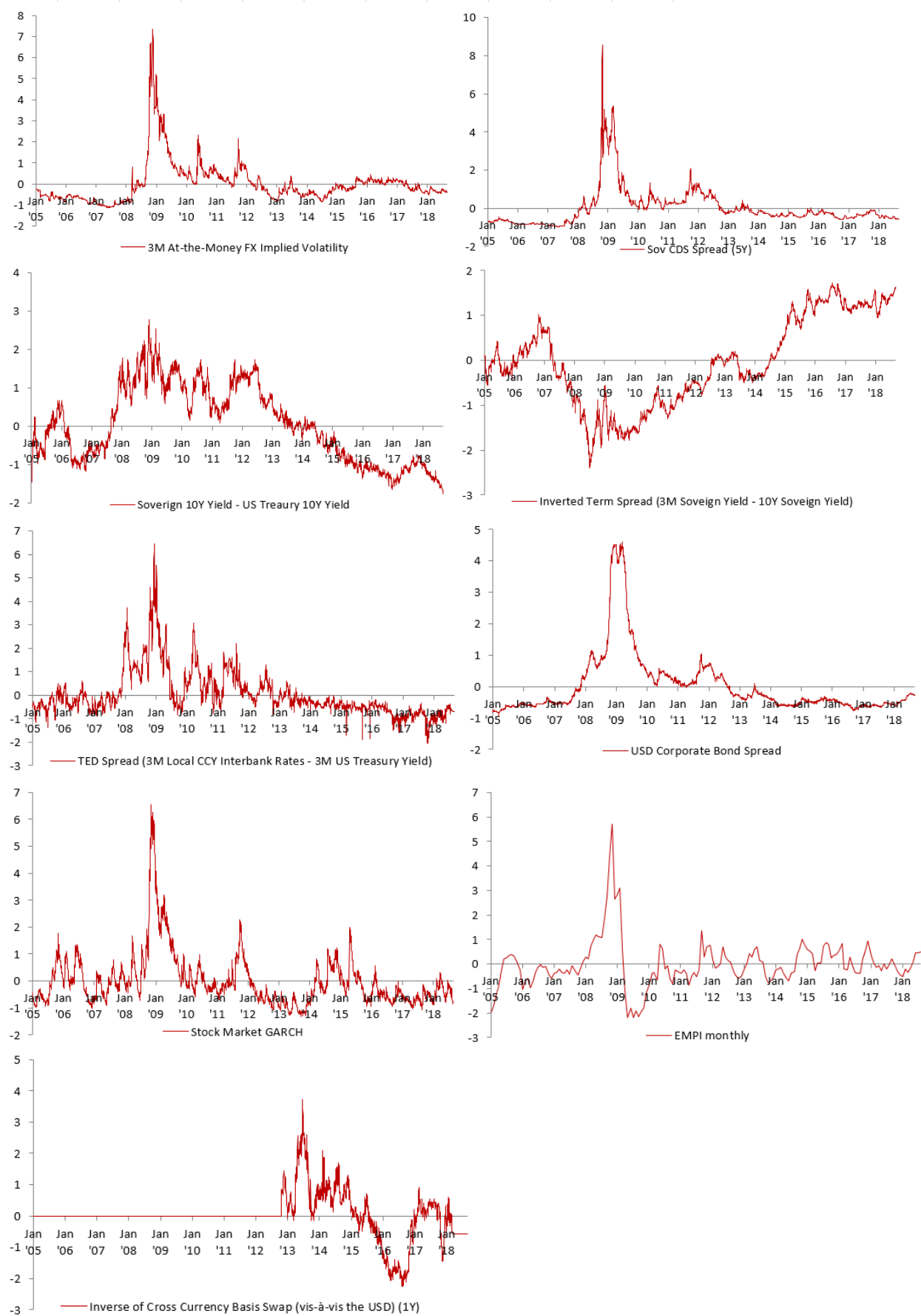
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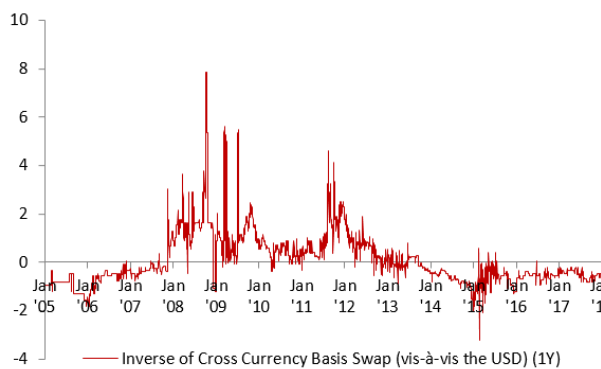
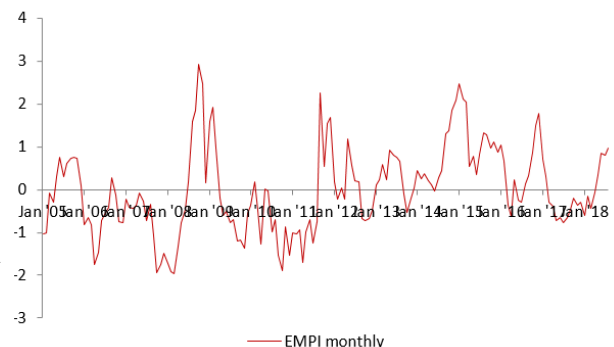
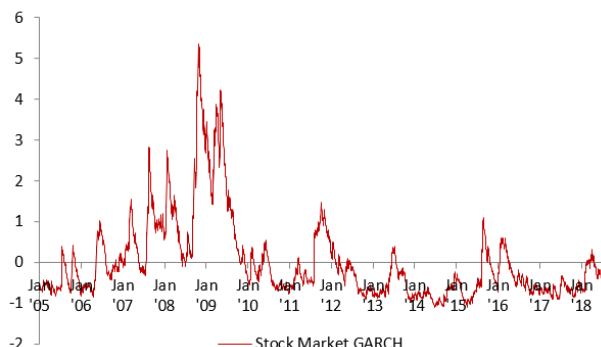
