



Faculty of Economics and Business

**Financial Vulnerability Indicator in Malaysia:
Construct and Forecasting Ability**

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Financial Vulnerability Indicator in Malaysia:
Construct and Forecasting Ability

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DECLARATION

I hereby declare that this research entitled “Financial Vulnerability Indicator in Malaysia: Construct and Forecasting Ability” is to the best of the author’s knowledge that of the author except where due reference is made. This thesis has not been accepted for any degree and is not concurrently submitted in candidature for any degree.

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ABSTRACT

This study attempts to investigate the fluctuations of the Malaysian financial market through predicting the early signals of financial market vulnerability using the Financial Vulnerability Indicator (FVI) constructed through the signalling approach and the dynamic approximate factor model (DAFM), using monthly data spanning from 1997 to 2017. The indicators were constructed from macroeconomic, financial and property market data, which comprises of imports, the real GDP, exports, M2, total reserves, the share price, loans and advances, the consumer price index, housing approvals and the real effective exchange rate. The empirical results from the FVI based on the signals approach proposed by Kaminsky and Reinhart (1996) and Kaminsky and Reinhart (1999) suggested that weak exports, a decline in housing approvals, an overvaluation of the exchange rate and an economic slowdown are the common triggers of the occurrence of a financial crisis in Malaysia. For the FVI constructed through the DAFM, following Banbura and Modugno (2010, 2014) and van Roye (2014), the empirical findings indicated that imports, the real GDP and exports contained good predictive ability in gauging financial vulnerabilities. Both indicators highlighted the importance of internal and external macroeconomic environments in defining the financial vulnerability of an economy. In the evaluation of forecasting performance, the FVI constructed through the DAFM contained better predictive power, reflected by a lower noise-to-signal ratio. The feedback and amplification of the effects of financial vulnerabilities on the real sector were explored through the MSBVAR, methodology proposed by Sims et al. (2008). The outcome revealed that financial vulnerability shock brought about significant negative effects on industrial production and inflation while producing significant positive effects on the short-

term interest rate, KLIBOR, in a high-vulnerability regime. This highlighted the prominence of the nonlinearities during a high vulnerability period and this is consistent with studies on other economies. To conclude, this study highlighted the usefulness of composite indicators as an early warning mechanism to gauge vulnerabilities in the financial system from a macroeconomic perspective through a non-parametric and model-based indicator construction methodology while recognising the feedback effects of the real sector during periods of high vulnerability. Hence, policymakers and stakeholders in the financial market may improvise financial vulnerability indicators as early signalling mechanisms to foretell the developments in the financial market.

Keywords: Financial vulnerability, financial crises, signals approach, dynamic model.

Petunjuk Kerentanan Kewangan di Malaysia: Pembinaan dan Keupayaan Peramalan

ABSTRAK

Tujuan kajian ini dilaksanakan untuk mengkaji turun naik pasaran kewangan di Malaysia dengan ramalan isyarat awal kelemahan dalam pasaran kewangan melalui Petunjuk Kerentanan Kewangan (FVI) yang dibina melalui pendekatan isyarat dan model faktor anggaran dinamik (DAFM), merangkumi 1997 hingga 2017 dengan menggunakan data bulanan. Petunjuk ini dibina daripada data pasaran makroekonomi, kewangan dan harta tanah, yang terdiri daripada import, KDNK sebenar, eksport, M2, jumlah rizab, harga saham, pinjaman dan pendahuluan, indeks harga pengguna, kelulusan perumahan dan kadar tukaran efektif sebenar. Keputusan empirikal dari FVI berdasarkan pendekatan isyarat yang dicadangkan oleh Kaminsky dan Reinhart (1996) dan Kaminsky dan Reinhart (1999) mencadangkan bahawa eksport yang lemah, penurunan kelulusan perumahan, kelebihan nilai tukar dan kelembapan ekonomi sebagai pemicu yang sering terjadi dalam krisis kewangan di Malaysia. Bagi FVI yang dibina melalui DAFM berikut Banbura dan Modugno (2010, 2014) dan van Roye (2014), penemuan empirikal menunjukkan bahawa import, KDNK sebenar dan eksport mengandungi keupayaan ramalan yang baik dalam mengukur kerentanan kewangan. Kedua-dua petunjuk ini menyerlahkan kepentingan persekitaran makroekonomi dalaman dan luaran dalam menentukan kerentanan kewangan dalam sesebuah ekonomi. Dalam penilaian prestasi ramalan, FVI yang dibina melalui DAFM mengandungi kuasa ramalan yang lebih baik, yang ditunjukkan oleh nisbah bunyi-kepada-isyarat yang lebih rendah. Maklum balas dan penguatan kesan kerentanan kewangan pada sektor sebenar diteroka melalui MSBVAR, metodologi yang dicadangkan

oleh Sims et al. (2008). Hasilnya mendedahkan bahawa kejutan kerentanan kewangan membawa kesan negatif yang besar terhadap pengeluaran perindustrian dan inflasi di samping menghasilkan kesan positif yang besar terhadap kadar faedah jangka pendek KLIBOR dalam rejim kerentanan tinggi. Ini menonjolkan kepentingan fenomena tidak linear semasa tempoh kerentanan yang tinggi dan kajian ini adalah konsisten dengan kajian bagi ekonomi lain. Sebagai simpulan, kajian ini menonjolkan kegunaan petunjuk komposit sebagai mekanisme amaran awal dalam mengukur kerentanan dalam sistem kewangan dari perspektif makroekonomi melalui metodologi pembinaan petunjuk yang tidak berparameter dan berasaskan model sambil mengiktiraf kesan maklum balas sektor sebenar dalam tempoh kerentanan yang tinggi. Oleh itu, para pembuat dasar dan pihak berkepentingan di pasaran kewangan boleh menjadikan petunjuk kerentanan kewangan sebagai mekanisme penandaan awal untuk meramalkan perkembangan dalam pasaran kewangan.

Kata kunci: Kerentanan kewangan, krisis kewangan, pendekatan isyarat, modal dinamik.

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LIST OF ABBREVIATIONS

BNM	Bank Negara Malaysia
CGDP	Credit-to-Gross Domestic Product Ratio
CPI	Consumer Price Index
DAFM	Dynamic Approximate Factor Model
EX	Exports
FDI	Foreign Direct Investment
FVI	Financial Vulnerability Indicator
GDP	Gross Domestic Product
GNP	Gross National Product
HA	Housing Approvals
IM	Imports
IMF	International Monetary Fund
IT	Information Technology
KLSE	Kuala Lumpur Stock Exchange
LA	Loan and Advances
MHPI	Malaysian House Price Index
MSBVAR	Markov Switching Bayesian Vector Autoregressive
NEP	New Economic Policy
NTS	Noise-to-Signal Ratio
OPR	Overnight Policy Rate
REER	Real Effective Exchange Rate
RGDP	Real Gross Domestic Product
RPGT	Real Property Gain Tax
SP	Share Prices
TR	Total Reserve
UK	United Kingdom
US	United States

CHAPTER 1

INTRODUCTION

1.1 Introduction

Recent experiences in the global property market, caused by the 2008-2009's Subprime Mortgage Crisis in the US, bear witness to increasing financial distress that in some way triggers the outbreak of a financial crisis. Manifestly, the recent Subprime Mortgage Crisis highlighted how a wavering property market, an upsurge in credit risk and rising asset prices could ultimately translate into financial instability. As with most economies, the property market in Malaysia could have an important impact on financial stability, for example China's high leverage on property has raised concerns about its instability to the financial system, as Malaysian financial institutions withstand coverage of the domestic property market at RM733.4 billion, amounting to 25.7% of total financial assets in 2015. The magnitude of the booms and busts in the property market carry significant implications for the demand for credit by households and their debt serving capability, particularly, in situations where economic conditions are still tough for many and severely unaffordable property prices are likely to place a further strain on homeowners. In turn, this brings about higher loan default and massive property overhang. In the event of excessive debt accumulation by households and property developers, a sharp downward adjustment in house prices or a sudden slump in the economic fundamentals are both likely to disorder the balance sheets of banking institutions, resulting in the collapse of the financial market as experienced in the Subprime Mortgage Crisis.

For many years, policymakers and academics alike have discovered that the property market and financial stability are inextricably linked (Zhu, 2005). The impact of the property market's interaction on credit spreads and bank solvencies have long been recognised as an important impetus to financial stability. Many economies have witnessed multiple episodes of a rapid upsurge in property prices that essentially mount financial stress. Among others, the Subprime Mortgage Crisis, popularly known as the 'mortgage mess' or 'mortgage meltdown' has evolved to offer valuable insights into the relationship between the property market and financial stability. It should be noted that the shock wave that emanated from the Asian Financial Crisis also warned of the tenacity of credit booms in the wake of huge private financial imprudence and household indebtedness, and the episode provided a salutary lesson to most developing Asian economies in the subsequent decade. In many respects, the painful lessons learnt over the past decade have evoked the boom-bust cycles of the property market as a mechanism for financial distress because the credit expansion in the aftermath of the real estate booms played a significant role in the run-up to past crises. In this regard, previous financial incidents have certainly increased the level of interest in the issues of financial stability since the current property market is underpinned by a wide demand-supply gap along with soaring property prices.

Since the occurrence of the Global Financial Crisis of 2008-2009, interest in early warning indicators has renewed, such indicators aim to assist in financial crisis forecasting by monitoring key variables. The G20 group of economies requested the International Monetary Fund (IMF) to conduct new early warning practices at the climax of the Global Financial Crisis in November 2008. In addition to that, the IMF was again requested as a result of the London Summit in April 2009 "to provide early warning of macroeconomic

and financial risks and the actions needed to address them.” These requests highlighted how vital leading indicators are in terms of predicting a country’s vulnerability to crises where previous episodes of financial crises would be useful in foretelling the future financial and economic outlook. Therefore, the construction of the financial vulnerability indicator (FVI) is essential for forecasting and determining the vulnerability of the financial market in a specific country and to avoid any detrimental circumstances that can be foreseen.

1.2 Malaysian Economy and Financial Market

Fluctuations in the financial and the real sector are closely intertwined where financial and credit conditions are the essential drivers of the economy. Moreover, financial and credit conditions are among the most significant contributors to the propagation of economic shocks. The severity of the Global Financial Crisis underlined that the financial sector has turned out to be inherently procyclical, capable of amplifying macroeconomic volatilities and business cycle fluctuations. During the periods of contraction of the business cycle, profitability falls as asset prices decline, credit conditions weaken, loan defaults upswing, and credit provision is tightened, infuriating the downturn. These pointed out the significance of the linkages and feedback that characterise the interaction between financial markets, the credit market, the property sector, and the real economy.

Similarly, fluctuations in the Malaysian financial and the real sector are closely intertwined and associated. The Malaysian financial sector is inherently procyclical,

correlated with the movements and performance of the economy. Since the country's independence in 1957 through to 1970, development in Malaysia was driven by the market forces. Economic growth in Malaysia accelerated in moderation, recording an annual rate of 6 percent in the 1960s (Khan, 2002). This economic acceleration relied heavily on the export of a narrow range of primary commodities and government revenue was mainly generated through taxes on these commodities, namely, rubber, tin and palm oil, from Malaya and timber from the Borneo Territories. Although export earnings from tin and rubber affected the money supply, a prudent monetary policy maintained the commodity prices.

Since independence, Malaysia experienced its first economic boom due to high production and the value of its exported commodities in the international market between 1963 and 1964. Increasing demand from foreign manufacturing sectors, specifically, Japan and the United Kingdom (UK), ensured stable earnings from the exported supplies in the following years. Despite the stable export earnings, Malaysia still suffered from an over-reliance on export earnings as a source of funds as alternative sources of funds had not been strongly implemented.

Since the economic booming, commodity prices stabilised until an ethnic riot happened in May 1969 which left the Malaysian economy in uncertainty until 1971. Following the ethnic chaos in 1969, the government's approach to development shifted radically in Malaysia and the New Economic Policy (NEP) was formulated at that time. The implementation of the NEP was intended to eradicate poverty and restructure the economic imbalances in Malaysian society. The NEP was introduced in the Second

Malaysia Plan (1971-1975) and designed to achieve the national objective of unity. The promulgation of the Second Malaysia Plan triggered an economic recovery in which a second boom occurred. Stoked up by the stability of commodity prices, urban migration and incremental enhancements in the purchasing power of the middle class, the public, finance and even business sectors expanded rapidly during this period. In 1971-1973, the government introduced a home ownership scheme for civil servants coupled with subsidised housing mortgages. These actions stimulated the confidence of property developers and owners throughout the country, who then commenced extensive housing developments.

After 1973, the property market in Malaysia continued to accelerate before a short recessionary spell in 1973 resulting from the spiralling of oil prices globally. The oil crisis happened at a time when Malaysia was at the start of a rapid economic expansion. The surge in oil prices and the consequent recession, especially in industrialised countries, affected Malaysia's exports, which fell tremendously due to sluggish world demand. At the same time, the country also 'virtually' brought in inflation due to its imports reliance. As a result, the sluggish growth stunted the country's economic development during 1973-1975. Growth in the gross national product (GNP) in 1974 of 8.4 percent fell to 2.2 percent in 1975 (Okposin & Cheng, 2000). Furthermore, by 1974, inflation had become a critical issue as oil prices outstripped the increases from other commodities while food prices nearly tripled compared with their level in the past three years.

Thereafter, property prices continued on an upward trend, which was attributed to the increased cost of labour and building materials. Several factors in the property market,

such as an overall supply shortage, a speculative market, favourable economic environments giving rise to effective borrowing and the acceptance of property as a medium of investment, contributed to the rising property prices. Strong growth in the construction industry between 1981 and 1983 was sustained mainly by the public sector's expansion programmes in physical infrastructure and major policy transformations. The government's policy on foreign direct investment (FDI) from the 1970s led to the existence of more free-trade zones. There was also a rapid development of oil installations and a continuing strong demand for housing. This led to the third boom in 1980-1983 where the average annual growth in the construction industry was 12.6 percent.

In the early 1980s, the economic recession in developed countries triggered by the United States' high-interest rate policy resulted in an immense collapse in the international commodity trade. Most of the new industries at that time who were in the early phases of production suffered due to the economic collapse. Malaysia's overall export price index waned by 30 percent and reflected a sharp decline in tin and palm oil prices between 1984 and 1986 (Athukorala, 2010). The unsustainable macroeconomic imbalance was mirrored by a sharp contraction in the economy where the growth rate registered negatively by 1 percent in 1985. On the business sector, corporate bankruptcies rose due to weak aggregate demand and the downturn also triggered a severe banking crisis, causing the non-performing loan ratio of commercial banks to hit 30 percent in 1987 and 1988.

To overcome the impact of the commodity crisis, the government undertook measures, which included the rationalisation of public development expenditure to increase growth in private investment, lightness in credit availability, higher costs of mortgage loans

and a provisional suspension on housing loans for public sector employees. The government stimulated private sector investment in low-cost housing and the revival of abandoned housing projects during the recession to further stimulate the economy and revitalise the construction industry. Following the amendments to the Investment Coordination Act and National Land Code in 1986, there was an influx of foreign investments in commercial and residential buildings. The economic recovery that followed was helped by an enhanced external sector and the adjustment efforts commenced by the government. These resulted in amplified investments and a recovery in construction demand as Malaysia benefitted from the foreign relocation of manufacturing bases by export-oriented firms in Japan, South Korea, Taiwan and Hong Kong during the late 1980s.

The early 1990s saw an ample amassing of outstanding domestic credit in the banking system, with heavy exposure to the property sector due to booming property prices between 1991 and 1996. This amplified exposure to the property market further deteriorated the banks' financial positions as this lending led to a property oversupply in the country, reflected with a peak in the credit-to-GDP ratio of 167.2 percent in the last quarter of 1997 (Refer to Figure 1.1). In July 1997, the Thai currency depreciated sharply, causing an abrupt withdrawal of short-term capital out of the country. Vulnerable to speculative attack, this transmitted a wave of uncertainty and volatility in the foreign exchange and equity market, where it caused a dramatic fall in the exchange rate of the ringgit and pushed a sharp rise in interest rates. The Kuala Lumpur Stock Exchange (KLSE) index declined drastically from 1216 points in January 1997 to only 302 points in August 1998 (Nambiar, 2003).

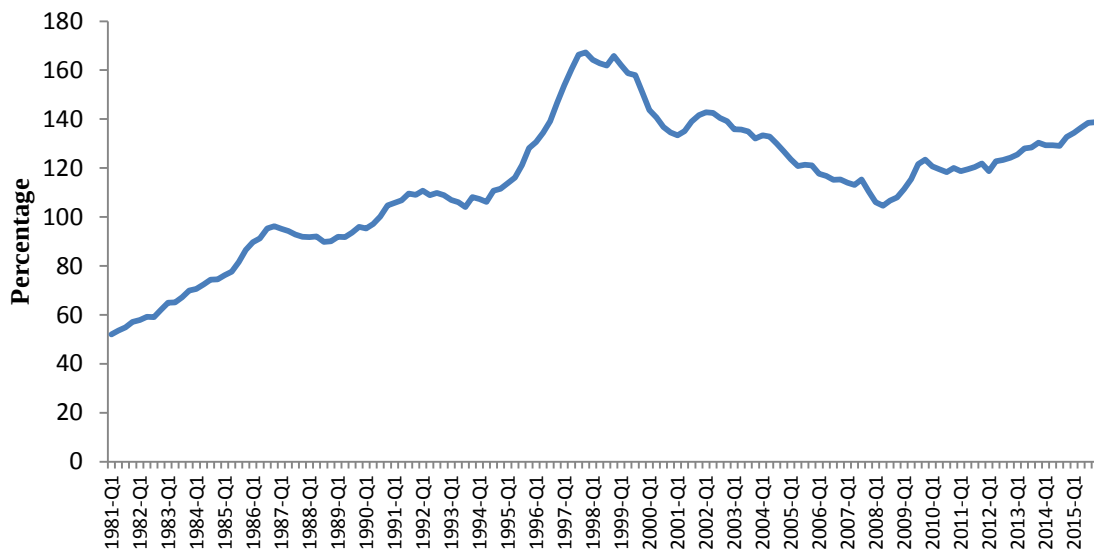


Figure 1.1: Credit-to-GDP Ratio for Malaysia, 1981-2015
(Bank of International Settlements, various issues)

As the rapid pulling out of short-term capital occurred, this led to a delay in major investment plans and risk accumulation in many businesses based on bankruptcies and non-performing loans. The downturn in the economy caused share and other asset prices to plunge severely, particularly, property prices due to the over-exposure of the property sector, driven by the speculative demand since the early 1990s. The breakdown in the financial sector impacted the real sector. By August 1998, the economy was in recession with shrinkage in output of 2.8 percent and 6.8 percent, respectively, in the first and second quarter (Athukorala, 2010). The unemployment and inflation rates increased tremendously, reaching 3.9 percent in 1998 and 6.3 percent in June 1998, respectively.

The combined effect of the economic collapse, property market crash and financial market breakdown was an enormous escalation in non-performing loans in the banking system. The Asian Financial Crisis was closely related to the vulnerabilities of short-term capital flows into the country's economy and the abnormal activities of currency traders. In

September 1998, an exchange control measure was implemented and the financial sector was restructured extensively. As a result of the government's further economic recovery measures, official government statistics showed that construction growth had increased by the end of 1999. The implementation of privatised projects and the expansion of government fiscal expenditure, particularly on infrastructure and residential developments, further supported the progression of the industry.

In the midst of recovering from the Asian Financial Crisis, the economy and particularly the stock market in the United States (US) were booming. During the dot-com boom, especially after 1996, the stock prices of Internet-based companies in the US shot up at a very fast pace. The dot-com boom resulted in the NASDAQ composite index increasing from about 600 points in 1996 to a peak of 5046.86 points during the year 2000. On March 13, 2000, the NASDAQ composite index dropped from 5038 points to 4879 points, which triggered a huge sell-off of information technology (IT) stocks. The NASDAQ stock index continued to plunge and the dot-com bubble in the US economy burst in 2001. As a result, interest rates were cut repeatedly to prevent any further meltdown while technology professionals were smashed with high unemployment.

The bursting of the dot-com bubble in the US triggered sell-off in the Malaysian financial market as well where the stock market index fell nearly 45 percent between February 2000 and April 2001. As Malaysia was one of the Asian economies that engaged in subordinate activities for dot-com companies in the US, the manufacturing sector was affected the most due to the low demand for electronic products following the bursting of the dot-com bubble, especially from the export markets of Europe and Japan. As a result, a

huge number of workers involved in manufacturing were suddenly out of work which caused Malaysia's unemployment rate to shoot up. Eventually, these affected the Malaysian economy adversely where the real gross domestic product (GDP) growth negated with 1.2 percent in the third quarter of 2001. To enhance the Malaysian property market and other economic conditions, policy measures were introduced in Budget 2001 which included the lowering of the ceiling rate of the ad-valorem stamp duty on property transfers, increasing housing mortgage eligibility for public servants and encouraging the acquisition of second homes. Moreover, a fiscal stimulus package of RM3 billion in March 2001 and another of RM4.3 million in September 2001 were also executed to instigate private spending and to boost economic development.

Commencing in 2003, the demand for crude oil began to increase as Asian economies recovered from the Asian Financial Crisis and the bursting of the dot-com bubble in the US in late 2001. Furthermore, global oil production was struggling to accommodate the rapidly growing demand for oil from China and the US. From 2003 to 2005, China alone accounted for nearly 35 percent of global crude oil demand. In 2004, crude oil prices began to increase and even doubled from the price level in 2003. Due to continued worldwide economic progression, the global crude oil demand grew and the crude oil price rose above US\$70 per barrel in 2006.

Even as an oil-exporting country, Malaysia still imports oil from other countries. Although revenue from the export of crude oil was profitable for Malaysia, the spike in oil prices pressured the overall price to a significantly higher level in the nation, which in turn brought about adverse effect to the economy. In 2003-2005, the impact of the oil price

hikes negated the development in the Malaysian construction sector, averaging at only 1.5 percent in growth rate. Moreover, the rising oil prices also pushed up the costs of raw materials for other economic sectors where the producer price index rose from 71.45 in the second quarter of 2003 to 81.44 in the same period of 2005 besides setting inflationary pressure on consumers. As a result, the demand for property declined and the number of property sales fell from 293,212 units in 2004 to only 276,508 units in the following year.

In view of the situations in the property market, the government proposed five measures to boost the property market in Malaysia as a part of Budget 2005. As a generator of economic growth, the tourism industry in the country was heavily promoted via education and health tourism; this promotion benefitted the hotel industry and the retail property sub-sector (National Property Informational Centre, 2005). Furthermore, RM 1 billion was also allocated in Budget 2005 for the delivery of affordable housing under three affordable housing schemes. In 2006, the Malaysian property market started to consolidate due to the supportive measures by the government as well as the positive financial and monetary policies in the economy. To further enhance the property market and alleviate the construction sector's contraction, Budget 2006 presented additional measures. Stimuli from Budget 2006 included the provision of low-cost housing, the maintenance of public facilities and rural development projects.

In 2008, the bursting of a speculative bubble in the US housing market triggered the Global Financial Crisis. The crisis spread to the rest of the world through capital flows, trade flows and commodity prices. The Global Financial Crisis impacted Malaysia through the financial and trade channels. In the aftermath of the crisis, the reversal of the capital

flows caused share prices in Malaysia to fall sharply from 95.0 in 2007 to 78.7 in 2009. Furthermore, this crisis also exposed the vulnerability of Malaysia's export-dependent growth where merchandise exports earnings recorded a contraction of 9.5 percent in 2009 due to poor demand in the world market, contributed by contracted manufacturing exports and reduced earnings from the primary commodity products of crude oil, rubber and palm oil. With the diversification of industry in Malaysia into manufacturing since the 1990s, the impact of the plunging of primary commodity prices due to global turmoil was cushioned.

The broad-based financial sector reforms and capacity building that was undertaken after the Asian Financial Crisis increased the financial sector's resilience to financial turmoil. Malaysia was the first country in the region to respond to the crisis with monetary expansion. Bank Negara Malaysia (BNM) lowered the overnight policy rate (OPR) from 2.5 percent in November 2008 to 2.0 percent in February 2009 in order to stimulate demand in the housing market. Monthly instalment payments on floating interest rate loans were immediately reduced to ensure that interest rate cuts led to an increase in borrowers' disposable income and thereby promoting higher domestic consumption.

On the fiscal front, the government implemented two stimulus packages. The first involved a direct cash injection amounting to RM 7 billion while the second stimulus of RM 60 billion involved direct cash injections and equity investment. This expansionary monetary policy was instrumental in cushioning the financial system against capital outflows and a share market collapse. Monetary aggregates continued to expand while the banking system remained resilient and the economy began to recover after 2009.

After implementing the stimulus packages to boost the domestic economy, the real property gains tax (RPGT) was exempted in 2008-2009 from the existing gains tax of 30 percent for properties selling in 2007. In turn, the property sector again became an attractive form of investment despite the Global Financial Crisis which had affected the rest of the world. The collapse of Lehman Brothers during the Global Financial Crisis spurred massive capital outflow from the developed economies to emerging economies in search of safer investment alternatives. Coupled with a stable financial system and good macroeconomic condition, the FDI flowing into Malaysia increased tremendously from US\$1.45 billion in 2009 to US\$12.20 billion in 2011 (see Figure 1.2). Owing to public investments and the fiscal stimulus packages, the growth in the construction sector remained positive throughout the year.

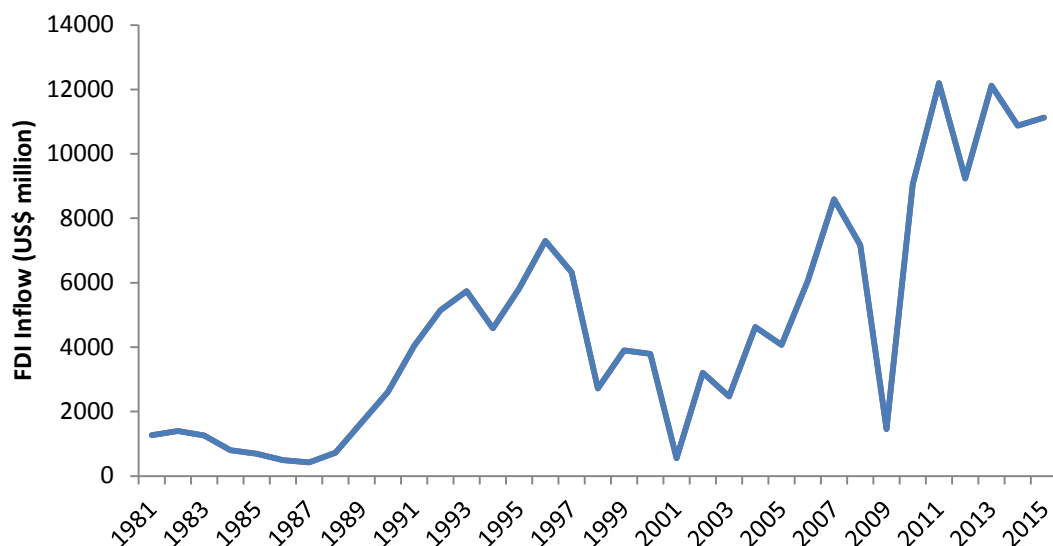


Figure 1.2: FDI Inflow in Malaysia, 1981-2015
(United Nations Conference on Trade and Development, various issues)

After 2009, demand and investment in the Malaysian property market surged, especially for residential properties. Property prices escalated significantly due to the increasing demand and supply factor where the total value of property sales in the country

was recorded at an average increasing rate of 30 percent from 2009 to 2011. The most striking figure was the Malaysian House Price Index (MHPI), which registered a strong rise from an annual growth rate of 3.2 percent in the preceding 10-year period to a rate exceeding 10 percent in 2012. These sharp rises in property values induced massive concerns regarding the sustainability of such price hikes (see Figure 1.3). As an unsustainable property market could drag other financial and economic sectors down as well, thus, the real property gains tax was reintroduced together with the imposition of a loan-to-value ratio of 70 percent which was enforced in 2010 to reduce speculative activities in the property market and to slow down sales in secondary markets.

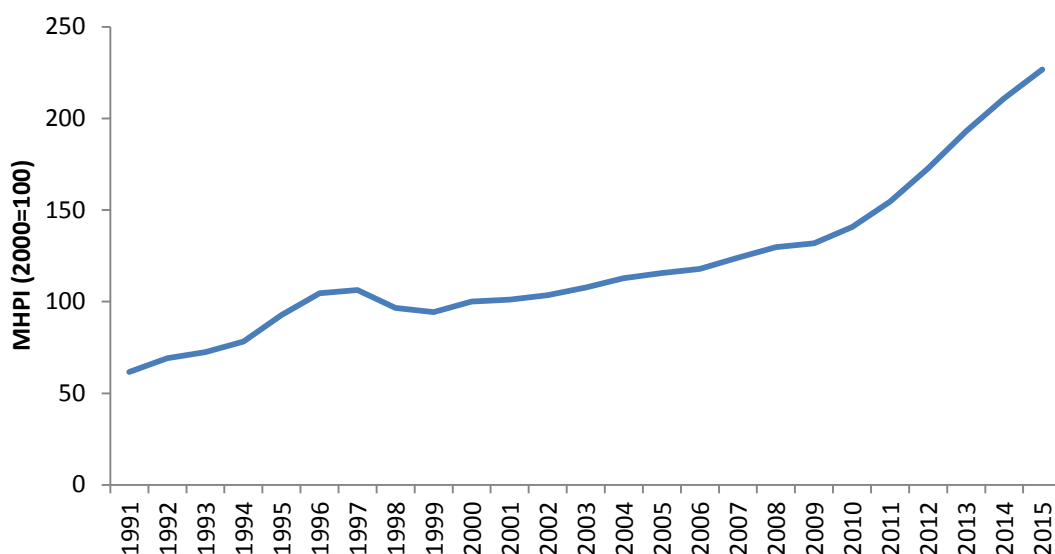


Figure 1.3: MHPI, 1991-2015
(Bank Negara Malaysia, various issues)

With regard to the issues arising from the huge growth in property prices, the government initiated various schemes to promote affordable housing for citizens, such as the My First Home Scheme and the 1Malaysia Housing Program. Towards the end of 2011, the household debt-to-GDP ratio was recorded at 74 percent, with a huge portion accounting for residential property loans (International Monetary Fund, 2014).

Unsustainable housing price escalation, which is unsupported by economic fundamentals, could be a source of risk for financial stability. Nevertheless, the government continued its effort to mitigate the risks of property and financial vulnerability by increasing the RGPT and the minimum price at which foreign buyers could purchase residential property in Malaysia. To further manage the household debt level, Bank Negara Malaysia imposed lending rules for personal loans and mortgages by decreasing maximum terms to 10 and 35 years, respectively.

Since late 2014, Malaysia's highly open and diversified economy was hit by a number of external and domestic shocks. As a net oil-exporting economy, Malaysia again was hit with the downturn in the crude oil industry towards October 2015 due to plunging crude oil prices. The oversupply of crude oil, coupled with declining demand, smashed the global market at a time where the economies of Europe and a number of developing countries were weakening. Particularly, the spill-overs from China, with its sluggish growth, impacted negatively on emerging market economies. Emerging market economies with a declining currency value, including Malaysia, became less attractive for investment and thus suffered capital outflows from the Malaysian financial market. These factors dragged down the broader market and put a toll on economic growth as a whole.

Amid weak global market sentiment, Malaysia recorded moderate growth in its nominal GDP in 2015. Nevertheless, household indebtedness and rising property prices remained a concern. These issues posed a risk to domestic financial stability and vulnerability where the household debt-to-GDP ratio continued to elevate to 89.1 percent. According to the Bank Negara Malaysia Report (2015b), residential property debt

consisted of 48.6 percent of the total household debt. To worsen the situation, in September 2016, the Minister of Urban Well-being, Housing, and Local Government Tan Sri Noh Omar announced the property loan licensing scheme for property developers which was not well received by the international rating agency Fitch Ratings as this added risk to the existing rising household debt. Thus, lowering the debt levels for households and improving the credit condition of the whole financial system would be vital to providing a buffer against unexpected events and the general rising costs of living.

1.3 Problem Statement

The property boom-bust cycle brings about far-reaching consequences. Generally, fast credit growth and sharp increases in leverage occur during property booms. In contrast, debt overhang and deleveraging spirals during property busts have negative impacts on financial and macroeconomic stability. More critically, property busts usually provide implications for financial instability. The losses against mortgages from unsustainable property booms and property lending have resulted in financial crises, considering the episodes in Japan during the early 1990s as an example. For instance, the collapse of the asset price bubble that occurred in the Japanese economy during the early 1990s had a negative effect on Japan's economy as a whole. The bursting of the bubble dragged the economy into a decade-long meltdown, known as the "Lost Decade," for the Japanese economy. After the bubble years, many Japanese firms and banks were loaded with a huge debt burden and it has taken quite some time for loans to be repaid. As a result, the Japanese economy suffered sluggish growth coupled with price deflation for decades after the asset bubble burst.

In Malaysia, the recent property price hikes coupled with the huge demand for property, especially, residential property has raised growing concern on the issue of mounting household debt in the country. The problems start to arise when household loans are disproportional to the means of the household. According to Bank Negara Malaysia, the ratio of household debt to the gross domestic product (GDP) in Malaysia was recorded as the highest among the developing economies in Asia with the ratio hitting 89.1 percent as of the end of 2015, an increase of 19.6 percent from the ratio in 2009. As compared to other developing Asian countries for the same period, Malaysia was followed closely by Taiwan with a ratio of 86.8 percent while Japan recorded a 71.8 percent ratio. Currently, Malaysia's household debt to GDP ratio is at a worrying level with a huge gap between the real GDP and the real loan amount.

Furthermore, the loan amount in Malaysian banking institutions has outpaced the growth of the GDP that had been slowing down since the Subprime Mortgage Crisis in 2009. The issue of mounting household debt is more severe when most of the household debts are due to housing loans with specific banking institutions. Data from Bank Negara Malaysia also showed that the ratio of housing loans to total loans in Malaysia has been accelerating from 10.9 percent in 2000 to 29 percent in 2015. Although this phenomenon would increase the book value of banking institutions, it indirectly exposes the financial sector to a more severe financial crisis once the property boom turns to become unsustainable and thus the sustainability of the financial market will be in jeopardy. The situation will turn even uglier when the spill-over effect of a financial crisis at the macroeconomic level, ends up in the long-term sluggish growth of the economy.

With the increasing financial and economic integration, this has strengthened the interlinkages between financial market and economies. Though integration promotes diversification and risk redistribution, extensive interlinkages could also increase contagion vulnerabilities. As experienced through the Global Financial Crisis in 2008-2009, increasingly complex networks of integration have further intensified the potential for idiosyncratic shocks on an integrated financial market and even cause amplified spillover to others (Bank Negara Malaysia, 2013). Contagion vulnerabilities are usually transmitted through the financial market, particularly the stock market during the Asian Financial Crisis, and international market, particularly the export performance during the bursting of Dot-com Bubble. As a highly open and diversified economy, Malaysia is prone to such contagion vulnerabilities which would bring about adverse impact to the growth of its real sector.

Pertaining to the issues discussed above, Lee (2010) warned that the residential property price hikes outpaced the income growth of the people while Mazlan (2014) noted that the loan amounts from financial institutions had also outpaced the GDP growth as a whole, which resulted in the fear that debt itself will be the platform for another financial crisis. Research conducted by the International Monetary Fund (2012) unveiled that a higher level of household debt will result in more severe downturns while Cecchetti et al. (2011) argued that although debt has a huge contribution to economic growth, it could also bring about an economic slump. Besides, though international financial integration promotes economic efficiency and growth, it might indirectly expose countries' vulnerabilities to contagion (Organisation for Economic Co-operation and Development, 2012). During unfavourable macroeconomic conditions where an increment in the

unemployment rate and a depreciation of household assets occur, such a tendency may result in an inability to pay off loans. In the meantime, confidence in certain assets will be lost and the setbacks incurred can be the major cause of financial crisis. Moreover, an overstretch of the booming property market will be very likely to slump the market into a longer and more severe downturn in the near future, particularly in the financial markets. In this case, the cost of a financial market downturn will be very substantial and would certainly spill-over into other economic sectors.

To the best of the author's knowledge, the Malaysian financial market has yet to implement an efficient and innovative early signalling tool that can provide an insightful outlook for the financial market in a timely manner. Hence, the present study was motivated to fill this gap by introducing an indicator-based forecasting instrument which has demonstrated to function well in predicting the majority of the cyclical processes of economic activities. The application of such an indicator has been particularly successful in business cycle analysis and macroeconomic study. Also, the construction of an indicator for the financial market is not entirely new, as discussed in the previous literature on past studies in developed countries. For instance, Park and Mercado (2013) constructed a financial stress index for 25 emerging markets and 15 advanced economies following Balakrishnan et al. (2009, 2011) while Huotari (2015) proposed a financial stress index for the Finnish financial system.

On the whole, the ideology of the construction of an indicator is considerably appealing for financial market vulnerability analysis. Therefore, the application of the construction of an indicator for the Malaysian financial market is an important attempt at

providing an understanding of the vulnerabilities of the financial market in Malaysia. Accordingly, the primary aim of this study was to construct a financial vulnerability indicator (FVI) that employs leading characteristics to foresee financial market fluctuations in a predictive manner.

1.4 Research Objective

1.4.1 General Objective

This study aimed to investigate the fluctuations of the Malaysian financial market and to predict the early signals of financial market vulnerability using the Financial Vulnerability Indicator (FVI) constructed through the signals approach and the dynamic approximate factor model before exploring the effect of financial vulnerabilities by implementing the Markov Switching Bayesian Vector Autoregressive (MSBVAR) model.

1.4.2 Specific Objectives

In order to conduct an indicator of financial vulnerability in Malaysia, the specific objectives of this study were:

- i. To construct an FVI that is able to offer early signals on financial market vulnerability;
- ii. To identify the episodes of financial vulnerability based on the constructed FVI;
- iii. To evaluate the predictive performance of the FVI constructed through the signalling approach and the dynamic approximate factor model on characterising the vulnerability of the Malaysian financial market;

- iv. To explore the feedback and amplification effects between economic activity and financial vulnerabilities using the MSBVAR model.

1.5 Significance of the Study

The intention of this study was to construct a financial vulnerability indicator for Malaysia. The benefits gained from this study can be seen from various aspects, especially from the perspective of the government as the policymaker in the economy. Moreover, the determination of a financial vulnerability indicator will ensure effective policy implication and implementation for a specific country.

From this study, the government is able to get some insight about the future financial market condition through the financial vulnerability indicator as an early warning mechanism. The government plays a crucial role in promoting economic growth and financial stability. By obtaining information about the future trends of the property market, it is possible to avoid financial crises by the implementation, or changing, of policies for their countries. An effective policy is essential to attract more investment especially in the property market and hence to promote economic growth so as to decrease the deficits of the country while providing better social welfare in terms of taxation etc.

Moreover, investors can also obtain valuable information regarding future financial market movements. In other words, the financial vulnerability indicator gives a picture of the financial and macroeconomic condition as a reference for investment decision-making. In turn, this might also help to boost the confidence of investors in planning future

investments. Therefore, this study can also aid investors in drafting out a set of significant indicators of future financial market fluctuations to ensure a better return on investment.

The FVI is expected to be a well-defined financial market signalling approach that aids policymakers, financial market players as well as the general public, to develop timely precautionary measures in order to counteract with the fluctuations in the Malaysian financial market. Therefore, the application of the FVI in future decision-making and policy development would lead to better financial decisions, market stabilisation policies, monetary-related development policies as well as the overall development of the economy. Last but not least, the FVI will be of great assistance to financial and banking institutions in forming appropriate borrowing schemes and lending standards to cater for changing credit demand and debt servicing capability based on the prospects of the economy in the near future. It is especially important to note that a well-informed individual, community or entity will be less likely to endure the harsh cost of market contraction, or at least the severity of any vulnerable episode could be reduced to a minimum.

1.6 Organisation of the Study

This thesis comprises of five chapters. Chapter One includes the introduction and background of the study, the problem statement, research objectives and the significance of the study. Chapter Two presents the literature review regarding financial vulnerability and its indicators. Chapter Three discusses the data and methodology used in the study while Chapter Four reports the empirical findings with a discussion and justification. Finally, the conclusion and recommendations are presented in Chapter Five.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Research interest on early warning indicators has renewed since the Global Financial Crisis in 2008-2009, the indicators aim to assist in financial crises forecasting by monitoring key variables. The G20 group of economies requested that the International Monetary Fund (IMF) conduct new early warning practices at the climax of the global; financial crisis in November 2008. In addition to that, the IMF was again requested as a result of the London Summit in April 2009 “to provide early warning of macroeconomic and financial risks and the actions needed to address them.”

Study on early warning systems for financial crisis forecasting dates back to 1996 when Kaminsky and Reinhart (1996) proposed a non-parametric approach, the signals approach, to assess the vulnerability of an economy. The approach aimed to select potential indicators of a crisis with determined threshold values of crisis signalling. The other popular approach for early warning systems has been the indicator construction approach where the aggregation of various potential variables into a single index is carried out. Over time, further innovation on early warning systems has been developed to improve the performance of the mechanism as the effects of financial globalisation kicked in.

2.2 Empirical Studies on Non-parametric Approach

One of the popular non-parametric approaches for financial crises forecasting was proposed by Kaminsky and Reinhart (1996, 1999). They proposed using the signals approach to assess the vulnerability of an economy and to act as an early warning system for currency and banking crises. Later, Kaminsky et al. (1998) identified the leading indicators of currency crises for 15 developing countries and 5 industrialised countries before the Asian Financial Crisis, 1997 (data covered the period 1970-1995). When implementing the signals approach using monthly based data, they discovered that exports, deviations of the real exchange rate from the trend, the ratio of broad money to gross international reserves, output and equity prices were among the potential explanatory variables. Based on the individual indicators' performance, they noted that the signals approach was supportive as an early warning mechanism and it would be a handy means for the timely valuation of the occurrence of a crisis.

Reinhart et al. (2000) assessed a methodology for an early warning system for 25 countries from the regions of Africa, Asia, Europe, the Middle East, and Latin America. Employing the signals approach using monthly data from the period 1970 to 1995, they found that the economy behaved contrarily before the occurrence of financial crises and this happened in a recurrent systematic pattern. They added that this systemic pattern was brought about through the evolution of economic and financial indicators.

Moreover, Bruggemann and Linne (2002) extended the work on the signals approach by employing a composite indicator for the Central and Eastern European transition countries. The period under study covered January 1993 to September 2001 in

assessing the countries' vulnerabilities to a financial crisis. Similar to that of Kaminsky et al. (1998), their findings showed that overvaluation of exchange rate, weakening of exports and dwindling of currency reserves were among the variables that possessed good predictive power on the assessment of crisis vulnerabilities besides indicators that were related to banking sector developments, such as the lending to deposit rate ratio and bank deposits.

On the other hand, Yap (2002) monitored economic vulnerability and performance in the Philippines, spanning the period from 1980 to 2002. He utilised limited dependent variables estimation and the signals approach to assess the economic prospects of the Philippines in the short and the medium-term. He discovered that foreign borrowing and high domestic credit exposed the economy to vulnerability, but that the transformation of vulnerability into weakness in the economy was due to crisis contagion from other countries.

Edison (2003) developed an operational early warning system that possessed financial crisis detection ability. There were two separate studies, one study concentrated on 20 countries from Latin America, Asia and other regions while the other study was country-specific and focused on Mexico only. The period of study spanned from January 1970 to May 1995, it used the signals approach. In assessing numerous indicators, he listed out a number of important indicators, namely, the distinct appreciation of the real exchange rate (relative to trend), a high short-term debt to reserves ratio, a high M2 to reserves ratio, significant declines in foreign exchange reserves and a sharp decline in equity prices. He also added that the early warning system was a useful diagnostic tool.

Contrary to other studies, Pranowo et al. (2010) examined the dynamics of corporate financial distress in Indonesia with data covering from 2004 to 2008. They employed the methodology of process integral financial distress and used debt service coverage to proxy corporate financial distress. The empirical outcome showed that oil price shocks and the Subprime Mortgage Crisis impacted the financial performance of companies differently where its impact varied across different industrial sectors.

Duca and Peltonen (2011) studied macro-financial vulnerabilities and future financial stress by assessing systemic risks and predicting systemic events, covering 18 emerging markets and 10 advanced economies. They utilised quarterly data frequency from 1990 till 2009 to construct a financial stress index. Their constructed index consisted of the spread of the 3-month interbank rate over the 3-month Government bill rate, negative quarterly equity returns, the realised volatility of the main equity index, the realised volatility of the nominal effective exchange rate and the realised volatility of the yield on the 3-month Government bill. They found that in order to greatly improve the performance of the forecasting models, domestic and global macro-financial vulnerabilities could be jointly implemented.

El-Shagi et al. (2012) conducted research to predict financial crises based on the statistical significance of the signals approach for multiple countries. Based on the bootstrap approach, statistical significance evaluation was added to augment previous signals approach applications. The authors discovered that the signals approach portrays advantages and favourable characteristics for an early warning system. They also added

that the produced composite indicators contained promising forecasting predictive power, although many individual indicators were possibly not statistically significant.

Percic et al. (2013) conducted research through analysing some early warning systems for predicting financial crises. The analysis was done on models based on the signals approach and the logit/probit models. They found that the prediction of a crisis occurring within a time frame could be carried out using an early warning system. They added that models based on both methodologies were a representation of an important stage in combating financial crises while the financial stability of an economy could be ensured through the use of an early warning system.