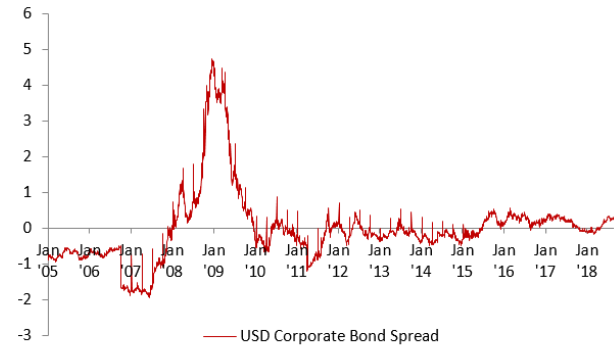
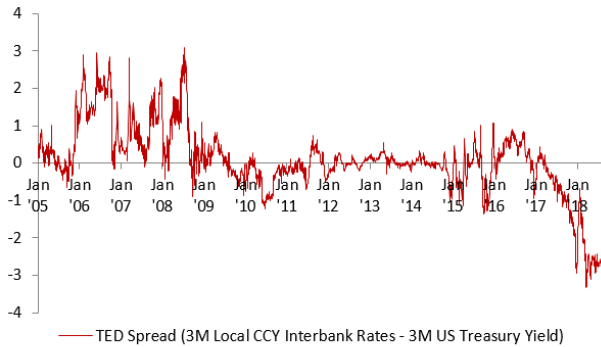
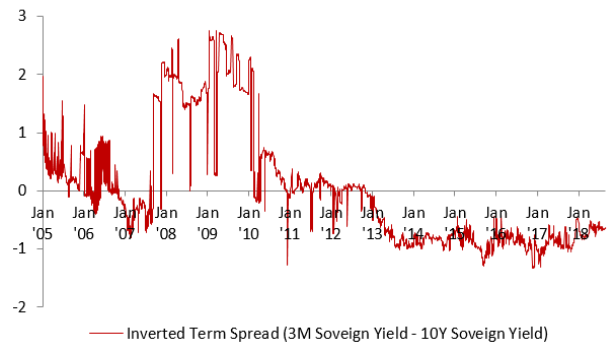
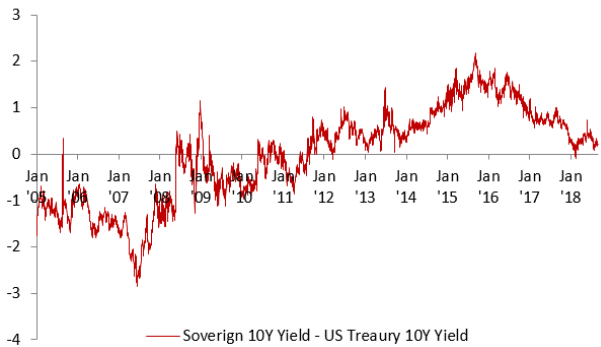
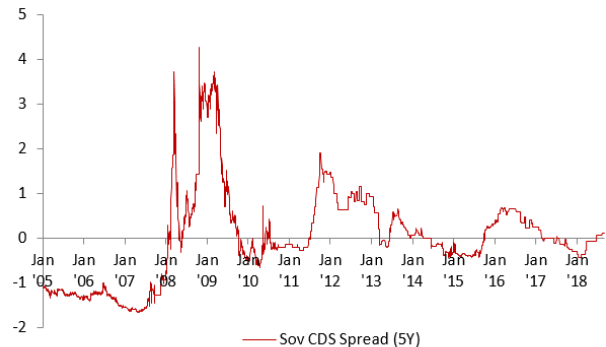
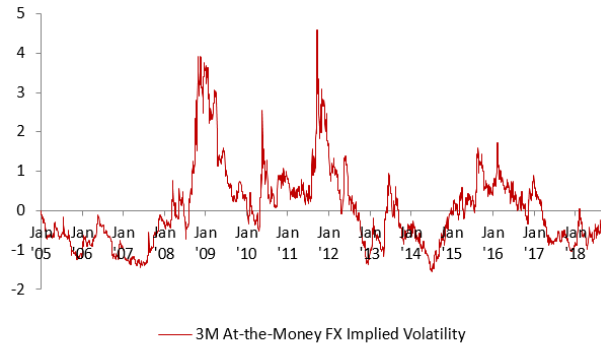