Drehmann and Juselius (2014) evaluated early warning indicators of banking crises for 26 countries. The sample data of the study covered the period from 1980 to 2012 using quarterly data. By employing a ROC curve, they discovered that the credit-to-GDP gap and the debt service ratio were among the outperforming measures. Over a longer time-frame, the credit-to-GDP gap would be the outperforming indicator while the debt service ratio showed domination over a shorter time-frame.

Christensen and Li (2014) conducted a study that proposed an early warning system that contained a predictive ability on the occurrence of financial stress events. The study covered 13 OECD countries, including Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States. Using the signals approach on data from 1981Q2-2011Q2, an assessment of the likelihood of an impending financial stress event was carried out. By incorporating a

different weightage for composite indicator construction, they discovered that the weighted composite indicator outperformed other indicator approaches where the weighted indicator signalled most of the financial stress events accurately.

Besides early warning system of multiple countries, Hernandez et al. (2014) developed a country-specific early warning system for the European region. Employing the signals approach, they improved existing warning indicators by signalling fiscal stress using annual data over the period 1970-2010. In their study, they included both fiscal and financial variables for index construction where fiscal sustainability directly triggered fiscal stress while financial variables represented the vulnerabilities to fiscal stress. Their finding indicated that fiscal stress could be detected earlier when using an early warning system based on a country-specific signals approach.

Similar to that of Duca and Peltonen (2011), Giese et al. (2014) conducted a study on the indicators for macro-prudential policy in the case of the United Kingdom. Using data between 1969Q1 to 2009Q1, they employed a non-parametric approach to evaluating various indicators, namely approaches of the area under the receiver operator characteristic curve (AUROC), the minimum noise ratio and the maximum signal ratio. They discovered that the credit-to-GDP gap signalled policy tightness in timely-mannered and added that property prices, sectoral credit ratios and indicators on banks' balance sheets (leverage ratio or loan-to-deposit ratios) would be of importance to picture different cyclical changes.

Feldkircher et al. (2014) examined the macroeconomic, external and financial vulnerabilities of 22 Central, Eastern and South-eastern European (CESEE) countries. The

period under study spanned from 1995 to 2012 using annual data. Using the signals approach, they found 18 valuable indicators for indicator construction which had the ability to signal an economy's vulnerability. Based on the empirical outcome, the constructed composite indicator reached about 73 percent accuracy in crisis prediction whereas 70 percent accuracy was achieved for non-crisis prediction. (Refer to Appendix for Summary of Review of Empirical Studies on Non-parametric Approach)

2.3 Empirical Studies on Indicator Approach

Extensive studies on crisis occurrence have emerged following the Subprime Mortgage Crisis during 2008-2009. Since then, interest regarding early warning systems based on the indicator approach has renewed and sparked research involvement from researchers, practitioners and policymakers. Nevertheless, the initial proposal for an early warning system in crisis forecasting dated from years before crisis. Illing and Liu (2006) carried out research to measure financial stress in Canada, a developed economy. In order to construct the Canadian Financial Stress Index (FSI), they employed factor analysis, credit aggregate-based weights, variance-equal weights and the sample cumulative distribution functions transformation approach using monthly data from 1980 to 2006. Based on their findings, a standard-variable version based on the credit aggregate weighting technique contained better forecasting performance. They noted that the accuracy in stress characterisation was important in financial crisis forecasting.

Albulescu (2010) conducted a study to forecast financial system stability for Romania. A stochastic simulation model was employed using quarterly data from 1996 to

2008 to perform financial stability forecasting. The constructed aggregate financial stability index (AFSI), using an aggregation of individual variables, consisted of potential indicators from financial development, financial vulnerability, financial soundness and the world economic climate. Through the evolution of the constructed indicator, they found that the Romanian financial stability level had improved since 2000.

Other than that, Morris (2010) developed an AFSI to measure and forecast financial stability in Jamaica. The period under study spanned from March 1997 to March 2010 with data in quarterly frequency. The author aggregated indicators representing the banking sector performance from different perspectives into a single AFSI while Monte Carlo simulations were used for one-year out-of-sample forecasting of financial stability. He discovered that the deterioration of the forecasted index was due to the seasonal increases in M2 where financial stability was affected.

Kim (2010) studied the effects of financial instability on real output in the United States and Korea. Using the sample period of 1995Q1 to 2009Q1, FSIs were constructed for both economies and a structural VAR model was used to investigate the effects. He discovered that the real output growth would be impacted negatively whenever national financial stress took place. Moreover, financial instability in the US could also affect other countries through the mass media, investor behaviour and other factors.

Van Roye (2011) conducted research on financial stress and economic activity in Germany and the European Area. This study covered the period 1981-2011 using monthly frequency data. The financial market stress indicators were constructed based on a dynamic

factor model and the Bayesian VAR model was used to obtain information on the effect of financial stress on economic output. The empirical outcome illustrated that financial stress brought about a negative impact on output growth and the inflation rate. Furthermore, he also concluded that indicator inclusion into the model improved the performance of out-of-sample forecasting to a greater extent.

Cardarelli et al. (2011) examined the relationship between financial stress and economic contractions in 17 advanced economies. Quarterly data over the period 1980-2009 was implemented to construct an FSI with a variance-weighted average for each economy. The component series that made up the FSI consisted of the slope of the yield curve, the TED spread, beta of the banking sector, corporate bond spreads, stock market returns, time-varying stock return volatility and time-varying volatility of the nominal exchange rate. When compared to foreign exchange market stress, they concluded that banking distress had a higher tendency to result in longer economic downturns.

Slingenberg and Haan (2011) carried out research to forecast financial stress for 13 OECD countries. They constructed a multi-country FSI for the period spanning from 1984 to 2010. Six indicating perspectives were merged into the indicator construction procedure to capture the possible financial stress contributors, including the current account, the capital account, the financial sector, the real and public sector, asset prices, and the foreign sector. They noticed that credit aggregates were among the best financial stress indicators with a leading attribute.

Mingione (2011) carried out research to forecast financial stability indices for Jamaica. The FSI was constructed using data from 1996Q1-2011Q1 based on the signals approach and the aggregate single index to forecast Jamaican financial vulnerability. He discovered that the autoregressive distributed lag model with principal component analysis factors performed better in forecasting and noted that the inclusion of data from building societies, merchant banks and macroeconomic variables improved the early warning system.

Louzis and Vouldis (2012) developed a financial systemic stress index for Greece. Using the constructing and evaluating index methodology suggested by Hollo et al. (2012), they applied it using data of monthly frequency from 1998 to 2010. The variables of the index were selected from market data from the banking sector, balance sheet data from the banking sector, equity and the money market. The empirical outcome indicated that the constructed index contained the ability to signal crises periods accurately. They also suggested that suitable policies could be implemented based on the precise indication of the nature of the systemic stress with respect to the detection of a financial crisis.

Frankel and Saravelos (2012) assessed the United States' vulnerability to global financial crises using leading indicators. Using 50 annual macroeconomic and financial variables up until 2007, multivariate regressions were used for empirical analysis. Six variables were included in their study, namely, drops in the GDP and industrial production, currency depreciation, stock market performance, reserve losses, and participation in IMF programs. They concluded that the level of reserves and the real appreciation of the exchange rate were the indicators which led to explaining the occurrence of a crisis.

Islami and Kurz-Kim (2013) constructed a single composite FSI for the European region. The period under study spanned from January 2007 to April 2013 using data of monthly frequency. Five market segments were considered before constructing the FSI, namely, credit, foreign exchange, the oil market, the stock and interbank market. Based on their findings, the constructed FSI performed better than the Euro STOXX 50 volatility index in terms of predictive ability. They also added that the constructed FSI had the ability to signal shocks from financial markets on the real economy by up to 1 to 4 months in advance.

As conducted by Illing and Liu (2006), Pasricha et al. (2013) conducted another research to assess vulnerabilities in the Canadian financial system. Using an early warning approach based on the IMF FSI and imbalance indicator model, the research was carried out on monthly data, spanning from December 1980 to December 2009. The components of the FSI included real effective exchange rate (REER) volatility, stock market volatility, stock market decline, corporate spread, inverted term spread, interbank lending spread, and beta of the banking sector. They showed that the model could indicate vulnerabilities in the financial system without neglecting information from market intelligence as well as regular monitoring of economic and financial data.

Cevik et al. (2013b) carried out a study to construct an FSI for Bulgaria, the Czech Republic, Hungary, Poland, and Russia. The monthly data based FSI was constructed on data from between February 1995 to June 2010. The constructed FSI was based on variables of banking sector fragility, time-varying stock market return volatility, sovereign debt spreads, an exchange market pressure index, and trade credit. Based on the empirical

findings from impulse response functions based on bivariate VARs, they noted that a strong connection existed between financial stress and the real economy. They also added that the constructed FSI contained valuable information on the economic condition.

Cevik et al. (2013a) developed an FSI for Turkey regarding financial stress assessment. The monthly data based FSI was constructed on data from 1997 through to 2010. A principal component analysis was employed for indicator construction of the variables of stock market volatility, exchange market pressure index, bond spreads, default probability of the banking sector, trade finance, and the growth rate of short-term external debt. The empirical analysis indicated that the index was a useful indicator with a leading attribute for the economy and recession in Turkey while a linkage between the FSI and the real economy existed.

Sinenko et al. (2013) developed an FSI for the economy of Latvia as the financial system stability monitoring framework. With a sample data period spanning from 1998Q1 through 2013Q1, three approaches of indicator construction were employed in their study, namely, aggregation with variance-equal weights, aggregation using principal component analysis-based weights and aggregation of variables using equal or chained weights. The FSI for Latvia was constructed from the variables of a decrease in the profitability of credit institutions, increase in the loan loss provision ratio, a sharp decline in lending, a deterioration of interbank lending, widening of credit spreads on the interbank market, deposit outflows, and increasing yields on government debt securities. The constructed FSI had the ability to signal periods of stress, during the vigorous and imbalanced development

of the Latvian financial system where it became a monitoring framework for the Bank of Latvia after 2010.

Braga et al. (2014) carried out a study to construct a composite indicator of financial stress for the economy of Portugal. The indicator construction procedure of the composite indicator of financial stress was similar to Hollo et al. (2012) by aggregating 5 sub-indices. The authors discovered that the constructed composite indicator provided accurate identification of financial stress events which had impacted Portugal's financial system since 1999 while they added that a clear divergence from composite stress indicators of Euro area could be noticed in some moments.

Dumicic (2015) conducted a study on financial stability indicators in the case of Croatia. Using principal component analysis, a systemic risk accumulation index and a systemic risk materialisation index were constructed based on quarterly data over the period 2001Q1-2014Q4. From the empirical findings, the author identified that strong lending activity was a great indicator of risk accumulation, particularly excessive credit growth and over-optimistic lending. The author also added that systemic risk could be materialised through the escalation of the non-performing loan ratio, which in turn impacted real sector development negatively.

Other than studies on developed countries, Vermeulen et al. (2015) developed an FSI for 28 OECD countries in relation to financial crises. Using the non-weighted sum of the standardised indicators, the FSI for the 28 OECD economies was constructed from the variables of stock price volatility, volatility of monthly changes in the nominal effective

exchange rate, beta of the banking sector, the US long-term interest rate, inverse yield curve, and the TED-spread with data covering 1980Q1 to 2010Q1. They discovered that the constructed FSI showed crisis occurrence to a varying degree, though the case for its relationship towards the onset of a crisis was weak. Therefore, they suggested the implementation of country-specific FSIs for improved empirical estimation.

Apart from the research done by Kim (2010) on the US, Kim and Shi (2015) also conducted a study on forecasting financial market vulnerability in the US. By employing principal component analysis, the sample period spanned from October 1991 to October 2014 using monthly frequency macroeconomic data. Based on the empirical findings, they found out that the factor models outperformed other models in out-of-sample short-term forecasting. They added that the first common factor of predicting financial vulnerability was associated with real activity, but not a nominal one.

On the other hand, Oyong et al. (2018) proposed an early warning mechanism for vulnerability to a currency crisis for the developing economy of Indonesia. Based on the sample from January 2002 to December 2012, they applied logistic regression and fuzzy logic in their indicator construction. They noted that vulnerability detection is more effective in offering more time for policymakers to establish the right policy to manage and avoid a crisis. Besides, the constructed vulnerability index can also be applied in monitoring the economic condition, as applied by Abu Mansor et al. (2015). (Refer to Appendix for Summary of Review of Empirical Studies on Indicator Approach)

2.4 Empirical Studies on Other Innovative Techniques

Apart from the non-parametric and indicator construction approaches, other innovative techniques have emerged and gained empirical interest from researchers and practitioners, particularly on nonlinear modelling. Hubrich and Tetlow (2014) noted the importance of coefficient switching and nonlinear dynamics as a linking mechanism between financial stress and macroeconomic outcomes while Aboura and van Roye (2013) highlighted the significance of nonlinearities during a crisis situation. Abiad (2003) proposed an alternative early warning system for Indonesia, the Republic of Korea, Malaysia, the Philippines and Thailand. The period under study covered from January 1972 to December 1999 with data of monthly frequency. Indicators from a macroeconomic perspective, capital flows and financial fragility were among the measures of early warning indicators. Using the Markov-switching model, the author discovered that signalled vulnerabilities in countries could be observed due to declines in competitiveness and slowdowns in exports. The author also added that external factors to crisis occurrence, such as the volatility of the global equity market and a high-yield bond spread, could be considered as a result of financial globalisation.

On the other hand, Bussiere and Fratzscher (2006) developed a new early warning system model for 20 open emerging markets. Using monthly data from 1993 to 2001, the early warning system was developed based on a multinomial logit model. The key indicators were inclusive of overvaluation, leading boom, the ratio of short-term debt and reserves, the ratio of the current account over GDP, financial contagion and growth. They noted that the early warning system was enhanced in terms of its predictive performance

with the use of proposed three-regime models. Most of the crises in emerging markets were also accurately forecasted using the model.

Knedlik and Scheufele (2007) conducted research by testing three methodologies to forecast currency crises in South Africa. The period of study spanned from January 1994 to January 2007. The signals approach, the probit approach and the Markov regime-switching approach were among the tested methodologies. They noted that the Markov switching approach was the best forecasting methodology as it signalled the most accurate pre-crisis calls and it also allowed out-of-sample crisis forecasting.

Yiu et al. (2009) developed an early warning system for the banking system and currency market vulnerability in 11 EMEAP countries. The study adopted separate panel probit models and a simultaneous probit equation system for the development of an early warning system using data of quarterly frequency, spanning from 1990 through 2008. For indicators of banking distress and currency pressure, asset-price misalignments, the default risk of commercial banks and the non-financial corporate sector, and the growth of real credit to the private sector were shown as leading attributes. In addition, they discovered that the country behind the stabilising role was China where any currency pressure might be lowered with a deeper trading relationship with China.

Andreou and Zdzienicka-Durand (2009) carried out research to analyse financial vulnerability in 4 Central and Eastern European economies. The study period covered 1995 to 2006 and contained data on a quarterly basis. The main indicators were inclusive of the current account balance in the percentage of GDP, FDI in the percentage of total

investments, CPI-based inflation, real effective exchange rates, bank credit to the private sector, year-on-year changes of the GDP, and gross external debt in percentage to the GDP. The authors discovered that the developed model, through panel probit modelling, was well-performed and that it could be a useful forecasting tool for the assessment of financial vulnerabilities in transition countries. By comparing the period of increased financial vulnerabilities with the actual happenings, the model successfully predicted 83 percent of the stressful events in the sample.

With Abiad (2003) focusing on Asian Financial Crisis, Stanga (2011) conducted a study on sovereign and bank credit risk in Ireland and Spain during the Global Financial Crisis. Monthly frequency data was used covering the period January 2007-March 2011. The restricted VAR model was adopted for analysing the relations between sovereign CDS spreads, bank CDS spreads, and a measure of the business cycle. Based on the empirical estimation, the outcomes indicated that a transfer of financial risk to the sovereign sector resulted in an escalation in the credit risk though it was only for a short period of time.

Milwood (2012) carried out a study by constructing a composite indicator of systemic stress for Jamaica. The period under study spanned from January 2002 through June 2012. The aggregation of the index was based on the cumulative distribution function while the threshold VAR was conducted to capture the systemic stress impact on real output growth. The author confirmed that the constructed indicator impacted the economy differently where the impact was more sustainable in a regime of high stress than in a low-stress regime.

Matkovskyy (2012a) forecasted the future condition of the South African index of financial safety. The period under study covered from 1992Q1 through 2011Q1. Using neural network tools, specifically the nonlinear autoregressive model with exogenous input, the index was forecasted by benchmarking with the Bayesian VAR model for comparison. Based on the empirical outcome, it indicated that the proposed model with the application of a South African index of financial safety contained sufficient predictive ability compared to the other model.

Bhattacharya and Roy (2012) conducted a study on an early warning system for banking fragility forecasting for the economy of India. Data on a monthly frequency was used for the empirical estimation, spanning from 1994 till 2007. The study adopted a multivariate probit regression for the relationship assessment and used the signals approach for the cross-checking of the identified indicators. The indications of fragility in the Indian banking sector were a slowdown in the real GDP, an escalation in the headline inflation rate, an escalation in the spread between the policy rate and the short-term risk-free rate, an escalation in broad money supply to foreign exchange reserves ratio, an overvaluation of the REER from the trend, and a decline in the trade balance to GDP ratio. With the average lead time of 8.5 months, the authors noted that banking stress indicators with leading attributes provided timing for policy adjustment.

Matkovskyy (2012b) forecasted the index of financial safety when exploring the strength of the South African financial system towards financial shocks. The period under study spanned from 1990Q1 through 2011Q1 with an extension for out-of-sample forecasting for the period 2011Q2-2017Q1. By implementing a Bayesian VAR model on

the constructed indicator, the author showed that fluctuations in the financial system could be identified through the indicator while the model itself contained the ability to forecast dynamism in the indicator.

Moreover, Aboura and van Roye (2013) developed a real-time financial stress index for the French economy. The French FSI was constructed based on data from 1971M1 to 2012M8 using monthly frequency data using a dynamic approximate factor model. With the application of the Markov-switching Bayesian VAR model, the authors learnt that high financial stress was associated with lower economic activity and added that the developed index could be employed to signal an early warning of systemic risk in the French financial sector.

Hartmann et al. (2013) conducted a study on systemic financial instability and the macroeconomy of the EU region. The period of study spanned from January 1987 until December 2010 using data on a monthly basis. With the adoption of the Markov-switching VAR model, they noticed an alteration of the parameters in transmission and variances of shocks during high-stress periods. As noted by Milwood (2012), Hartmann et al. (2013) added that an escalation in financial stress brought about stronger negative output effects after regime change compared to during tranquil times.

Abdymomunov (2013) proposed an approach to measure systemic financial stress for the US financial system. The study implemented a multivariate SWARCH model on weekly data, spanning from 6 December 2000 to 29 September 2010. The author noticed that during high volatility regimes, the TED spread, the return on the NYSE index, and the

capital-weighted CDS spread for large banks were associated with financial stress periods while they also discovered that stressful episodes were detected using the probability of the joint regime of high volatility.

Glocker and Kaniovski (2014) developed a financial market stress indicator for Austria. Monthly frequency data, spanning from January 2000 to December 2012, were analysed using principal component analysis for composite indicator aggregation. By employing the bivariate threshold VAR and the Markov-switching VAR model, they discovered that the effects of a threshold existed in the stress transmission from the financial system to real output during high-stress periods for the Austrian economy. They added that the threshold value provided an indication of the stress level which was also a warning of an impending downturn.

Hubrich and Tetlow (2014) introduced a financial stress index for the economy of the US. By adopting a richly parameterised Markov-switching VAR model with Bayesian methods estimation similar to that of Glocker and Kaniovski (2014), the data of period between 1988M12-2011M12 was analysed. According to the author, the definition of a stress event was a period where the variances of shock and the coefficients of the model of the latent Markov states were contrary. They found out that stressful events subsequently tailed with financial events where a shift to a stressful event impacted the real economy prospects adversely.

Semmler and Chen (2014) conducted a study on financial stress, regime switching and macro dynamics in the US, the EU and non-EU countries. The period under study

spanned from 1980 through 2012. The Multi-regime VAR was employed for the assessment of financial stress on the macroeconomy of multiple economies in this study. During a high-stress regime, the financial shock could impact the real economy insistently while during a low-stress regime, the shock would have no lasting effects. The outcome is particularly consistent with that of Milwood (2012) and Hartmann et al. (2013). Based on the empirical findings, asymmetric effects existed between financial stress shocks and output shocks where it relied on the regime of the economy.

Sarafrazi et al (2015) examined the interactions between the real economic and financial viewpoints in the US. Apart from Markov-switching VAR model, this study instead employed a linear model and a nonlinear Markov-switching VECM model on data on a monthly basis, spanning from December 1993 through October 2015. The variables under study were real private capital stock per capita, real industrial production per capita, total non-farm employment, the crude oil spot price (WTI), financial stress indicator, the real interest rate, and the VIX. From the empirical evidence, it was suggested that during a stressful time, the significance of the financial system towards the real economy intensified and added that more fluctuations could be noticed, particularly, during a high volatility regime.

Duprey et al. (2016) conducted a study on dating systemic financial stress episodes in EU countries. The period under study spanned from April 1984 through May 2014. Using the Markov-switching model, 68 episodes of systemic financial stress were identified through the period under study. They noted that the country-specific financial stress index, of which in monthly basis, was used to capture the cyclical component of the

financial market. Based on the empirical evidence, the authors concluded that patterns of recurring financial stress events could be identified, namely, that financial stress led to real economic stress, recession lasted more than 6 months and additionally output declined by three percentage points if that was due to stress from the financial market, and systemic financial stress impacted few countries at once.

Li and Xiao (2016) developed an early warning system for financial stress events in Canada. The period under study covered 1982Q1 to 2013Q4 and employed a threshold regression model and a non-parametric bootstrap procedure. Based on the empirical evidence, the model based on the credit-regime-switching approach contained a higher predictive ability compared to the benchmark models based on a linear regression and the signals approach.

On the other hand, Suidarma et al. (2017) piloted research on the indicators that affected vulnerability to the stability of the Indonesian financial system. They implemented the Markov switching vector autoregressive model and utilised indicators from financial development, financial vulnerability and the world economic climate. They noticed early signs of vulnerability through the growth of credit to GDP, the spread of interest rates, fiscal deficit, the current account, the exchange rate and differentials in the interest rate. They also highlighted the importance of an early warning system to mitigate any financial crisis through effective policy establishment. (Refer to Appendix for Summary of Review of Empirical Studies on Other Innovative Techniques)

2.5 Review on Vulnerable Episodes

Japanese Asset Price Bubble

The collapse of the asset price bubble that occurred in the Japanese economy during the early 1990s had a negative impact on Japan's economy as a whole. The bubble burst dragged the economy into a decade-long meltdown, known as the "Lost Decade," for the Japanese economy. Before the asset price bubble burst in 1990, the Japanese economy was admired by most economies in the world as Japan had both the highest saving rate in the world and the latest industrial technology, particularly in the manufacturing sector. During the mid-1980s, the Japanese economy was in shock when the yen rose rapidly due to high manufacturing exports, particularly to the US. More expansionary monetary policy was implemented to deal with further yen appreciation while financial liberalisation took place at the same time.

In the late 1980s, the Japan's banking system vulnerability increased substantively (Shiratsuka, 2003). From 1985 till 1989, the combination of financial liberalisation and monetary expansion created asset price inflation. At the same time, financial firms began to turn to real estate investments and stock lending due to business losses in manufacturing firms. After 1986, stock and land prices surged and even doubled in value before losing their gains of the previous four years when monetary policy was tightened in 1989 and 1990. In late 1990, the stock market and property market collapsed. Fiscal stimulus packages totalling 54 trillion yen were adopted between 1992 and 1995 which created huge public debt. Nevertheless, the economic recovery was not sustainable. After the bubble years, many Japanese firms and banks have been loaded with a huge debt burden and it has

taken quite some time for loan repayment. As a result, the Japanese economy suffered sluggish growth coupled with price deflation for decades after the asset bubble burst.

Asian Financial Crisis

The early 1990s saw an ample amassing of outstanding domestic credit in the banking system, with heavy exposure to the property sector due to booming property prices between 1991 and 1996. This amplified exposure to the property market further deteriorated the banks' financial positions as this lending led to a property oversupply in the country, reflected with a peak in the credit-to-GDP ratio of 167.2 percent in the last quarter of 1997. In July 1997, the Thai currency depreciated sharply, causing an abrupt withdrawal of short-term capital out of the country. Vulnerable to speculative attack, this transmitted a wave of uncertainty and volatility in the foreign exchange and equity market, where it caused a dramatic fall in the exchange rate of the ringgit and pushed a sharp rise in interest rates. The Kuala Lumpur Stock Exchange (KLSE) index declined drastically from 1216 points in January 1997 to only 302 points in August 1998 (Nambiar, 2003).

As the rapid pulling out of short-term capital occurred, this led to a delay in major investment plans and risk accumulation in many businesses based on bankruptcies and non-performing loans. The downturn in the economy caused share and other asset prices to plunge severely, particularly, property prices due to the over-exposure of the property sector, driven by the speculative demand since the early 1990s. The breakdown in the financial sector impacted the real sector. By August 1998, the economy was in recession with shrinkage in output of 2.8 percent and 6.8 percent, respectively, in the first and second

quarter (Athukorala, 2010). The unemployment and inflation rates increased tremendously, reaching 3.9 percent in 1998 and 6.3 percent in June 1998, respectively.

The combined effect of the economic collapse, property market crash and financial market breakdown was an enormous escalation in non-performing loans in the banking system. The Asian Financial Crisis was closely related to the vulnerabilities of short-term capital flows into the country's economy and the abnormal activities of currency traders. In September 1998, an exchange control measure was implemented and the financial sector was restructured extensively. As a result of the government's further economic recovery measures, official government statistics showed that construction growth had increased by the end of 1999. The implementation of privatised projects and the expansion of government fiscal expenditure, particularly on infrastructure and residential developments, further supported the progression of the industry.

Dotcom Bubble

In the midst of recovering from the Asian Financial Crisis, the economy and particularly the stock market in the United States (US) were booming. During the dot-com boom, especially after 1996, the stock prices of Internet-based companies in the US shot up at a very fast pace. The dot-com boom resulted in the NASDAQ composite index increasing from about 600 points in 1996 to a peak of 5046.86 points during the year 2000. On March 13, 2000, the NASDAQ composite index dropped from 5038 points to 4879 points, which triggered a huge sell-off of information technology (IT) stocks. The NASDAQ stock index continued to plunge and the dot-com bubble in the US economy

burst in 2001. As a result, interest rates were cut repeatedly to prevent any further meltdown while technology professionals were smashed with high unemployment.

The bursting of the dot-com bubble in the US adversely affected the Malaysian economy where the real gross domestic product (GDP) growth negated with 1.2 percent in the third quarter of 2001. As Malaysia was one of the Asian economies that engaged in subordinate activities for dot-com companies in the US, the manufacturing sector was affected the most due to the low demand for electronic products following the bursting of the dot-com bubble, especially from the export markets of Europe and Japan. As a result, a huge number of workers involved in manufacturing were suddenly out of work which caused Malaysia's unemployment rate to shoot up. To enhance the Malaysian property market and other economic conditions, policy measures were introduced in Budget 2001 which included the lowering of the ceiling rate of the ad-valorem stamp duty on property transfers, increasing housing mortgage eligibility for public servants and encouraging the acquisition of second homes. Moreover, a fiscal stimulus package of RM3 billion in March 2001 and another of RM4.3 million in September 2001 were also executed to instigate private spending and to boost economic development.

Subprime Mortgage Crisis

The Subprime Mortgage Crisis began with the bursting of the US housing bubble that peaked in 2005. Many economists believed that the housing bubble in US was typically triggered by the low interest rate sentiment and the boom in subprime lending. After 17 times of interest rate raises by the Federal Reserve Board before 2006, the Fed stopped the practice due to the fear of housing market downturn could eventually weaken

the overall US economy. By 2005, the housing bubble had burst with the drastic increase in foreclosures of homes purchased with subprime loans.

By January 2007, the subprime mortgage industry in the US started to show cyphers of collapsing where foreclosures continued to escalate due to failure in mortgage payment while interest rates rose to the highest level in years. Furthermore, with the bankruptcy in majority of subprime lenders, the collapse eventually hit Wall Street investment banks trading in mortgage-backed securities. In turn, it impacted on the stock market and other industries. The bursting of a speculative bubble in the US housing market triggered the Global Financial Crisis. The crisis spread to the rest of the world through capital flows, trade flows and commodity prices. In the aftermath of the crisis, share prices in Malaysia fell sharply from 95.0 in 2007 to 78.7 in 2009. Furthermore, merchandise exports earnings recorded a contraction of 9.5 percent in 2009 due to poor demand in the world market, contributed by contracted manufacturing exports and reduced earnings from the primary commodity products of crude oil, rubber and palm oil.

Global Economic Meltdown

Since late 2014, Malaysia's highly open and diversified economy was hit by a number of external and domestic shocks (IMF, 2016). As a net oil-exporting economy, Malaysia again was hit with the downturn in the crude oil industry towards October 2015 due to plunging crude oil prices. The oversupply of crude oil, coupled with declining demand, smashed the global market at a time where the economies of Europe and a number of developing countries were weakening due to sovereign debt issues and weak currency, respectively. Particularly, the spill-overs from China, with its sluggish growth, impacted

negatively on emerging market economies. Emerging market economies with a declining currency value, including Malaysia, became less attractive for investment and thus suffered capital outflows. These factors put a toll on economic growth as a whole.

2.6 Review on Leading Indicators

With the implementation of signals approach, Kaminsky et al. (1998) discovered that exports, deviations of the real exchange rate from trend, the ratio of broad money to gross international reserves, output and equity prices were among the potential explanatory variables due to their persistency in signalling during crisis periods. On the other hand, Bruggemann and Linne (2002) showed that overvalued exchange rate, weak exports and dwindling currency reserves are among the variables that possess good predictive power on crisis vulnerabilities assessment. Abiad (2003) discovered that signalled vulnerabilities of countries could be observed due to decline in competitiveness and slowdown in exports.

Yap (2002) discovered that foreign borrowing and high domestic credit exposed the economy to vulnerability, but the transformation of vulnerability to weakness in economy was due to crisis contagion from other country. Bussiere and Fratzscher (2006) revealed that overvaluation, lending boom, ratio of short term debt and reserve, ratio of current account over GDP, financial contagion and growth were among the key indicators contributing to the increment of crisis probability while Slingenberg and Haan (2011) noted that credit growth contains forecasting power for most of the 13 OECD countries under their research. Domicic (2015) identified that strong lending activity was a great

indicators for risk accumulation, particularly excessive credit growth and over-optimism in lending.

In assessing numerous indicators, Edison (2003) listed out a number of important indicators, namely, marked appreciation of the real exchange rate (relative to trend), high ratio of short-term debt to reserves, high ratio of M2 to reserves, substantial losses of foreign exchange reserves and sharp decline in equity prices while Andreou and Zdzienicka-Durand (2009) argued that real appreciation and short-term capital inflows are standard signals of impending financial market imbalance. Moreover, Morris (2010) utilised the data of inflation rate, budget deficit, current account deficit, changes in real effective exchange rate, loan and moving ratios as the leading indicators in developing its financial vulnerability index.

Six variables were included in Frankel and Saravelos's (2012) study, namely, drops in GDP and industrial production, currency depreciation, stock market performance, reserve losses, and participation in an IMF program. They concluded that level of reserves and real appreciation were the indicators which led in explaining crisis occurrence. In Bhattacharya and Roy's (2012) study on the case of India, the indications of fragility in Indian banking sector were real GDP slowdown, escalation in headline inflation rate, escalation in spread between policy rate and short term risk-free rate, escalation in broad money supply to foreign exchange reserves ratio, overvaluation of REER from trend, and decline in trade balance to GDP ratio. For the case of Indonesia, Suidarma et al. (2017) found that indicators of the growth of credit to total GDP, interest rate spread, the fiscal

deficit, current account, exchange rates and interest rate differentials were showing characteristic of early warning to its financial system vulnerability.

Pasricha et al. (2013) included REER volatility, stock market volatility, stock market decline, corporate spread, inverted term spread, interbank lending spread, and beta of banking sector in developing a financial stress index. They showed that the model could indicate vulnerabilities in financial system without neglecting information from market intelligence as well as regular monitoring of economic and financial data. In measuring financial stress for Turkish economy, Cevik et al. (2013a) discovered that the indicators of stock market volatility, exchange market pressure index, bonds spread and default probability of banking sector raised the country's financial stress. Islami and Kurz-Kim (2013) included five market segments of credit, foreign exchange, oil market, stock market and interbank market which are associated with the European economy. Other than that, Matkovskyy's (2012b) study focused on financial safety of South Africa by employing the indicators of monetary safety, currency safety and stock market safety.

As a result of financial globalisation, Abiad (2003) added that external factors to crises occurrence, such as volatility of global equity market and high-yield bond spread, can be considered for indicator development. Louzis and Vouldis (2012) distinguished the utilisation of market and balance sheet data was a novel feature in constructing systemic stress indicators. Moreover, domestic and global macro-financial vulnerabilities could be jointly implemented in order to greatly improve the performance of the forecasting models, as noted by Duca and Peltonen (2011). Li and Xiao (2016) incorporated domestic and

foreign variables from category of credit measures, asset prices, macroeconomic and foreign variables for the case of Canadian financial system due to its highly open economy.

Percic et al. (2013) revealed that financial liberalization usually precedes a banking crisis which is supported by credit booms, capital inflows and overvaluation of exchange rate while Feldkircher et al. (2014) discovered that high growth rate, large capital inflows, rapid credit expansion and real estate bubble typically occurred before a crisis starts to unfold. Oyong et al. (2018) added that vulnerabilities detection is more effective to offer more time for policymakers in establishing right policy to manage and avoid crisis besides monitoring economic condition.

2.7 Concluding Remarks

Since the Global Financial Crisis that shocked the world during 2008 and 2009, studies on financial stress in order to forecast financial crises have intensified. Central banks from developed, as well as developing countries, have been encouraged to develop effective early warning mechanisms to curb such impending crises where the spill-over effects, particularly, on the real economy, are beyond our imagination. Thereafter, non-parametric, indicator construction and other innovative approaches have emerged and gained empirical interest from researchers and practitioners for the development of early warning mechanisms that can at least trim down the spill-over effects in the case of crisis occurrence. Therefore, it is of interest to forecast vulnerabilities in the financial market for a whole economy. The focus of the study on a developing economy could contribute to the

literature of similar research where majorities of such studies emphasized on developed countries and regions.

The review on literature unveiled mixed findings for a potential indicator which pictures financial market vulnerability. Various indicators with characteristics from sentiment to leading have been adopted to forecast fluctuations in the financial market. Nevertheless, consideration of the best possible segment to represent financial market vulnerability, including external factors, should be made as financial globalisation is no longer common. As Aboura and van Roye (2013) highlighted, due to the significance of nonlinearities during a crisis situation, more innovative techniques should be implemented for the assessment of the actual spill-over effect of financial crises.

With the effect of financial globalisation and highly open economy of Malaysia, domestic and foreign indicators are as vital in assessing the vulnerability of Malaysian financial market. As noted by Feldkircher et al. (2014), high growth rate, large capital inflows, rapid credit expansion and real estate bubble typically occurred before a crisis starts to unfold. As a foundation for every economy, GDP measure would be a significant indicator for real sector while rapid credit expansion can be measured through credit growth or loan. Moreover, indicator related to housing approval or property price is useful in measuring impending issues from real estate sector which serves as an important investment sector for the economy of Malaysia.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In Chapter 3, the methodologies employed in this study are discussed by section. The first section touches on the data description and the sources of data. In addition, a discussion on the methodological foundation of the signals approach and the dynamic approximate factor model are presented in second and third sections, respectively, whereas the MSBVAR model is discussed in the following section. Finally, the selection of the leading indicators used in constructing the FVI is justified in the last section of this chapter.

3.2 Data Description

In the present study, the FVI was constructed by compiling macroeconomic, financial and property-related leading indicators into a single indicator. The selected leading indicators from the macroeconomy, the financial and the property markets comprised of imports (IM), the real GDP (RGDP), exports (EX), M2, total reserves (TR), share prices (SP), loans and advances (LA), the consumer price index (CPI), housing approvals (HA) and the real effective exchange rate (REER). To allow for benchmarking and directional accuracy, the credit-to-GDP ratio (CGDP) was employed as a benchmark series to proxy a country's financial vulnerability.

All available data were obtained on a monthly basis while the GDP and CGDP data were only available on a quarterly basis from their respective sources. All of the data mentioned above were compiled from the CEIC database except the CGDP, which was compiled and published by the Bank of International Settlements. The RGDP was computed by dividing the GDP with the CPI to obtain the data series in real terms. The interpolation technique proposed by Chow-Lin was applied to interpolate the volume and index data into a higher frequency series, ie, from a quarterly basis into monthly based data.

The period under study for forecasting vulnerability in the Malaysian financial system spanned from 1997 through 2017. For the empirical analysis in the present study, higher frequency data on a monthly basis were employed to gain a clearer picture of fluctuations in the Malaysian financial market and financial crisis forecasting. For all of the selected variables, the indicator carried the definition of the percentage change in the level of the variable with respect to its level 12 months before. The filtering of data using the 12-month percentage change ensured that the variables were stationary and did not contain seasonal effects.

3.3 Financial Vulnerabilities and Crises

Financial vulnerabilities are defined as situations of the greater possibility of causing stress to the future financial system (Pasricha et al, 2013). The exposure of particular risks to the financial system would determine the degree of financial vulnerability. Financial vulnerability, due to imbalances in the financial system, could

cause the risk of unexpected corrections to the system and even reducing its ability to endure other shocks.

To identify financial vulnerability, the detection of financial system imbalances is carried out to signal future financial stress episodes. A severe episode of financial stress is considered as a financial crisis. A financial crisis usually has a strong linkage with some phenomena, namely, a substantial change in the credit volume and asset prices, severe disruptions to the financial system in terms of intermediation and financing, serious issues on balance sheets and government intervention (Claessens & Kose, 2013). These phenomena often result in poor efficiency in the financial system, leading to a severe decline in economic activity (Mishkin, 1991).

As financial globalisation kicks in, the contemporary financial market is no longer evolving around the fundamental factors. Typically, financial crises are multidimensional events where a single indicator can hardly describe the whole phenomena, needless to say, it is difficult to find the exact roots of the crises. Though fundamental aspects, such as macroeconomic imbalances, internal or external shocks, are closely monitored by the relevant authorities, financial crises sometimes occur due to irrational factors (Claessens & Kose, 2013). The factors leading to financial turmoil may consist of an abrupt bank run, contagion and spill-over effects among financial markets, limits to arbitrage during a stressful time, the occurrence of asset busts, credit crunches, fire sales, and other related characteristics. Nevertheless, financial crises are often headed with booms in assets and credit which ultimately tail into busts (Thakor, 2015).

As financial crises are multidimensional events where a single indicator can hardly describe the occurrence, looking at a crisis from a macroeconomic point of view would be much more comprehensive. Accordingly, blending a series of financial and macroeconomic factors into a composite indicator will gauge the fundamental thinking behind the fluctuating financial market in Malaysia. To attain the objectives of this research, a non-parametric signals approach and a model-based dynamic approximate factor model, as proposed by Kaminsky et al. (1998), and Banbura and Modugno (2010, 2014) respectively, were adopted for the situation in Malaysia to construct the composite FVI with forward-looking features coupled with substantial forecasting power.

Alike to majority of indicator construction approaches, namely Puah et al. (2016) and Chong et al. (2018), this study initiated with the selection of a benchmark series that served as a good representation of the financial market in Malaysia. The credit-to-GDP ratio (CGDP) was selected as a benchmark series that characterised the evolvement of the financial market in Malaysia. A report by the Malaysian Rating Corporation Berhad (2016) distinguished the robustness of the credit-to-GDP ratio as a single indicator that can amass the financial vulnerabilities and crisis episodes for most economies. Moreover, Drehmann and Juselius (2014) pointed out the usefulness of the credit-to-GDP measure in vulnerabilities assessment. Moreover, Alessi and Detken (2018) and the European Central Bank (2017) noted that the sensibility of the credit-to-GDP measure as a buffer guide for countercyclical macroprudential. Following the procedure by Kaminsky and Reinhart (1999) and Puah et al. (2017), the occurrence of crises are identified when a deviation of 1.00 times above the measure's mean is seen during the period under study. The deviation is determined based on the accuracy of the crisis episodes identified.

Subsequently, this study deals with the selection of the individual leading indicators from financial and macroeconomic variables which contain the ability to signal vulnerabilities in the Malaysian financial market. The FVIs were constructed based on the signals approach and the dynamic approximate factor model to assess the forecasting performance of the non-parametric and model-based approaches in indicator construction respectively. The predictive ability of the composite indicators was assessed based on the noise-to-signal ratio (NTS) proposed by Kaminsky et al. (1998) and Kaminsky and Reinhart (1999). Moreover, episodes of financial vulnerability which signal an impending financial crisis would be identified through a period of crisis probability against the benchmark series in the Malaysian financial market.

Taking into consideration that the Malaysian financial market may inherit the non-linearity feature, we also modelled the financial market via a model-based approach. The model-based approach also aimed to capture the co-movement and asymmetric features of the potential variables into a well-defined model specification so as to characterise the evolution of the financial market within a parametric framework. As such, a sound statistical profile of the financial market was established. Given that the Malaysian financial market is cyclical in nature, the decomposition of the financial cycle into phases was almost as sensible as the business cycle. Therefore, the regime-switching framework was considered as an empirically sufficient method to characterise the dynamic financial market that endures recurrent switching of the cyclical phases in a persistent but irregular form. Among the classes of regime-switching models available in previous literature, the Markov-switching Bayesian vector auto-regression (MSBVAR) model proposed by Sims et al. (2008) was extended for financial vulnerability modelling for the Malaysian case.

The MSBVAR model permits for a great diversity of model specifications and dissimilar dynamic modifications of the observed variables after an alteration in regime.

3.4 Signals Approach

The signals approach, originally proposed by Kaminsky and Reinhart (1996, 1999), is an approach based on the extraction of signals by assessing the behaviour of single indicators. Before and during an event of financial stress, single indicators are believed to behave differently where signals will be emitted. The logical idea behind this approach is by quantifying the behaviour of a single indicator, moving from a tranquil to an abnormal stage, to act as an early warning tool for a financial stress event. They proposed using the signals approach to assess the vulnerability of an economy and to act as an early warning system for currency and banking crises. Later, Kaminsky et al. (1998) identified the leading indicators of currency crises for 15 developing countries and 5 industrial countries before the Asian Financial Crisis, 1997 (data period of 1970-1995). Based on the individual indicators' performance, they noted that the signals approach was supportive as an early warning system and that it would be a valuable instrument for the timely evaluation of the occurrence of a crisis.

Following Kaminsky and Reinhart (1996, 1999), the construction of the FVI based on the signals approach involved the selection of a group of potential indicators, followed by combining the single potential indicators into a composite indicator. The index aggregation procedure is detailed as follows:

- (i) Definition of financial crises that occurred during the period of observation.
- (ii) Identification of potential explanatory variables, which have the ability in signalling financial crises.
- (iii) Generation of an appropriate time series and its sample period and data frequency.
- (iv) Decision-making on the crisis window of 12 months, the timeframe in which the explanatory variables are likely to emit signals before a crisis as most of the macroeconomic and financial data available have relatively short series. Bruggemann and Linne (2002) and Kaminsky et al. (1998) employed a crisis window of 18 months to 24 months while Megersa and Cassimon (2015) and Nguyen and Duy (2017) utilised a 12-month or 24-month window.
- (v) Calculation of singular thresholds of crisis for each explanatory variable, where it cuts tranquil periods from crisis periods. Setting thresholds might be tricky as a threshold which is too high will result in a tendency to miss out on crisis detection, whereas, too setting the threshold too low will result in false alarms of impending crises. To detect the optimal threshold, minimisation of the NTS ratio is employed:

$$\omega_i = \frac{B/(B + D)}{A/(A + C)}$$

Where A is the quantity of months where a good signal was emitted (a crisis is accurately signalled), B is the quantity of months where a false alarm signal was emitted, C is the quantity of months where no signal was detected but was followed by a crisis and D is the quantity of months where no signal was emitted and was followed by a detected crisis. In short, the NTS ratio is the ratio of false alarms as a part of non-crisis tailed months and good signals as part of crisis tailed

months. This ratio is computed with various thresholds of crisis, which range from 5 to 30 percent for lower risk tail or 70 to 95 percent for upper risk tail of the distribution, relying on the predictable impact of the variable for each measure. For advance computation of the signals approach, thresholds generating the best-fit or lowest NTS ratio are implemented. For further analysis, the indicators that yield more false alarms than good signals (with a NTS ratio of above one) are neglected.