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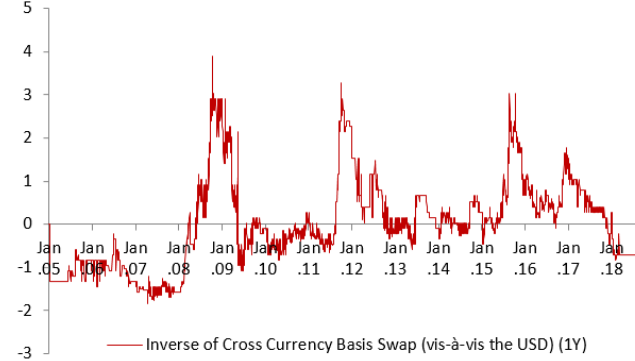
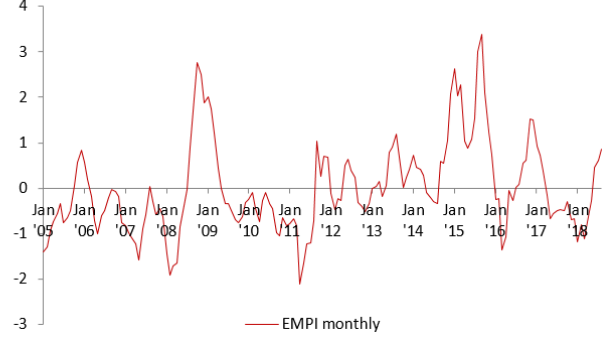
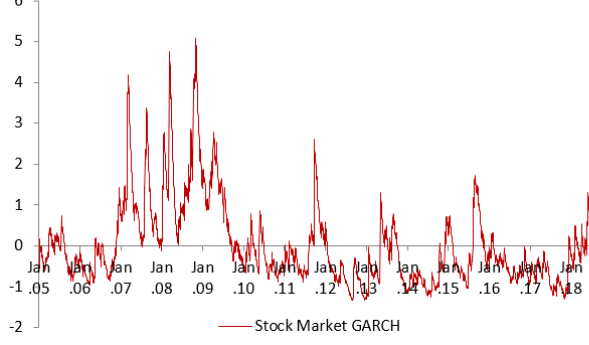
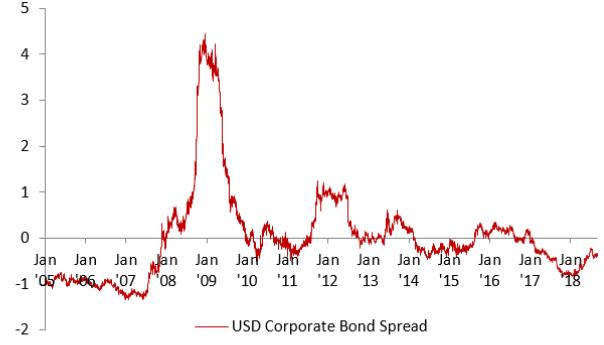
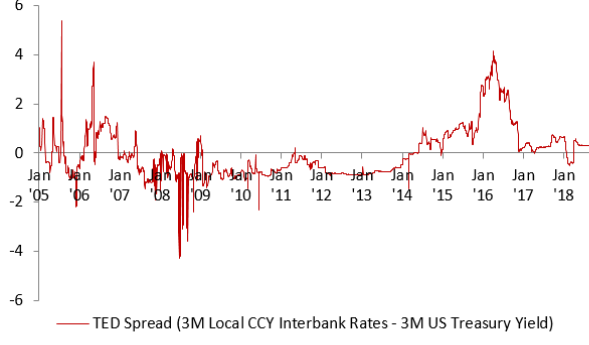