- (vi) Calculation of a composite indicator by introducing a second threshold (represented by T) to discriminate weak from strong signals, and by considering the timing of a signal where more current signals contain a higher weightage in the composite indicator. Firstly, the second threshold is calculated, by halving the percentile of the frequency distribution which was calculated for the first threshold. If a single indicator (represented by I) remains below its first threshold then it will be taken as zero value, if it passes the first threshold then it will be taken as a value of 1, if it passes the second threshold then it will be taken as a value of 2 where $k = 252$:

$$I_t^i = \begin{cases} 0 & I_t^i < T_1^i \\ 1 & \text{for } T_1^i \leq I_t^i < T_2^i \\ 2 & I_t^i \geq T_2^i \end{cases}; i = 1, \dots, k.$$

Secondly, a moving 12-month crisis window is computed, relying on the time-window determined beforehand, to compute a geometrically weighted signal of each indicator.

$$Z_t^i = \sum_{q=1}^l \frac{I_{t+1-q}^i}{i} ; l = \begin{cases} 18 \\ 24 \end{cases}, \text{ for } t \geq \begin{cases} 18 \\ 24 \end{cases}.$$

Third, these so-calculated Z-signals of each variable are combined by taking into account their prognostic quality through division with their individual NTS ratio.

$$CI_t = \sum_{i=1}^k \frac{Z_t^i}{\omega_i}.$$

The procedure generates a composite indicator of financial crises.

Though the deviations in the intensity of financial crisis signals can be observed using the composite indicator, the level of the index is unable to be interpreted. In this case, there is no possibility to draw implications on the probability of a financial crisis occurrence from the index. Therefore, following Bruggemann and Linne (2002), and Edison (2000), the calculation of the conditional probabilities for financial crises is carried out as follows:

$$\begin{aligned} P(\text{crises}_{t,t+12} | CI_l \leq CI_t < CI_u) \\ = \frac{\sum \#months \text{ for } CI_l \leq CI_t < CI_u \text{ and crisis follows}}{\sum \#months \text{ for } CI_l \leq CI_t < CI_u}. \end{aligned}$$

The calculation of the conditional probability can be conducted for each arbitrarily chosen interval between a lower and an upper limit. This conditional probability is the probability of a crisis occurring within 12-months under the condition that the indicator ranges between the lower and upper band. The calculation is done through division of total

number of months where the composite indicator falls between the lower and upper limits set follows by crisis happenings over the total number of months where the composite indicator falls between the lower and upper limits set. The lower and upper limits are categorised based on the distribution of composite indicators where equal range is set for each brackets. The calculated conditional probability is used to signal the risk of impending financial crises.

The compilation of the composite indicator yields the FVI in an index form. The movement of component of the FVI in relation to the benchmark series is assessed through a graphical examination. It is essential to note that, in multiple simulations of all of the possible groupings of the potential leading indicators, the graphical demonstration of the index component aided in the selection of the well-defined FVI that can replicate the fluctuations of the real financial vulnerabilities in Malaysia with practical leading qualities. Furthermore, forecasting ability analysis between the FVI and the benchmark series of the CGDP was undertaken to assess the ability of the constructed FVI in outlining the developments in the Malaysian financial market.

Given the simplicity of the signals approach, the approach offers substantial added value to the study of financial crisis forecasting (El-shagi et al, 2012). Firstly, without requiring highly restrictive assumptions compared to many nonlinear techniques, for example, the functional form of the nonlinearity, the signals approach permits the relationship between the indicators and the crisis probability to be in strong nonlinearities. Secondly, as the emitted signals originate from individual indicators, the sources of the signals in the composite indicator can be identified precisely. This enables policymakers to

identify the source of financial vulnerability and stress for a better response in terms of policy implementation.

3.5 Dynamic Approximate Factor Model

Financial vulnerability is unobservable and can only be reflected in fluctuations of various financial market and macroeconomic variables. In order to proxy financial vulnerability, construction of one single index is possible to act as an early warning tool for the state of financial vulnerability and therefore as a barometer of the financial system. Since financial vulnerability is reflected through different financial market and macroeconomic variables, a wide range of indicators from various market segments are considered.

To construct a single index of financial vulnerability, a model-based indicator construction approach of the dynamic approximate factor model (DAFM) was employed in this study. Originally, the dynamic factor model approach was frequently proposed by Geweke (1977), for forecasting, structural analysis and indicator construction in econometric applications. The application of the DAFM in this study follows the work of Banbura and Modugno (2010, 2014) and van Roye (2014) where the DAFM was built based on Watson and Engle's (1983) dynamic factor model. The factor model is employed to gauge the co-movement of the financial market and macroeconomic variables by extracting the underlying latent factor which is interpreted as a financial vulnerability. The financial/macroeconomic variable time series are de-meant and standardised before

proceeding with the analysis. In particular, the model can be written in state space form and the measurement equation is in the following form:

$$y_t = \Lambda f_t + \mu_t, \quad \text{where } \mu_t \sim iid N(0, C)$$

where y_t is a vector of stationary and standardised endogenous financial and macroeconomic variables, f_t is the $1 \times T$ common latent factor, while Λ is a $N \times 1$ vector of factor loadings for the time series. The factor loading values are the representation of a certain extent where the common factor influences the financial/macroeconomic variable time series. Using ten different variables in the construction, the value of T and N is ten each. The FVI is then denoted by $FVI_t = \Lambda f_t$. The $N \times 1$ vector μ_t is the denotation of the idiosyncratic component, which can be marginally correlated at all leads and lags. The dynamics of the latent factor f_t are defined in the following equation of transition:

$$f_t = A f_{t-1} + \varphi_t, \quad \text{where } \varphi_t \sim iid N(0, D).$$

where A is the matrix of coefficients of autoregressive to capture the latent factor f_t development in an autoregressive model across time. It is assumed that each μ_t and φ_t is normally distributed and cross-sectionally uncorrelated while the covariance matrix of C and D are computed as the expectations of sum of squared residuals conditional on the updated estimates of Λ and A . Following Banbura and Modugno (2010, 2014), a combination of a maximum-likelihood approach and the Expectation Maximisation algorithm, initially proposed by Dempster et al. (1977), was implemented for model estimation. In addition, a single factor was assumed to reflect the financial vulnerabilities

as additional factors do not significantly alter the outcome following the study by van Roye (2014). Using this approach, the treatment of data with ragged edges, mixed frequencies and an arbitrary pattern of missing data can be undertaken efficiently. Secondly, it provides a framework for the application of restrictions on the parameters. Finally, it is more efficient for small samples.

3.6 Diebold-Mariano Forecasting Ability Test

The Diebold-Mariano (2012) test is a test on two competing forecasts if they contain equal forecasting accuracy. The computation of the test statistic for one-step ahead forecasts is as follows:

$$s = \frac{\bar{d}}{s_d}$$

where $d = L_1 - L_2$ and L_i , $i = 1, 2$ is either a squared or absolute difference between the forecast and the actual,

$$L_i = (\hat{y}_i - y)^2 \text{ or } L_i = |\hat{y}_i - y|$$

where $\bar{d}$ and s_d are the mean and sample standard deviation of d .

3.7 Markov Switching Bayesian Vector Autoregression Model

Apart from the simplicity of financial crisis forecasting using the non-parametric and model-based indicator construction approach, theoretical and empirical financial cycle forecasting has revived interest in the co-movement of macroeconomic time series and the regime-switching nature of the macroeconomic activity and financial market. Generally, since the original contribution of Hamilton (1989), the concept behind regime-switching models of the business cycle is that the parameters of a time series model of some macroeconomic variables rely upon a stochastic, unobservable regime variable $s_t \in \{1, \dots, M\}$ which signifies the state of the business cycle. The number of regimes, M , is frequently presumed to be two, reflecting economic expansions and contractions.

The Markov-switching autoregressive time series model has arose as a leading methodology for the detection and dating of business cycle turning points, where later, it has also been successfully applied in to the financial and property cycles. Since Hamilton's (1989) original application of the Markov-switching model for the forecasting of the US business cycle, various extensions and refinements to the original version have been subsequently developed. Due to the inability of Hamilton's (1989) univariate Markov-switching models to reflect the idea of co-movement among time economic series, Krolzig (2003) proposed a Markov-switching vector autoregression model utilising multivariate generalisations of Hamilton's approach for the modelling of the Euro-zone business cycle using the real GDP and industrial production time series for European countries.

In order to investigate the amplification effects and feedback mechanism of financial vulnerabilities towards real economic activity, a richly specified Markov-

switching VAR (MSVAR) model was adopted in this study. The MSVAR framework employed in this study was able to identify two types of regime switches, namely, shifts in the volatility of shocks and changes in the structure of the shock transmission. Specifically, the estimation and statistical inference of the MSVAR model was based on the Bayesian methods, developed by Sims and Zha (2006) and Sims et al. (2008), which the Markov-switching Bayesian VAR (MSBVAR) model was named after. The model was set up with four endogenous variables: the financial vulnerability indicator, the inflation rate, the growth of industrial production and the change in the short-term interest rate (3-month KLIBOR). Similarly, to other regime-switching models, non-linear vector stochastic processes in form as follows should be considered:

$$y_t' A_0(s_t^c) = \sum_{j=1}^l y_{t-j}' A_j(s_t^c) + z_t' C(s_t^c) + \varepsilon_t' \theta^{-1}(s_t^v), \quad t = 1, 2, \dots, T$$

where y_t is an $n \times 1$ vector of endogenous variables, taking the value of 4; s_t^m , $m = v, c$ are unobservable (latent) state variables, defining diverse regimes for error variances, v , and for intercepts and slope coefficients, c . l is the VAR's lag length, taking the value of 1. z_t is a matrix of exogenous variables, which are set to a column vector of constants 1_n , for example, one intercept per equation. $A_0(s_t^c)$ is an $n \times n$ matrix of parameters describing contemporaneous relationships between the elements of y_t , $C(s_t^c)$ is an $1 \times n$ vector of parameters of the exogenous variables and $A_j(s_t^c)$ is a $n \times n$ matrix of parameters of the endogenous variables and T is the size of sample. ε_t is the $n \times 1$ vector of random shocks. The diagonal $n \times n$ matrix $\theta^{-1}(s_t^v)$ comprises of the standard deviations of ε_t . $\varepsilon_t' \theta^{-1}(s_t^v)$ epitomizes the structural shocks. The values of s_t^m are elements of $\{1, 2, \dots, h^m\}$ and change according to a first-order Markov process with the following state probabilities:

$$\Pr(s_t^m = i | s_{t-1}^m = k) = p_{ik}^m, \quad i, k = 1, 2, \dots, h^m.$$

Let us designate $Y_t = \{y_0, y_1 \dots y_t\}$ as the vector y stacked in the time dimension. We assume that ε_t is conditionally standard normal:

$$p(\varepsilon_t | Y_{t-1}, S_t, A_i) \sim N(0_{n \times 1}, I_n).$$

The variance-covariance matrix $\Sigma(s_t^m)$ of the correlated reduced-form regression errors can be recovered as follows:

$$\Sigma(s_t^m) = (A_0(s_t^c) \theta^2 (s_t^v) A_0'(s_t^c))^{-1}.$$

Since the matrix A_0 varies across coefficient regimes, s_t^c , the number of regimes of the correlated shocks is obtained as a multiple of the number of variance regimes of the structural shocks s_t^v since the coefficients and variances are presumed to switch stochastically and independently.

For structural model identification, the well-known Choleski decomposition technique, the basis of a triangular representation analogue, was adopted to identify the contemporaneous associations between the endogenous variables, as revealed in Matrix A_0 . The contemporaneous causality structure is determined by the ordering of the variables in triangular identification. For example, the assumption is that the variable of the first order is contemporaneously not correlated with other variables. The main interest of this study focuses on the linkages between financial vulnerability and the real economy where it is the main agenda of structural model identification.

Further, following Sims et al. (2008), a blockwise optimisation algorithm was employed to estimate the posterior mode. Firstly, the categorisation of parameters into blocks was carried out and the subsequent initial presumptions for the parameters were utilised in a hill-climbing quasi-Newton routine. At candidate maximum points, the estimator was subjected to random perturbations where the preliminary values were generated from where the optimisation process was restarted. This was done to ensure that the estimated posterior mode obtained was the most likely estimate.

The adopted MSBVAR model allowed for the estimation of two independent Markov chains, where one was on the structural error variances and the other was the identification of the dynamic interactions between the model variables as reflected in the parameters. For alternative specification assessment, the logarithm of marginal data densities (MDDs) as computed for each candidate specifications and the comparison on the goodness of fit was carried out. An elliptical distribution as a weighting function for the MDDs calculation was used to overcome numerical issues and better estimate the posterior density function. Two different sets of priors were used for model estimation where the standard Minnesota priors were used for the VAR parameters and the Dirichlet prior was used for the transition matrix.

Before investigating the transmission of financial shocks, the smoothed regime probabilities were assessed. Then, the regime-dependent impulse response functions (IRFs) were adopted for the assessment of economic reactions towards financial shocks in various regimes. To study potential state dependencies in the transmission of financial vulnerability

to the economic activity, a particular focus was on the implementation of the IRFs to capture the dynamic effects caused by structural shocks to the FVI.

As in all Bayesian models, the priors have to be selected cautiously as the outcomes rely essentially on them. Following Sims et al. (2008), the selection of priors was similar to that of their work, where it was suitable for a monthly model. The overall tightness of 0.65 was set for the matrices A and F . For relative tightness of the matrix F and the constant term, it was set at 0.13 and 0.1, respectively. For both the variances and coefficients, the Dirichlet priors were set to 5.6.

The MSBVAR framework adopted in this study brought about several advantages. Firstly, it provided a formal framework to study the existence of nonlinearities where it allowed discrete shifts rather than a framework with time-varying-parameters, as drifting parameters will be unable to capture the shifting occurrences that frequently happen in the financial markets. Secondly, variance and coefficient switching can be differentiated where coefficient switching signifies either changes in an agents' behaviour at times of high financial vulnerability or that the environment they face is substantially dissimilar while variance switching signifies that financial crises are a matter of happenchance. Thirdly, the feedback and amplification effects between the economic and financial sectors can be explored using the adopted framework. Finally, the employed Markov-switching framework allowed estimation on a model with a combination of high dimensionality.

3.8 Chow-Lin (1971) Interpolation Technique

The Chow-Lin (1971) interpolation method is a regression-based technique which searches for series values, x , by linking one or more higher-frequency indicator series, Z , to a lower-frequency benchmark series following the equation below:

$$x(t) = Z(t)\beta + a(t)$$

where β is a coefficient vector while $a(t)$ is a random variable of zero mean and covariance matrix V . For index, stock and flow variables, the same constraints are applicable to the interpolated series where Chow and Lin (1971) originally implemented the generalised least squares method for estimation purpose of the covariance matrix assuming that the errors followed an AR(1) process. Nevertheless, a state space model is used in the Eviews econometric analysis software. The following time series model is implemented for the states:

$$a(t) = pa(t - 1) + \epsilon(t)$$

Where $\epsilon(t) \sim N(0, \sigma^2)$ and $|p| < 1$. For the estimation of parameter p and β , maximum likelihood and the Kalman filter was used where later, the series was interpolated by means of calculation with Kalman smoothing.

3.9 Selection of Leading Indicators

As financial crises are multidimensional events where a single indicator can hardly describe the occurrence, looking at a crisis from a macroeconomic point of view would be

much more comprehensive. Accordingly, blending a series of financial and macroeconomic factors into a composite indicator will gauge the fundamental thinking behind the fluctuating financial market in Malaysia. Subsequently, this study deals with the selection of the individual leading indicators from financial and macroeconomic variables which contain the ability to signal vulnerabilities in the Malaysian financial market. Table 3.1 summarizes the selected leading indicators with justification.

Table 3.1: Justification for Selected Leading Indicators

Leading Indicator	Justification
Real Sector	
Real GDP	Economic recession often precedes crises. The crisis vulnerability of an economy increases as economic growth slows down. (Slingenberg and Haan, 2011; Frankel and Saravelos, 2012; Bhattacharya and Roy, 2012)
Share Price	Downturns in the stock market are linked with crises. (Pasricha et al., 2013; Cevik et al., 2013a)
Housing Approvals	The property sector plays a huge part in the whole economy where it is associated closely with economic development. Low housing approvals indicate a slowdown in economic growth. (Feldkircher et al., 2014; Kim and Shi, 2015)
CPI	High inflationary pressure negatively affects the financial sector through various channels and it may proxy for misalignments at the macroeconomic level. (Morris, 2010; Bhattacharya and Roy, 2012)
External Sector	
Exports	Weak exports reduce a country's income from foreign exchange trading for public financing. (Kaminsky et al., 1998; Yap, 2002; Abiad, 2003; Percic et al., 2013)
Imports	Rising imports are a symptom of an overvalued exchange rate, which also signals a loss of competitiveness. (Kaminsky et al., 1998; Abiad, 2003; Percic et al., 2013)
Real Effective Exchange Rate	Overvaluation of exchange rates is a driving force to potential crisis build-up. (Bussiere and Fratzscher, 2006; Bhattacharya and Roy, 2012; Percic et al., 2013)
Financial Sector	
M2	Expansionary monetary policy is related to the onset of a crisis. (Bhattacharya and Roy, 2012; Matkovskyy, 2012b)
Loans and Advances	Rapid credit expansion exposes the financial system to the risk of balance sheet imbalance. (Morris, 2010; Duminic, 2015)
Capital Account	
Total Reserve	A country's total reserve provides a cushion for financial or economic shocks. (Bruggemann and Linne, 2002; Edison, 2003; Frankel and Saravelos, 2012)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Chapter 4 reports the empirical findings together with discussion and justification. The empirical findings on the financial vulnerability indicator construction analysis are divided into two sections. The first section discusses indicator construction analysis based on the non-parametric methodology of the signals approach while the second section touches on the indicator construction analysis based on the methodology of the dynamic approximate factor model. The analysis of the feedback effect follows after the discussion on indicator construction. The last section of the chapter presents on the outcome of spill-over effect analysis through the utilisation of the Markov Switching Bayesian Vector Autoregression Model.

4.2 Analysis Outcome of Signals Approach

Prior to the construction of the FVI using the signals approach, the potential leading indicators were filtered from data on macroeconomic, financial market and property-related series. The selection of potential leading indicators was carried out based on the NTS ratio, proposed by the signals approach. Ten individual indicators containing leading attributes with an NTS ratio of less than 1.0 were selected through the process, primarily from the real sector, external sector, financial sector and the capital account. For the real sector indicators, the real GDP, Malaysian share prices, housing approvals and the CPI

were selected while the leading indicators measuring the performance of the external sector included exports, imports and the real effective exchange rate. For the financial sector and the capital account, the leading indicators selected were M2, loans and advances, and total reserves, respectively. In addition, the risk tails for each leading indicator are presented in Table 4.1. Based on the period under study, the leading indicators of real GDP, share price, housing approvals, exports, real effective exchange rate and total reserve raise financial vulnerability prior to crisis occurrence. On the other hand, the leading indicators of CPI, imports, M2 and, loan and advances demonstrate negative impact towards financial vulnerability prior to crisis happening.

Table 4.1: Risk Tails of Leading Indicators

Leading Indicators	Risk Tail
Real Sector	
Real GDP	Lower Tail
Share Price	Lower Tail
Housing Approvals	Lower Tail
CPI	Upper Tail
External Sector	
Exports	Lower Tail
Imports	Upper Tail
Real Effective Exchange Rate	Lower Tail
Financial Sector	
M2	Upper Tail
Loans and Advances	Upper Tail
Capital Account	
Total Reserve	Lower Tail

Most of the selected indicators held a good predictive ability in measuring vulnerabilities towards financial crises. All of the ten selected indicators contained an NTS ratio of less than 1. Figure 4.1 depicts the NTS ratio of the selected indicators. Among the ten selected indicators, exports had the lowest NTS ratio of 0.025, followed by housing approvals with 0.101, the real effective exchange rate with 0.138, the real GDP with 0.148, share prices with 0.203, total reserves with 0.329 and the consumer price index with 0.391. Indicators with an NTS ratio of higher than 0.5 included imports with 0.536 while M2 with 0.614. The indicator with the highest NTS ratio was loans and advances, holding a ratio of 0.686. The empirical findings of the FVI constructed based on the signals approach revealed that weak export, the decline in housing approvals, an overvaluation of the exchange rate and economic slowdowns as the most common triggers of the occurrence of a financial crisis in Malaysia.

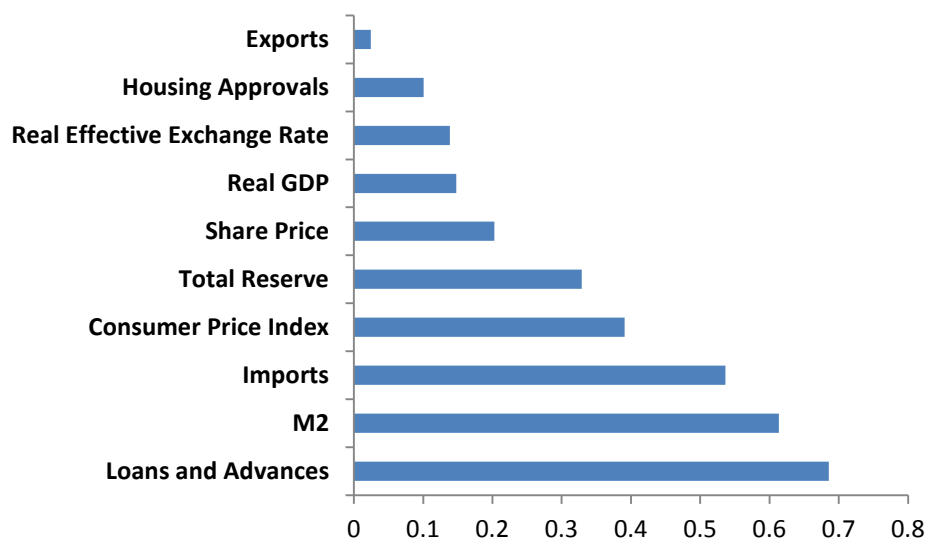
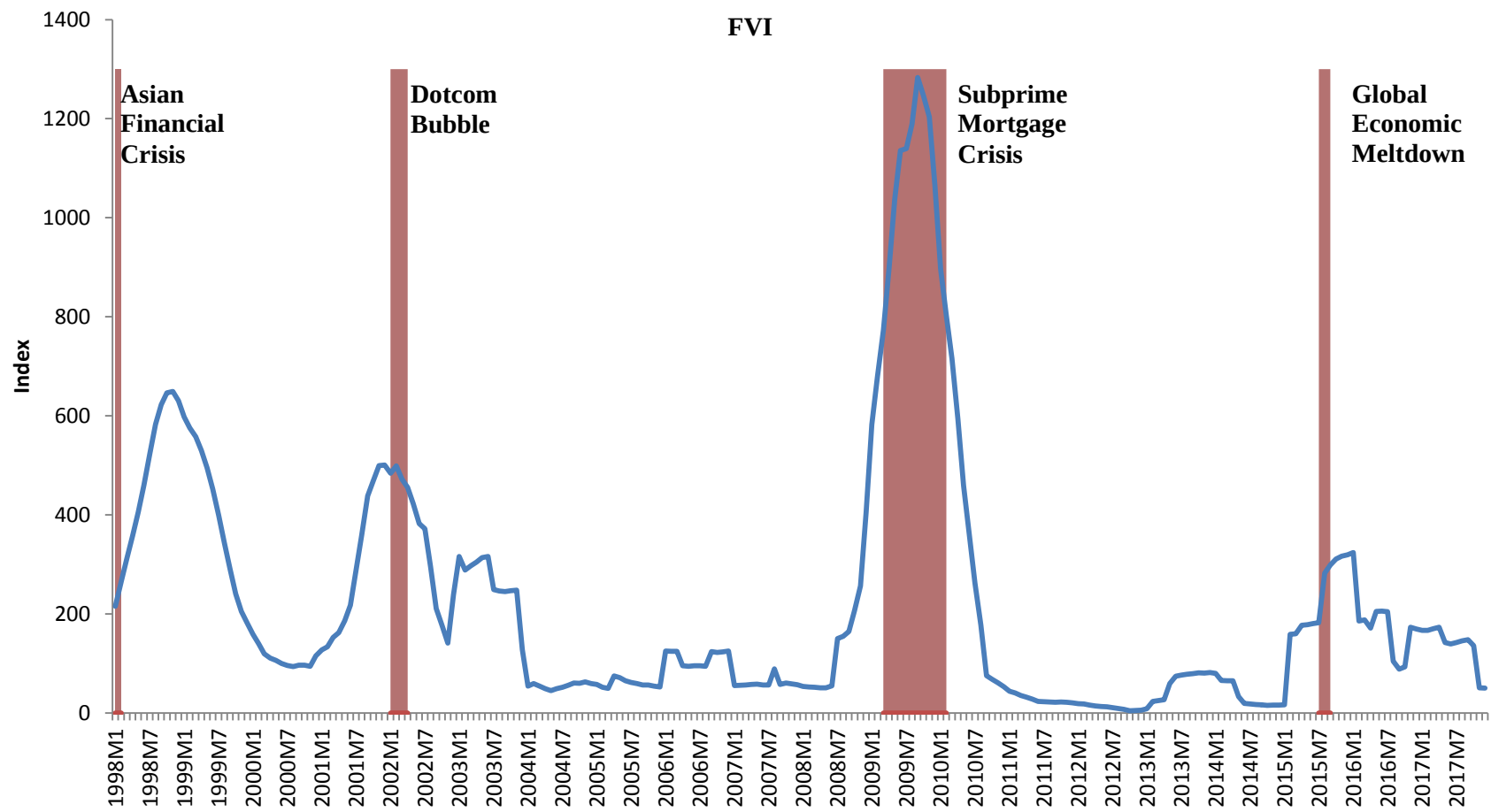


Figure 4.1: Noise-to-signal Ratio of Each Indicator

As for the average lead time of an indicator emitting the first signal of a possible detected crisis, expanding money supply was among the initial indicators coupling with

higher CPI and the shrinking in investment activities, particularly the equities market prior to the occurrence of a crisis. Hence, based on the lead time of the signals emitted by individual leading indicators prior to crisis, M2 had an average lead time of 9.0 months, share price with 7.5 months while the consumer price index recorded 5.2 months in advance on average.

Following the selection of leading indicators, the individual indicators were then compiled into a single composite indicator of financial vulnerability by employing the compilation procedure of Bruggemann and Linne (2002). The vulnerability of the Malaysian financial market and economy as a whole to financial crisis increases with the upsurges in the constructed indicator itself. Figure 4.2 shows the graphical illustrations of the FVI and the credit-to-GDP ratio. Chronologically, the constructed FVI through the signals approach successfully traced four major financial episodes for the Malaysian financial market during the period of study between 1998M1 and 2017M12. The four major financial events encompassed the Asian Financial Crisis in 1998, the dot-com bubble in 2001, the Subprime Mortgage Crisis in 2008-2009 and the global economic meltdown in 2015.



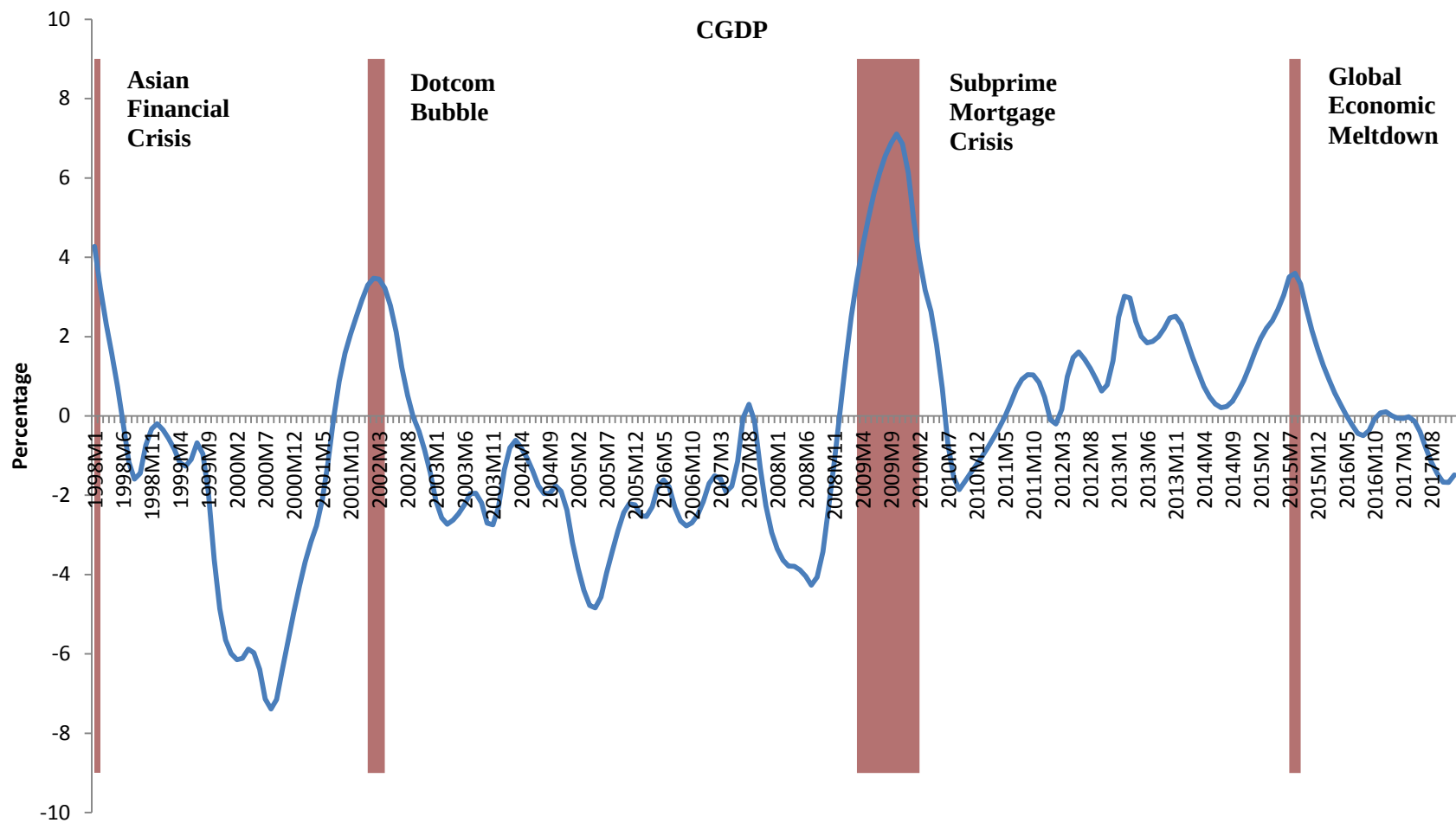


Figure 4.2: Graphs of FVI and CGDP, 1998M1-2017M12

Table 4.2 depicts the conditional probabilities of a financial crisis through the constructed FVI. For a wide range of values of the FVI, the probability of a crisis occurrence upsurges along with the increment in the indicator itself. The value of the constructed FVI surpassing 600 and above would imply that the probability of a crisis occurring would be 72.22 percent. On the other hand, the unconditional probability is recorded at only 12.58 percent.

Table 4.2: Conditional Probabilities of a Financial Crisis

Financial Vulnerability Indicator	Probability of a Crisis (%)
0 - 200	13.92
201 - 400	21.95
401 - 600	43.48
> 600	72.22
Unconditional Probability: 12.58%	

The empirical findings of the FVI constructed based on the signals approach revealed that the causes of crises are multidimensional. As the fundamental drivers of an economy, weak exports, a decline in housing approvals, an overvaluation of the exchange rate and economic slowdowns are the common triggers of the occurrence of a financial crisis in Malaysia. The weakening of exports and property demand indicate poor business sentiment both locally and internationally which then leads to an economic slowdown as a whole. This highlights the importance of internal and external macroeconomic environments in defining the financial vulnerability of an economy.

4.3 Analysis Outcome of Dynamic Approximate Factor Model

Besides the indicator construction based on the non-parametric procedure, this study also employed a model-based methodology of the dynamic approximate factor model. Following the factor modelling proposed by Banbura and Modugno (2010, 2014) and van Roye (2014), the FVI was constructed according to the factor loadings of the DAFM presented in Table 4.3. The selected indicators from the macroeconomy, the financial and property markets comprised of imports, the real GDP, exports, M2, total reserves, share prices, loans and advances, the consumer price index, housing approvals and the real effective exchange rate. The top three indicators with the highest factor loadings of the DAFM were imports, the real GDP and exports with loadings of 0.897, 0.894 and 0.819, respectively. The empirical findings of the constructed FVI based on the DAFM showed that a weakening of the international trading market would eventually lead to an economic downturn as the source of the fundamental driver became affected. This also highlighted the importance of both internal and external macroeconomic environments in defining the financial vulnerability of an economy.

Table 4.3: Factor Loadings of the DAFM

Indicator	λ_i
Imports	0.897
Real GDP	0.894
Exports	0.819
M2	0.526
Total Reserve	0.405
Share Price	0.345
Loans and Advances	0.235
Consumer Price Index	0.155
Housing Approvals	0.118
Real Effective Exchange Rate	-0.159

Note: The values are extracted from the loading matrix Λ of the DAFM.

Chronologically, Figure 4.3 illustrates the contribution of the key indicators to financial vulnerabilities and Figure 4.4 depicts the graphical illustration of the constructed FVI based on the DAFM. The constructed FVI successfully traced six major financial episodes for the Malaysian financial market, encompassing the Asian Financial Crisis in 1998, the dot-com bubble in 2001, the oil price hike in 2004, the Subprime Mortgage Crisis in 2008-2009, the property cooling in Malaysia in 2013 and the global economic meltdown in 2015. During the Asian Financial Crisis in 1998, the main contributor of financial vulnerabilities build-up was from the financial sector, spilling over to the external and real sector while the dot-com bubble bursting in 2001 contributed hugely by both a weak external sector and real sector. Besides, the weak external factor, the spill-over effect of the bubble burst in the US housing market, led to a meltdown of the real sector in Malaysia during the Subprime Mortgage Crisis in 2008-2009. As for the property cooling in Malaysia in 2013 and the global economic meltdown in 2015, the slowdown in real sector

and the weak external environment contributed to the vulnerabilities in the Malaysian financial market, respectively.

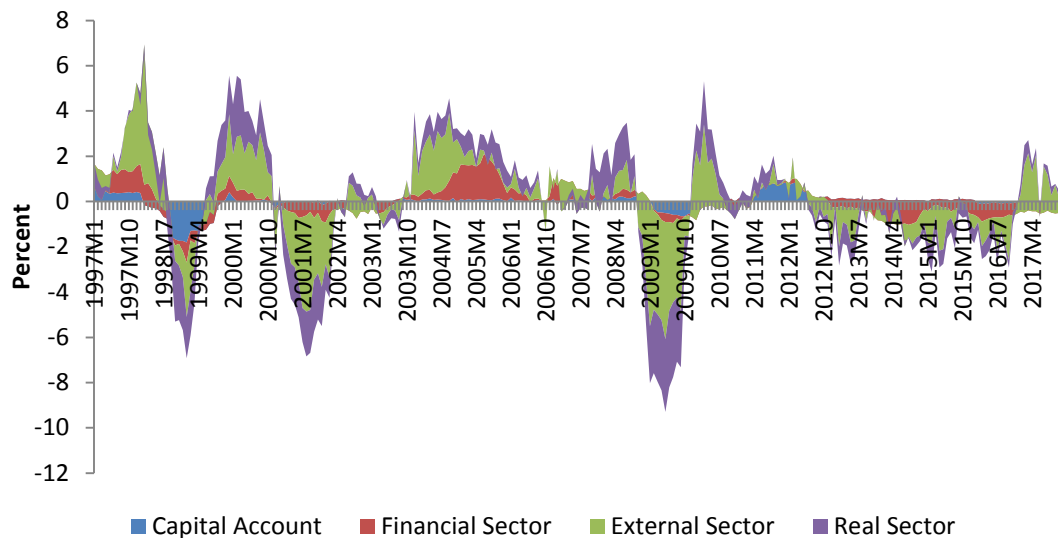


Figure 4.3: Contribution of Key Indicator for FVI of DAFM

The early 1990s saw an ample amassing of outstanding domestic credit in the banking system, with heavy exposure to the property sector due to booming property prices between 1991 and 1996. This amplified exposure to the property market further deteriorated the banks' financial positions as this lending led to a property oversupply in the country, reflected with a peak in the credit-to-GDP ratio of 167.2 percent in the last quarter of 1997 (Refer Figure 1.1). The main contributor of financial vulnerabilities build-up was from the financial sector, spilling over to the external and real sector. In July 1997, the Thai currency depreciated sharply, causing an abrupt withdrawal of short-term capital out of the country. Vulnerable to speculative attack, this transmitted a wave of uncertainty and volatility in the foreign exchange and equity markets where the Kuala Lumpur Stock Exchange (KLSE) index declined drastically from 1216 points in January 1997 to only 302 points in August 1998 (Nambiar, 2003). The breakdown in the financial sector impacted

the real sector. By August 1998, the economy was in recession with shrinkage in output of 2.8 percent and 6.8 percent, respectively, in the first and second quarter (Athukorala, 2010). The unemployment and inflation rates increased tremendously, reaching 3.9 percent in 1998 and 6.3 percent in June 1998, respectively.

In the midst of recovering from the Asian Financial Crisis, the economy and particularly the stock market in the United States (US) were booming. During the dot-com boom, especially after 1996, stock prices of Internet-based companies in the US shot up at a very fast pace. The dot-com boom resulted in the NASDAQ composite index increasing from about 600 points in 1996 to peak at 5046.86 points in 2000. On March 13, 2000, the NASDAQ composite index dropped from 5038 points to 4879 points, which triggered a huge sell-off of information technology (IT) stocks. The NASDAQ stock index continued to plunge and the dot-com bubble in the US economy burst in 2001. The bursting of the dot-com bubble in the US adversely affected the Malaysian external sector and real sector where the real gross domestic product (GDP) growth negated with 1.2 percent in the third quarter of 2001. As Malaysia was one of the Asian economies engaging in subordinate activities for dot-com companies in the US, the manufacturing sector was affected the most due to the low demand for electronic products following the dot-com bubble, especially from export markets of Europe and Japan, with a plummet of 10.4 percent in total export in 2001 as compared to the preceding year. As a result, a huge number of workers involved in manufacturing were out of work suddenly which caused the unemployment rate to shoot up.

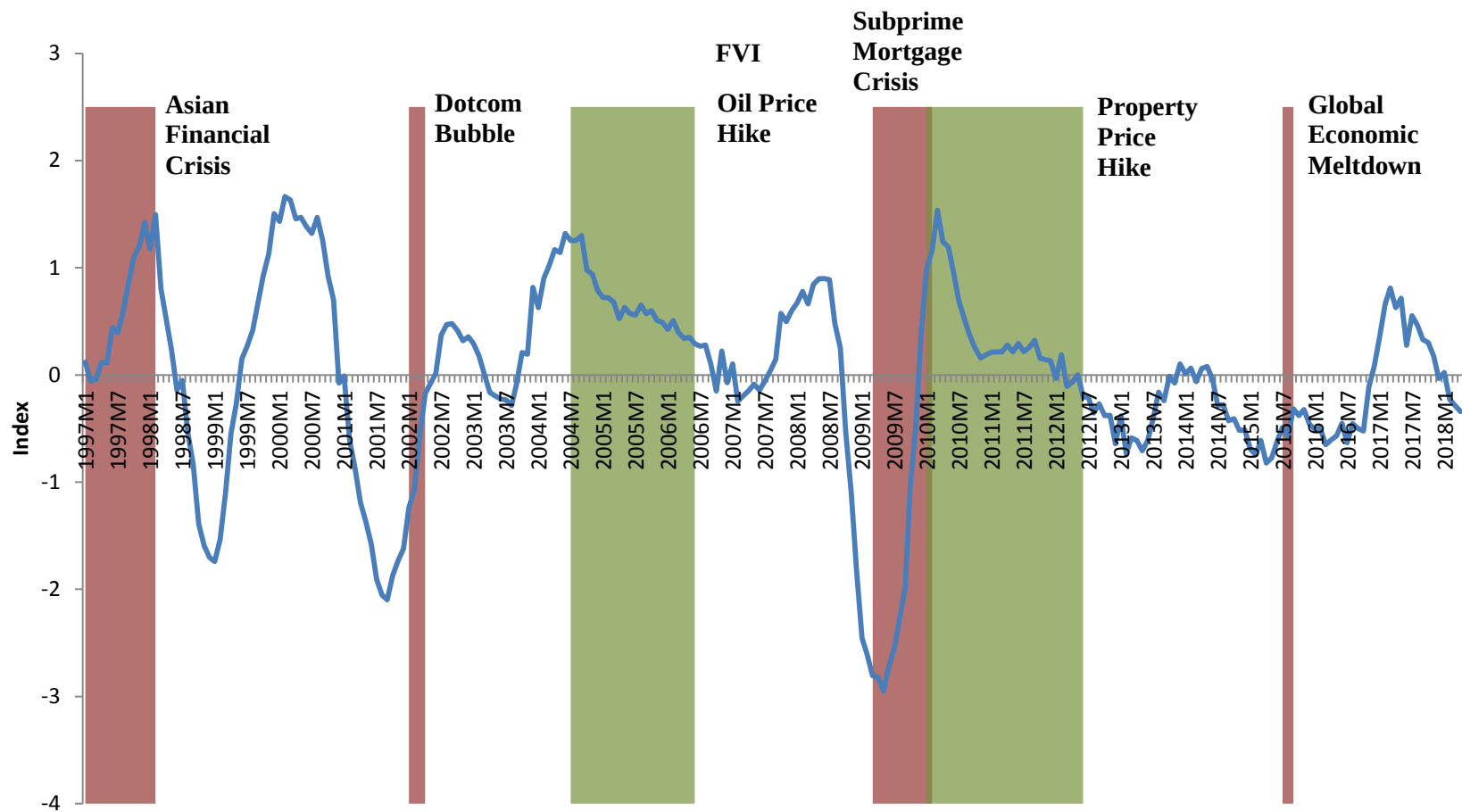
Starting in 2003, the demand for crude oil began to increase as Asian economies recovered from the Asian Financial Crisis and the bursting of the dot-com bubble in the US in late 2001. Furthermore, global oil production struggled to accommodate the rapidly growing demand from China and the US. From 2003 to 2005, China alone accounted for nearly 35 percent of global crude oil demand. In 2004, crude oil prices began to increase and even doubled from the price level in 2003. Due to continued worldwide economic progression, the global crude oil demand grew and the crude oil price rose above US\$70 per barrel in 2006. As an oil-exporting country, Malaysia also imports oil from other countries. Although revenue from exporting crude oil was profitable for Malaysia, the spike in oil prices pressured the overall price to a significantly higher level in the nation, which in turn brought about adverse effect to the economy besides setting inflationary pressures on consumers. As a result, the demand for property declined as shown through the tumble in housing approvals of 36 percent between 2003 and 2006.

In 2008, the bursting of the speculative bubble in the US housing market triggered the Global Financial Crisis. The crisis spread to the rest of the world through capital flows, trade flows and commodity prices. In the aftermath of the crisis, share prices in Malaysia fell sharply from 95.0 in 2007 to 78.7 in 2009. The bursting of the US housing market bubble impacted on the housing demand in the local front, with the decrease of 15.4 percent in housing approvals between 2007 and 2009. Furthermore, merchandise export earnings recorded a contraction of 9.5 percent in 2009 due to poor demand in the world market, contributed by contracted manufacturing exports and reduced earnings from the primary commodity products of crude petroleum, rubber and palm oil. With Malaysia's

industrial diversification into manufacturing since the 1990s, the impact of plunging primary commodity prices due to the global turmoil was cushioned.

After 2009, demand and investment in the Malaysian property market surged, especially for residential properties. Property prices escalated significantly due to the increasing demand and supply factor where the housing approvals for the period of 2010-2012 nearly doubled. The most striking figure was the Malaysian House Price Index (MHPI), which registered a strong rise from an annual growth rate of 3.2 percent in the preceding 10-year period to a rate exceeding 10 percent in 2012, which induced massive concerns regarding the sustainability of such price hikes. As an unsustainable property market could drag the financial and economic markets down as well, the real property gains tax was reintroduced and the imposition of a loan-to-value ratio of 70 percent was enforced in 2010 to reduce the speculative activities in the property market and to slow down sales in secondary markets.

Since late 2014, Malaysia's highly open and diversified economy has been hit by a number of external and domestic shocks. As a net oil-exporting economy, Malaysia was again hit by the downturn in the crude oil industry around October 2015 due to plunging crude oil prices. The oversupply of crude oil, coupled with declining demand, hit the global market at a time when economies of Europe and some developing countries were weakening. In particular, the spillover from China with its sluggish growth impacted negatively on emerging market economies. These emerging market economies with a declining currency value, including Malaysia, became less attractive for investment and thus suffered capital outflows. This put a toll on economic growth as a whole.



Notes: Shaded regions in green indicate recessions based on report of various issues on Malaysia by BNM and World Bank.