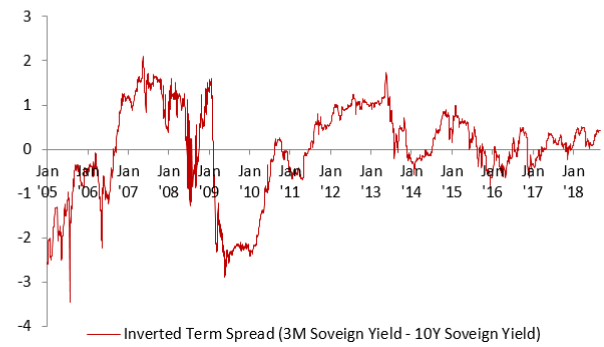
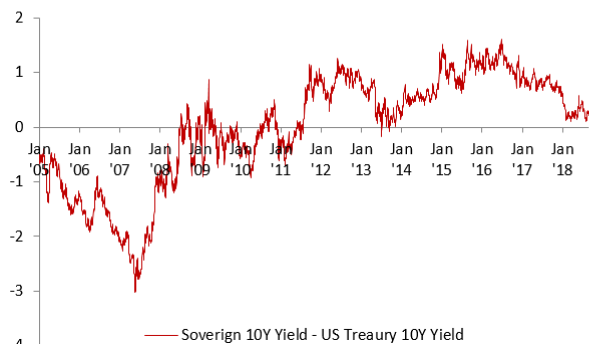
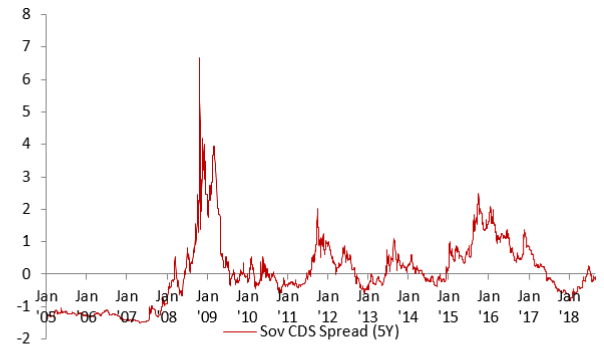
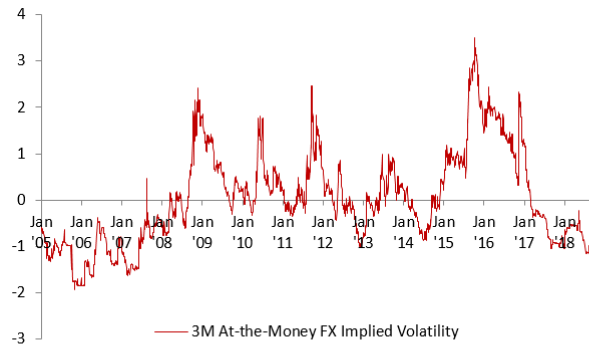
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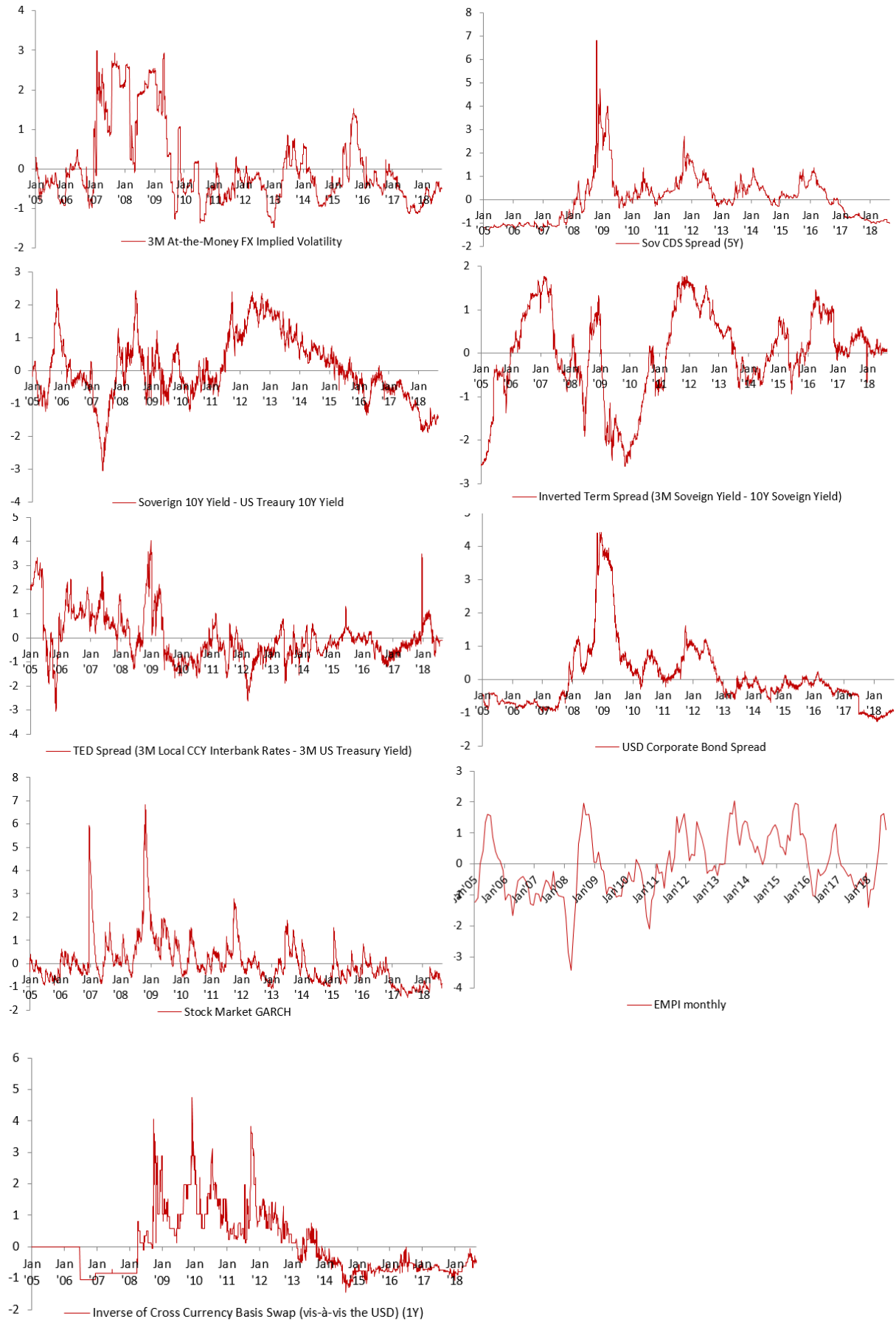