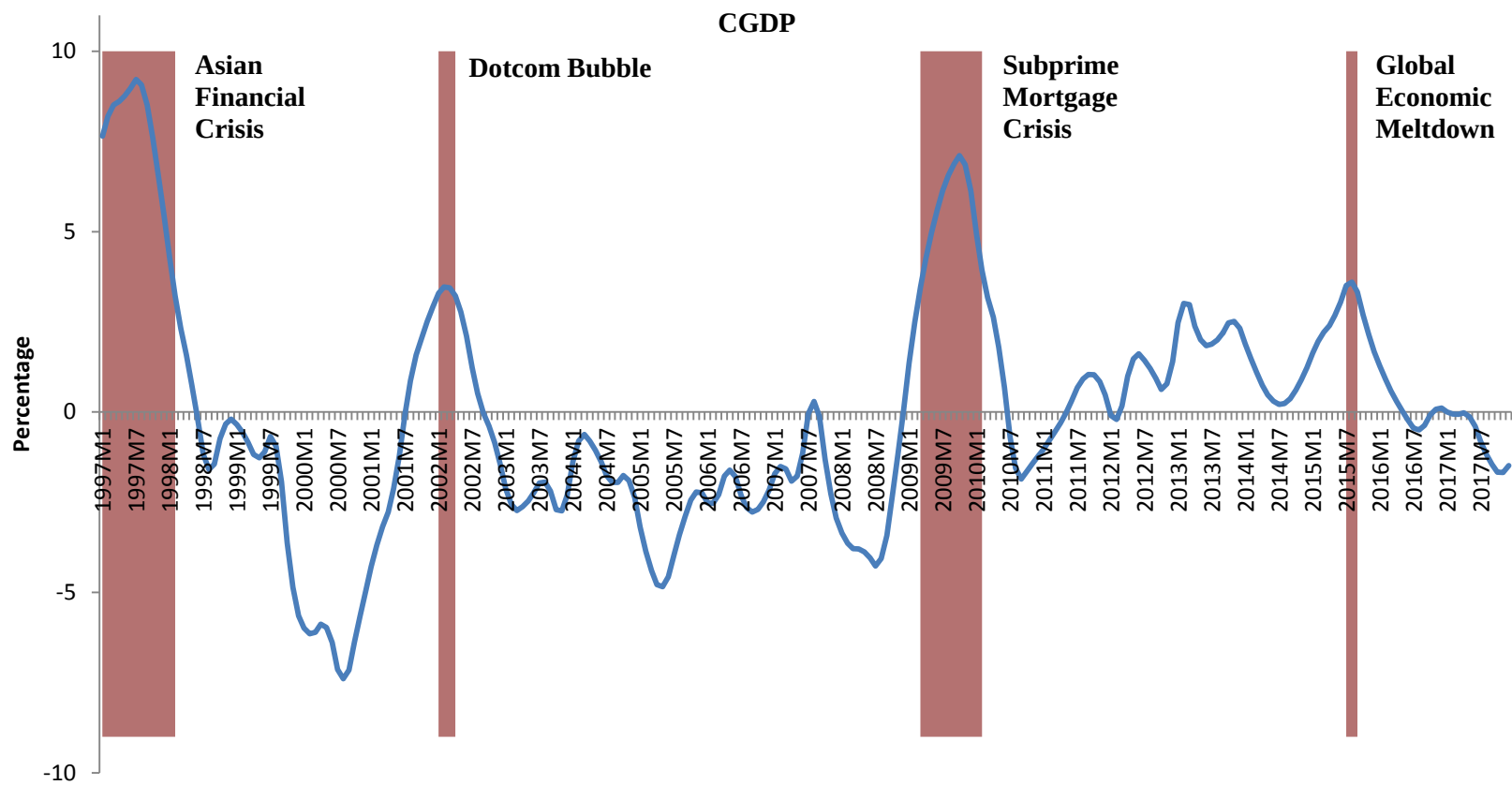


Figure 4.4: Graphs of FVI and CGDP, 1997M1-2018M4

4.4 Analysis Outcome of Noise-to-signal Ratio

In order to evaluate the forecasting performance of the constructed FVI based on the signal approach and the DAFM, the constructed indicators were compared to the benchmark of the CGDP for the computation of the NTS ratio for each indicator, as proposed by Kaminsky et al. (1998). The outcome of the analysis of the NTS ratio is presented in Table 4.5 and Table 4.5. For the FVI constructed through the signal approach, the indicator with the lowest NTS ratio at a threshold of 0.2 with 0.188, hitting 84.62 percent in true signal rate and 15.82 percent in false signal rate. For the FVI constructed through the DAFM, the indicator with the lowest NTS ratio was at the threshold of 0.2 with 0.098, hitting 83.87 percent in true signal rate and 8.23 percent in false signal rate. On the lowest NTS ratio of both indicators, the FVIs constructed through the signal approach and the DAFM contain an average lead time in crisis detection of 2.67 months and 5.25 months, respectively. This concluded that the constructed FVI based on the DAFM was a comparatively better indicator in terms of a lower NTS ratio and the average lead time, which will be implemented for further analysis.

Table 4.4: Number of Signals Emitted by Signal Quality

Threshold	FVI_Signals Approach on CGDP				FVI_DAFM on CGDP			
	A	B	C	D	A	B	C	D
0.2	22	25	4	133	26	13	5	145
0.3	24	41	4	117	30	20	4	138
0.4	28	48	3	110	31	43	4	115
0.5	35	54	2	104	35	62	3	96
0.6	35	75	2	83	38	83	3	75
0.7	35	99	2	59	13	58	3	101
0.8	36	122	2	36	10	39	4	120
0.9	39	141	1	17	4	22	5	137

Note: A is the quantity of months where a good signal was emitted (a crisis is accurately signalled), B is the quantity of months where a false alarm signal was emitted, C is the quantity of months where no signal was detected but was followed by a crisis and D is the quantity of months where no signal was emitted and was followed by a detected crisis.

Table 4.5: Noise-to-signal Ratio

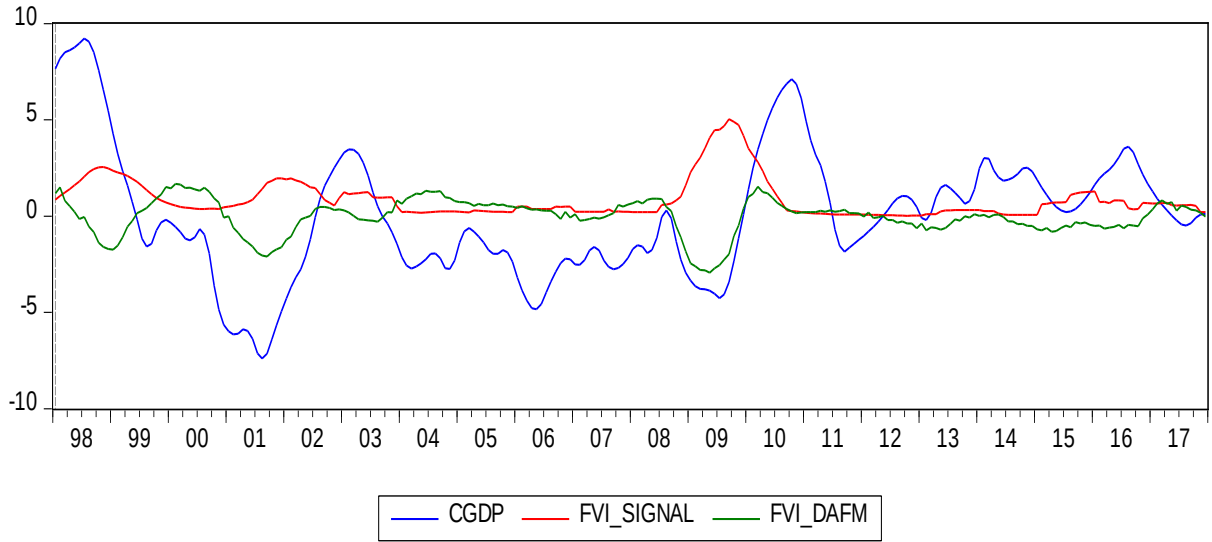
Threshold	FVI_Signals Approach on CGDP			FVI_DAFM on CGDP		
	True	False	Noise-to-	True	False	Noise-to-
0.2	84.62	15.82	0.188	83.87	8.23	0.098
0.3	85.71	25.95	0.303	88.24	12.66	0.143
0.4	90.32	30.38	0.336	88.57	27.22	0.307
0.5	94.59	34.18	0.361	92.11	39.24	0.426
0.6	94.59	47.47	0.502	92.68	52.53	0.567
0.7	94.59	62.66	0.662	81.25	36.48	0.449
0.8	94.74	77.22	0.815	71.43	24.53	0.343
0.9	97.50	89.24	0.915	44.44	13.84	0.311

4.5 Analysis Outcome of Forecasting Ability of Indicators

In order to evaluate the forecasting ability of the FVIs constructed through signals approach and DAFM approach, the forecasting evaluation is done following Diebold and Mariano (2012). Based on the forecasting evaluation of the indicators from Table 4.6, the evaluation findings reveal that four out of six of the forecasting evaluation criteria pointing towards the FVI constructed through DAFM approach. This suggests that the FVI constructed through DAFM approach outperforms and contains higher forecasting power compared to the FVI constructed through signals approach. Shaded boxes in Table 4.6 represent the outperforming indicator for each forecasting evaluation criteria and vice versa. In addition, Figure 4.5 illustrates forecast comparison graph of CGDP, FVI_Signal and FVI_DAFM.

Table 4.6: Forecasting Evaluation of Indicators

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
FVI_Signal	3.561735	2.736085	192.8084	161.6282	0.767684	1.963235
FVI_DAFM	3.291064	2.647183	153.4202	173.0772	0.778610	1.410812

**Figure 4.5:** Forecast Comparison Graph of CGDP, FVI_Signal and FVI_DAFM

4.6 Analysis Outcome of Markov Switching Bayesian VAR

Financial vulnerability can be considered as a tail event with the assumption of two regimes a priori. Financial vulnerability can be a sudden and stochastically stressful event with certain tenacity within either regime. With the implementation of the Markov Switching Bayesian Vector Autoregression model (MSBVAR), the identification of low-vulnerability and high-vulnerability regimes can be undertaken. Following Sims et al. (2008), four variables were selected for the purpose of the MSBVAR modelling. The MSBVAR model encompassed the FVI, the inflation rate, industrial production growth and the short-term interest rate KLIBOR. The FVI constructed through DAFM approach is

selected for analysis of MSBVAR model based as it demonstrates better forecasting ability compared to that constructed through signals approach. Figure 4.7, Figure 4.8, Figure 4.9 and Figure 4.9 depict the trends of each of the four selected variables for the MSBVAR model.

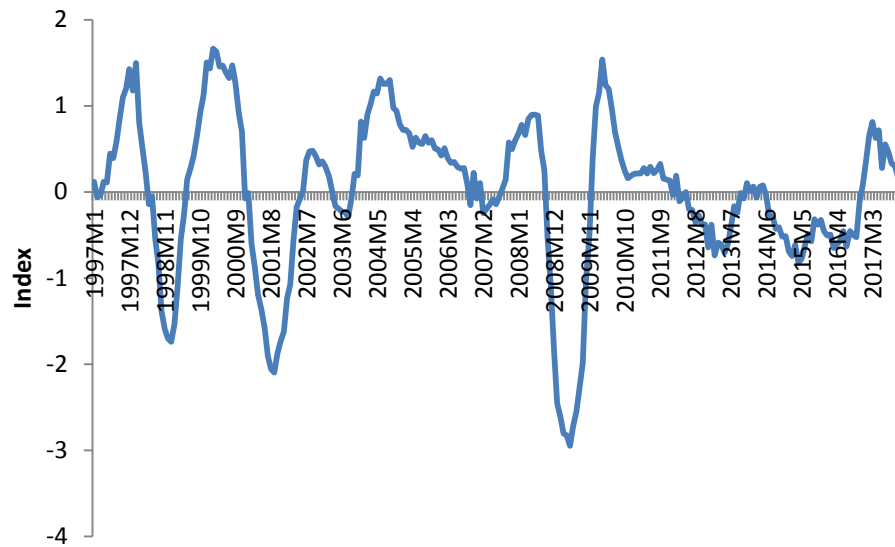


Figure 4.6: Financial Vulnerability Indicator, 1997M1-2017M12

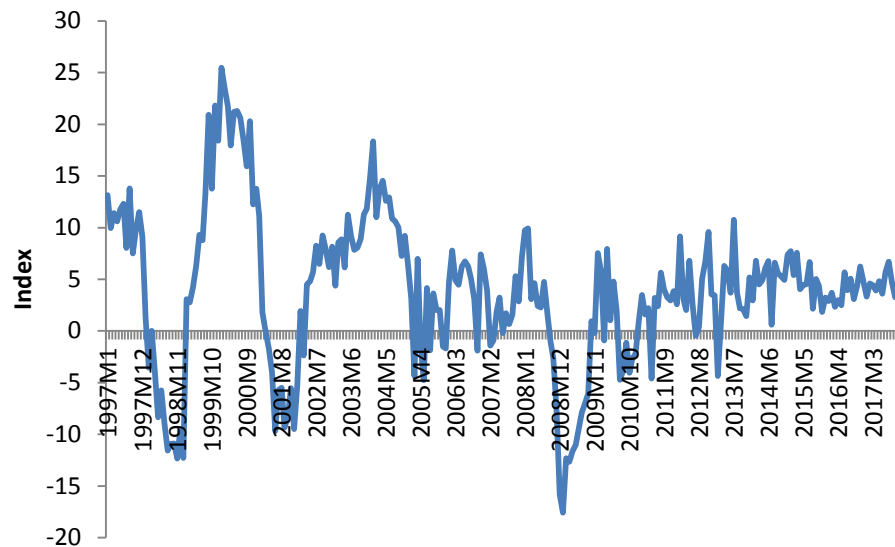


Figure 4.7: Changes in Industrial Production Index, 1997M1-2017M12

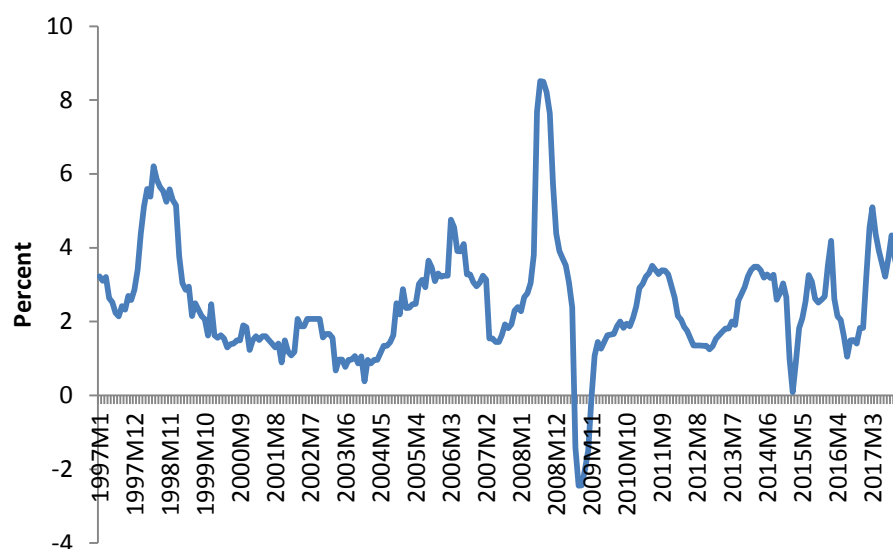


Figure 4.8: Inflation Rate, 1997M1-2017M12

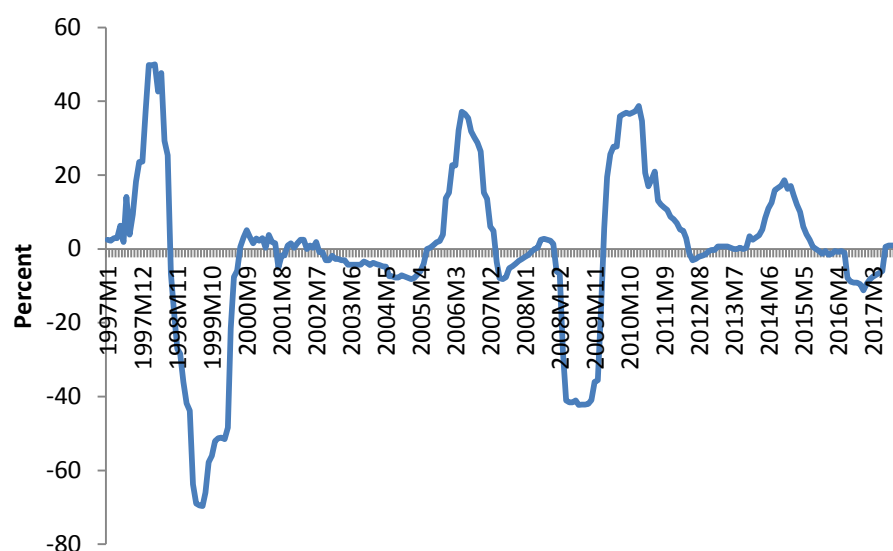


Figure 4.9: Changes in Short-term Interest Rate KLIBOR, 1997M1-2017M12

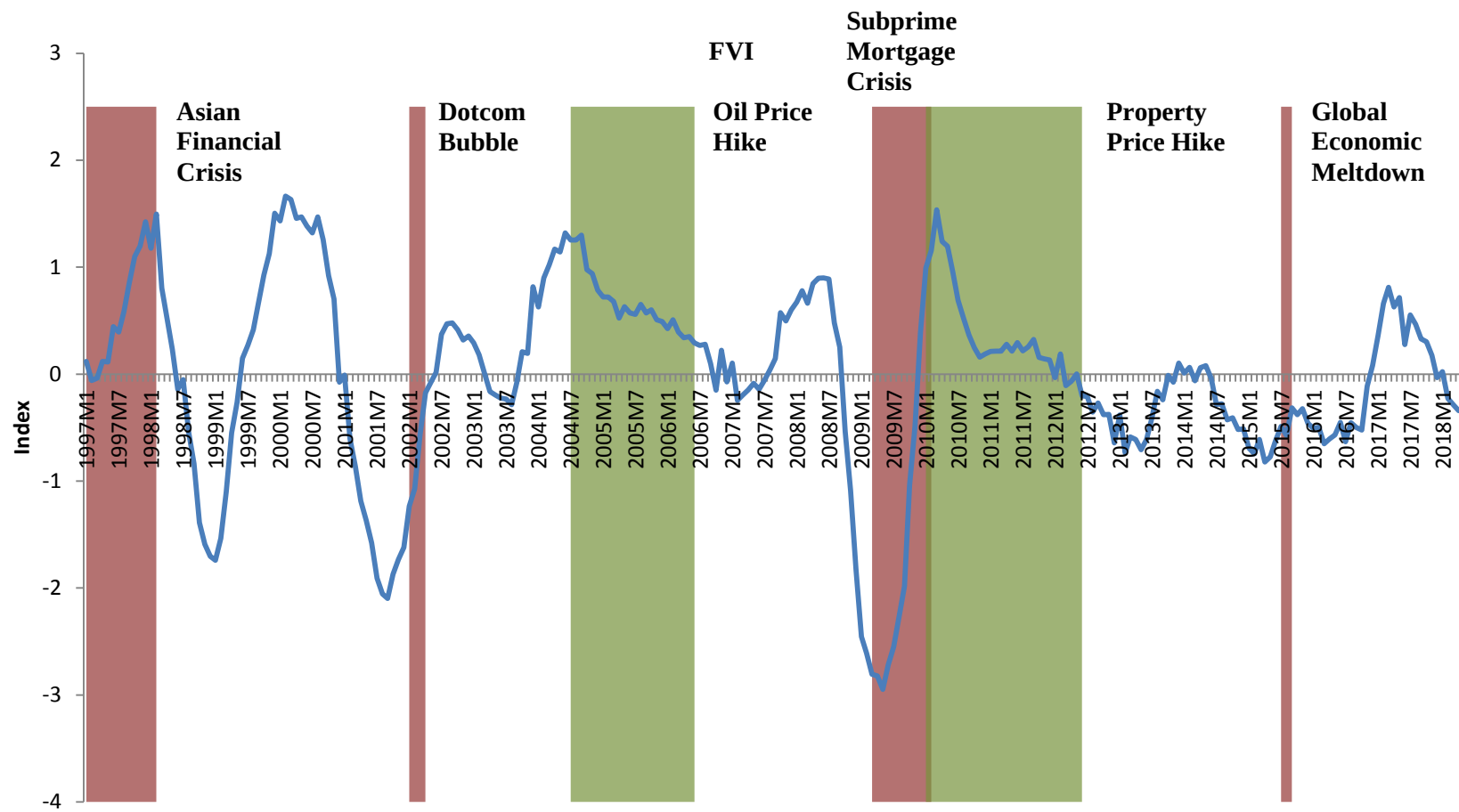
Table 4.7 shows the analysis outcome of the MSBVAR model. The MSBVAR model enables the differentiation between variance and coefficient switching. Coefficient switching signifies either changes in an agents' behaviour at times of high financial vulnerability or that the environment they face is substantially dissimilar while variance

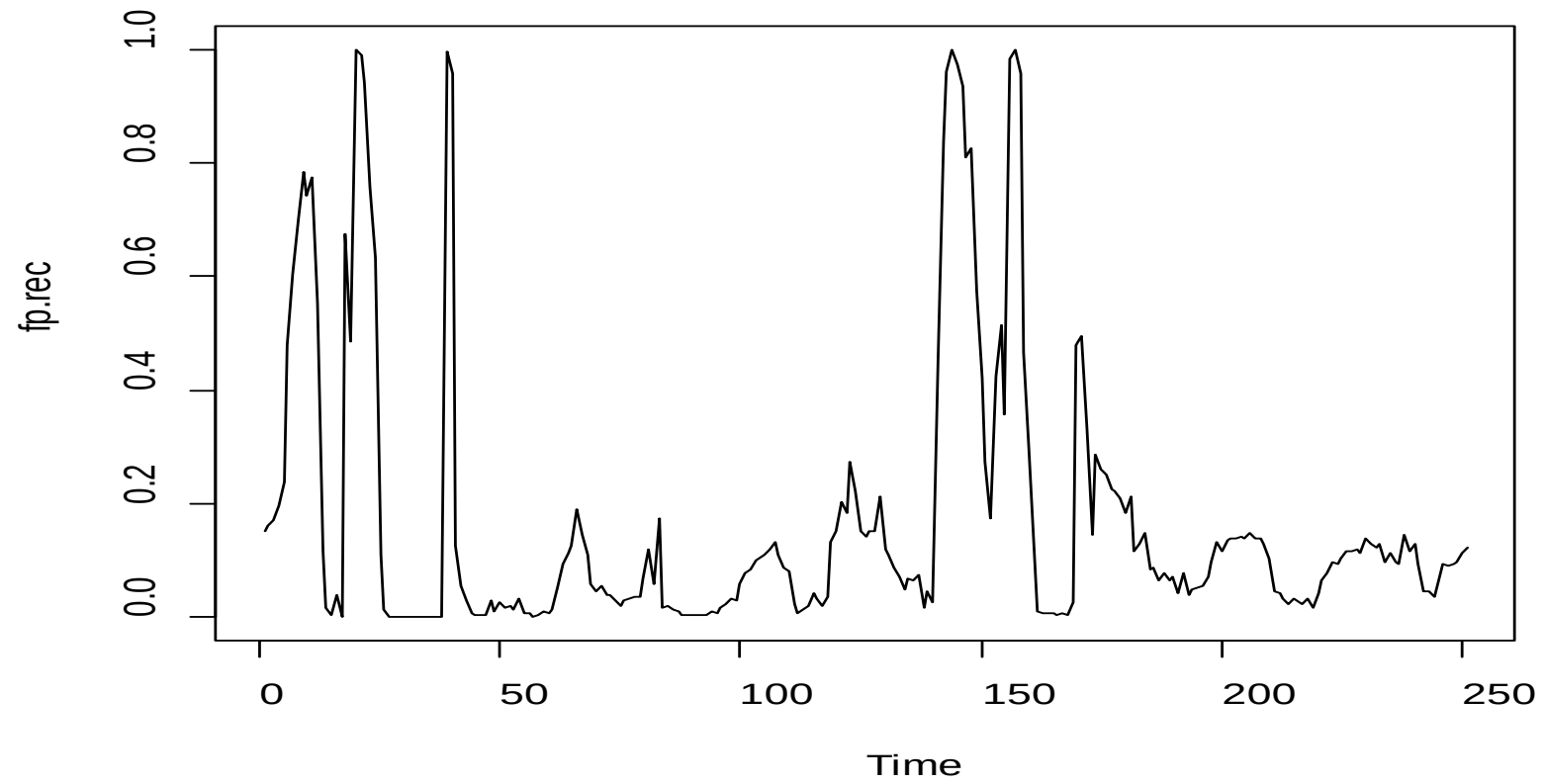
switching signifies that financial crises are a matter of happenchance. Firstly, the model of 1v1c with constant coefficients and constant shock variances was not a favourable model according to the data. Extending the constant model with a second state in coefficients did not improve the goodness-of-fit. This implied that the transmission of financial vulnerability in the Malaysian economy should be anticipated either as a nonlinear or a non-Gaussian phenomenon, or both. With that, the comparison between the 2v1c model and 2v2c model concludes that the 2v1c model recorded a better goodness-of-fit. Therefore, the transmission of crises is not simply a non-Gaussian phenomenon, but a non-linear phenomenon as well.