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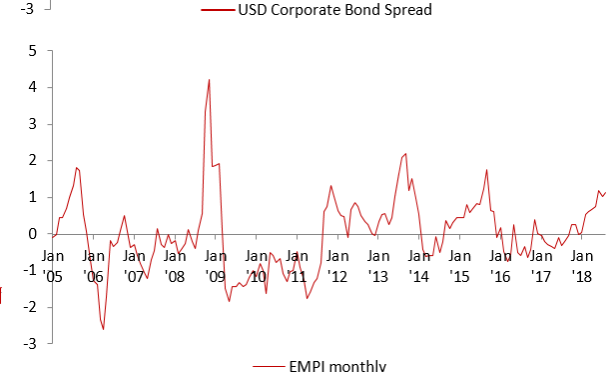
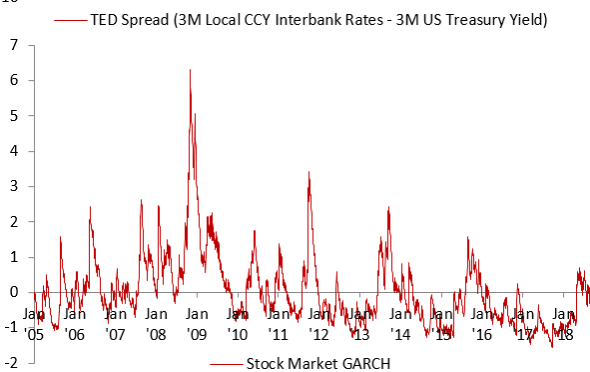
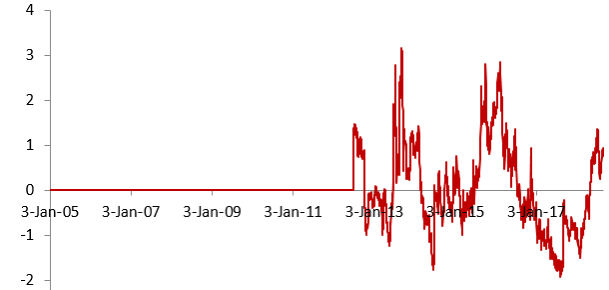
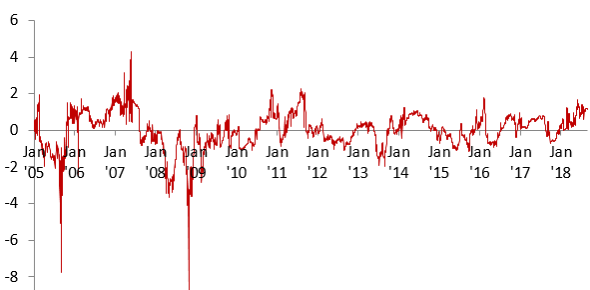
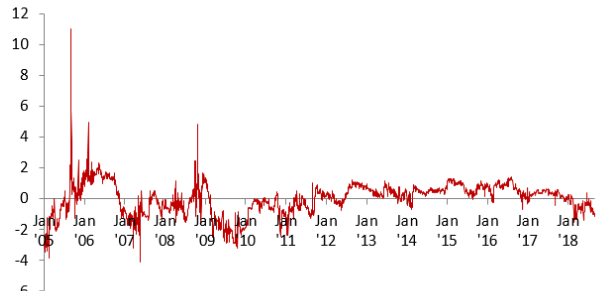
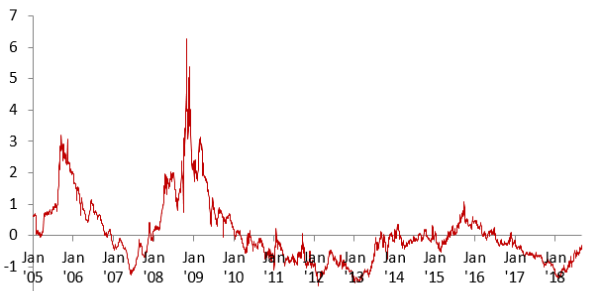
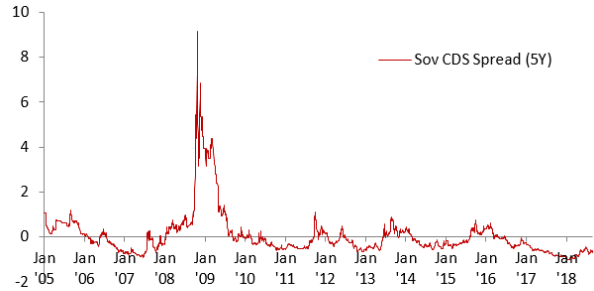
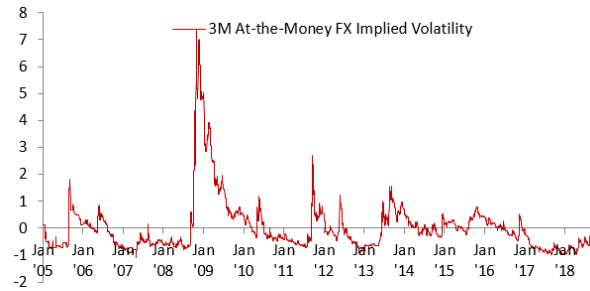
6. Malaysia



7. Thailand



8. Indonesia



9. Philippines