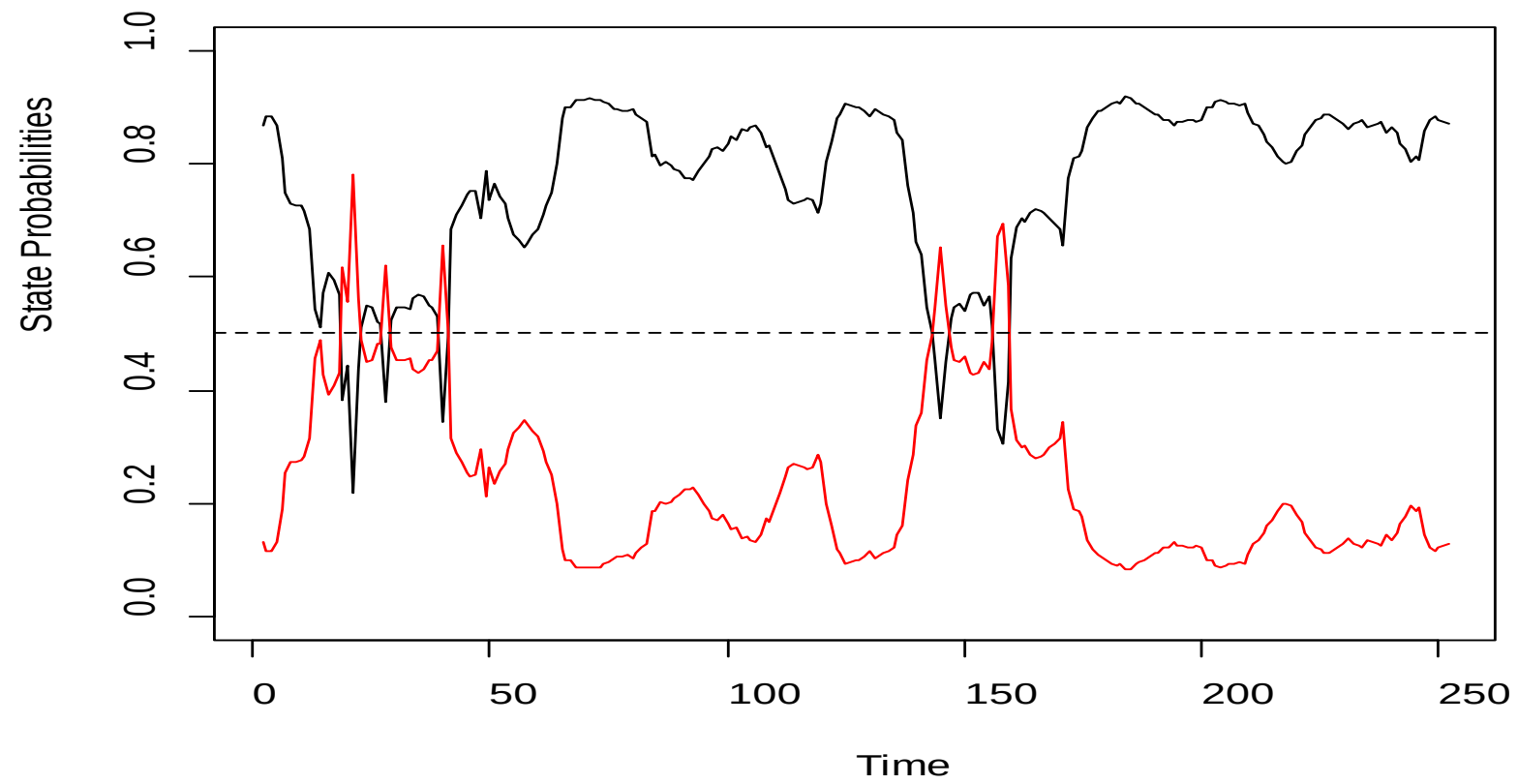
Table 4.7: Analysis Outcome of MSBVAR Model

Model	1v1c	1v2c	2v1c	2v2c
Marginal Data Densities	2117.39	1928.40	6340.31	3456.17
Difference from the best-fit	-4222.92	-4411.91	0	-2884.14

Figure 4.10 illustrates the FVI, its conditional standard deviation and the smoothed state probabilities over the period of study. The model reveals that the probability of the Malaysian economy to be in a high-vulnerability regime (state 2) was very high during the Asian Financial Crisis, the dot-com bubble burst and the Subprime Mortgage Crisis. On the other hand, the high probability of regime switching was detected during the period of the property price hike in 2011 and the global economic meltdown in 2015. As for the variance switching, the empirical findings indicate a short period of switching in variance after the Asian Financial Crisis and before the Subprime Mortgage Crisis, serving as a robust check for coefficient switching.



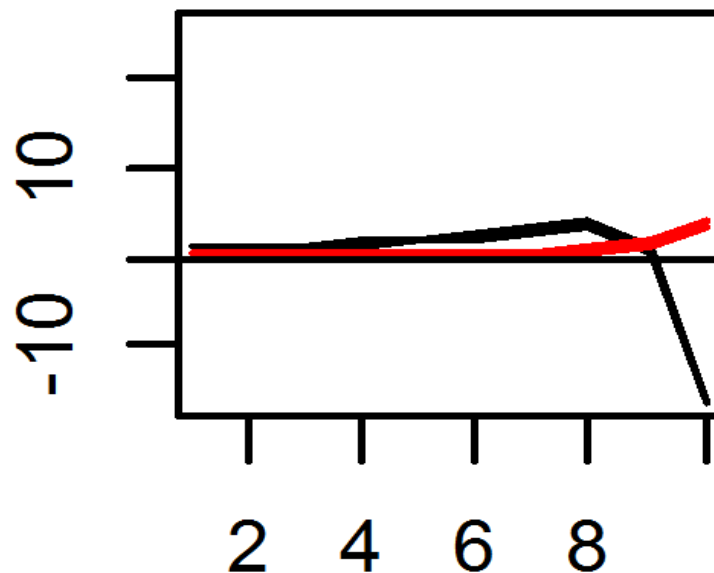




Note: The time frame for 0 to 252 represents 1997M01 to 2017M12.

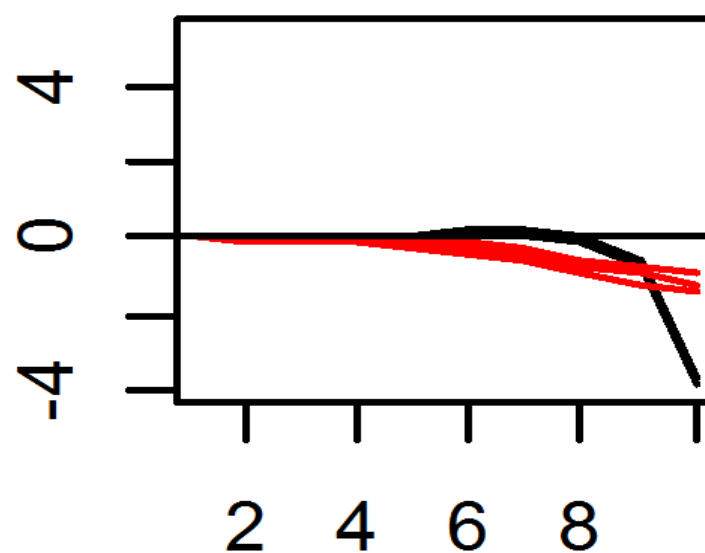
Figure 4.10: Markov Switching Model for FVI

For impulse response analysis, the graphical responses of a change in industrial production, the inflation rate and the short-term interest rate to a shock in the constructed FVI are documented in Figure 4.11, Figure 4.12 and Figure 4.13, respectively. Between low-vulnerability and high-vulnerability regimes, the feedback effects of financial vulnerability are substantially dissimilar. In a low-vulnerability regime, there are no significant changes in production, the inflation rate and the short-term interest rate in response to a financial vulnerability shock. On the other hand, a financial vulnerability shock brought about significant negative effects on industrial production and the inflation rate while it produced a significant positive effect on the short-term interest rate in a high-vulnerability regime. The findings from the MSBVAR model highlighted the prominence of nonlinearities during a high vulnerability period and this was consistent with studies in other economies.



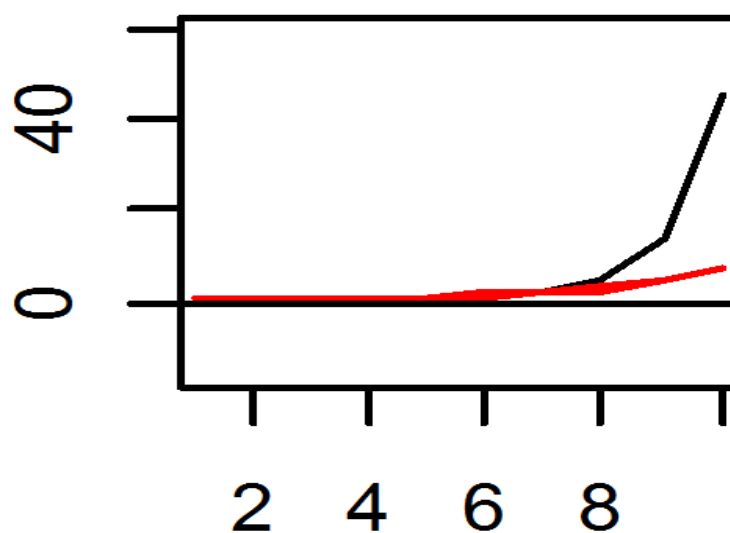
Note: The red line refers to the response in a low-vulnerability regime and the black line refers to the response in a high-vulnerability regime.

Figure 4.11: Impulse Responses of IPI for Shock to the FVI



Note: The red line refers to the response in a low-vulnerability regime and the black line refers to the response in a high-vulnerability regime.

Figure 4.12: Impulse Responses of Inflation Rate for Shock to the FVI



Note: The red line refers to the response in a low-vulnerability regime and the black line refers to the response in a high-vulnerability regime.

Figure 4.13: Impulse Responses of KLIBOR for Shock to the FVI

During the period of high vulnerability, financial vulnerability shock brings about a significant negative effect on industrial production. Based on the chronology of high financial vulnerabilities in Malaysia, this phenomenon is significant with the slowdown in industrial production. The weak global condition and demand during the Subprime Mortgage Crisis in 2008-09 adversely impacted economic development in Malaysia, indicated by the rapid dwindling in export performance and industrial production (Bank Negara Malaysia, 2008).

As for inflation, a financial vulnerability shock produces a significant negative effect on the inflation rate in the high-vulnerability regime. Based on past Malaysian financial development, the inflation rate does not necessarily show a sign of increasing during a high vulnerability period. This scenario can be pictured during the Subprime Mortgage Crisis in 2008-09 where the inflationary pressure was abated due to poor global demand, a sharp fall in commodity prices and the prevalent contagion effect across financial markets (Bank Negara Malaysia, 2008). Other than that, during the period of high vulnerability during the Global Economic Meltdown in 2015, the inflationary pressure in Malaysia remained subdued as a result of a decline in crude oil and commodity prices (Bank Negara Malaysia, 2015a). Based on the IMF Primary Commodity Price Index, the index signified a 32.2 percent decline in global commodity prices during that period of time.

On the other hand, a financial vulnerability shock produces a significant positive effect on the short-term interest rate in the high-vulnerability regime. During the period of high vulnerabilities in Malaysia, the short-term interest rate, KLIBOR, was used as a major

policy instrument in order to promote the attractiveness of investment in Malaysia and to prevent the outflow of funds. Particularly, during the Asian Financial Crisis in 1997-98, the 3-month KLIBOR was raised to 11.06 percent in June 1998 to curb the excessive outflow of funds from the country (Hasan, 2001). As for the period of high vulnerability during the Subprime Mortgage Crisis in 2008-09, the KLIBOR remained stable before rising as a result of the anticipation of the monetary policy response to rising inflation from the market (Bank Negara Malaysia, 2008).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study investigated the fluctuations of the Malaysian financial market and predicted the early signals of financial market vulnerability using the Financial Vulnerability Indicator (FVI) constructed through the signals approach and the dynamic approximate factor model before exploring the effect of financial vulnerabilities by implementing the Markov Switching Bayesian Vector Autoregressive (MSBVAR) model. The period under study spanned from 1997 through to 2017. For empirical analysis, data on a monthly basis were utilised to construct the FVI for the Malaysian financial market.

Through the construction of the FVI based on the signals approach proposed by Kaminsky and Reinhart (1996, 1999), ten individual indicators containing leading attributes with an NTS ratio of less than 1.0 were selected through a methodological process, primarily from the real sector, the external sector, the financial sector and the capital account. Among the ten selected indicators, the top four leading indicators with the lowest NTS ratio were exports with 0.025, followed by housing approvals with 0.101, the real effective exchange rate with 0.138 and the real GDP with 0.148, implying that weak exports, a decline in housing approvals, an overvaluation of the exchange rate and an economic downturn contain good data to enable forecasting to gauge financial vulnerabilities during crises. Hence, the constructed FVI successfully traced four major financial episodes for the Malaysian financial market, encompassing the Asian Financial

Crisis in 1998, the dot-com bubble in 2001, the Subprime Mortgage Crisis in 2008-2009 and the global economic meltdown in 2015. The empirical findings of the constructed FVI based on the signals approach revealed that the causes of crises are multidimensional with weak exports, a decline in housing approvals, an overvaluation of the exchange rate and economic slowdowns as the most common triggers of the occurrence of financial crises in Malaysia. Thus, they highlight the importance of internal and external macroeconomic environments in defining the financial vulnerability of an economy.

Besides the indicator construction based on the non-parametric procedure, this study also employed a model-based methodology using the dynamic approximate factor model following the methodology by Banbura and Modugno (2010, 2014) and van Roye (2014) in constructing an FVI for financial vulnerabilities. The selected indicators from the macroeconomy, the financial and the property markets comprised of imports, the real GDP, exports, M2, total reserves, share prices, loans and advances, the consumer price index, housing approvals and the real effective exchange rate. The top three indicators with the highest factor loadings in the DAFM were imports, the real GDP and exports with loadings of 0.897, 0.894 and 0.819, respectively. The constructed FVI successfully traced six major financial episodes for the Malaysian financial market, encompassing the Asian Financial Crisis in 1998, the dot-com bubble in 2001, the oil price hike in 2004, the Subprime Mortgage Crisis in 2008-2009, property cooling in Malaysia in 2013 and the global economic meltdown in 2015. The empirical findings of the FVI constructed based on the DAFM showed that a weakening in the international trading market would eventually lead to an economic downturn as the source of the fundamental driver became affected. This

also highlighted the importance of internal and external macroeconomic environments in defining the financial vulnerability of an economy.

To evaluate the forecasting performance of the constructed FVI based on the signals approach and the DAFM, the constructed indicators were compared to the benchmark of the CGDP for the computation of the NTS ratio of each indicator, as proposed by Kaminsky et al. (1998) and Kaminsky and Reinhart (1999). The constructed FVI through the DAFM had the lowest NTS ratio at the threshold value of 0.2 with 0.098, hitting 83.87 percent in true signal rate and 8.23 percent in false signal rate. Regarding the lowest NTS ratio of both indicators, the FVIs constructed through the signals approach and the DAFM contained an average lead time in crisis detection of 2.67 months and 5.25 months, respectively. This concluded that the constructed FVI based on the DAFM was a comparatively better indicator in terms of a lower NTS ratio and the average lead time to foretell financial vulnerabilities prior to crisis occurrence.

Financial vulnerability can be considered as a tail event with the assumption of two prior regimes. With the implementation of the Markov Switching Bayesian Vector Autoregression model (MSBVAR), the identification between low-vulnerability and high-vulnerability regimes can be undertaken. Following the methodology of Sims et al. (2008), four variables were selected for the purpose of MSBVAR modelling, namely, the FVI constructed through the DAFM, the inflation rate, industrial production growth and the short-term interest rate KLIBOR. Based on the computation of marginal data densities, the 2v1c model recorded a better goodness-of-fit, suggesting that the transmission of crises was not simply a non-Gaussian phenomenon, but a non-linear phenomenon as well. The

model revealed that the probability of the Malaysian economy in a high-vulnerability regime (state 2) was very high during the Asian Financial Crisis, the bursting of the dot-com bubble and the Subprime Mortgage Crisis. On the other hand, the high probability of regime switching was detected during the period of property price hikes during 2011 and the global economic meltdown in 2015. Through the impulse response analysis, there were no significant changes in production, the inflation rate and the short-term interest rate in response to a financial vulnerability shock in a low-vulnerability regime but financial vulnerability shock brings about significant negative effects on industrial production and inflation while producing significant positive effects on the short-term interest rate KLIBOR in a high-vulnerability regime. The findings from the MSBVAR model highlighted the prominence of nonlinearities during a high vulnerability period and this is consistent with studies on other economies.

5.2 Policy Recommendations

This segment provides recommendations for policy formation to monitor and, at least to a certain extent, to minimise the impacts of financial vulnerabilities on the Malaysian financial market and the wider economy. From a macroeconomic perspective, the empirical findings highlighted the importance of both the internal and external macroeconomic environments through the selected leading indicators in defining the financial vulnerability of an economy. These vital leading indicators should be the key focus when it comes to policy making and the management of financial vulnerabilities.

Based on the empirical estimation, the constructed FVI based on the signals approach and the DAFM provided information on the selected leading indicators and common crisis triggers to gauge vulnerabilities in the Malaysian financial market. Based on the timing and amplitude of fluctuations in the Malaysian financial market, the present study underlined the potential capability of the leading indicators to foretell the outlook of the financial market using a non-parametric technique of the signals approach and a model-based methodology based on the DAFM from a macroeconomic perspective. The information content from these indicators for the Malaysian financial market fluctuations provides insights for policy establishment and investment management.

Based on the empirical outcomes, a few recommendations can be presented for policy establishment. First, the attractiveness of exports through an exchange rate policy helps to protect a country from vulnerability. As an overvaluation of the exchange rate is a driving force of a potential crisis build-up, the crucial aspect of an exchange rate policy is to prevent a high appreciation of the real exchange rate. This ensures that domestic goods and services remain competitive in international markets and export earnings can boost the country's economic growth.

Second, the attractiveness of the property market can ensure a steady flow of domestic and foreign investment in property. The property market is no longer an economic sector characterised predominantly by domestic property-specific forces and conventional demand and supply. With the interconnectedness between the property market and the economy, an overstretching of the booming property market will be very likely to lead to a slump in the market with a longer and more severe downturn in the

foreseeable future, particularly on the financial market and the economy. Maintaining a steady and well-regulated flow of investment into the property market will eventually lead to a multiplier effect for economic development. To promote the attractiveness of property investment, the real property gains tax should be considered to be lowered or even exempted to attract greater interest in property investment whilst avoiding speculation in the market. Moreover, corporate tax should also be considered to be reduced from the current rate of 24 percent or exempted for the first five years of operations of foreign firms in Malaysia. This may boost investment in the industrial and commercial property market in the long-run.

Third, financial market conditions can be enhanced through an investment policy to provide an attractive investment environment. Foreign direct investment (FDI) is a major catalyst for economic development and, needless to say, income growth and employment. The liberalisation of FDI regimes and the implementation of other policies are vital to attracting investment. The monitoring of the mobilisation of investment resources has to go deeper so as to protect the interests of foreign investors and boost their confidence to invest confidence in the host country. At the same time, the domestic economy can also maximise the benefits of a foreign presence through its investment activities.

Fourth, the financial authorities and the central bank of Malaysia, Bank Negara Malaysia, should consider the implementation of the constructed FVIs in monitoring financial vulnerabilities in Malaysia. Both of the constructed FVIs have their own advantages where the FVI constructed based on the signals approach can be used for short and medium-term forecasting while the constructed FVI based on the DAFM can be used

for short and long-term forecasting. For the FVI constructed based on the signals approach, the responses of each of the individual leading indicators of an impending crisis can be differentiated by emitting crisis signals besides identifying the causes of the impending crisis. For the constructed FVI based on the DAFM, the causes of an impending crisis can be identified based on the main indicator group. The identification of the culprits of financial vulnerabilities can at least trim down the impact of an impending crisis towards the financial market and economy.

Fifth, the macroprudential authorities and Bank Negara Malaysia can also utilise the MSBVAR model in policy establishment. The MSBVAR model implemented in this study highlighted the huge variations in the feedback of the real sector towards a financial vulnerability shock between a period of high vulnerability and a period of low vulnerability. The macroprudential authorities could simulate the feedback of the real sector in the event of changes in the monetary or macroprudential policies. Thus, the impacts of financial vulnerability can be pared down during a period of high vulnerability while the attractiveness of the financial market and the economy in Malaysia could also be stimulated during a period of low vulnerability through effective policy establishment.

Lastly, policymakers and the government are encouraged to compile and publish more specific and complete data, particularly property-specific data. Moreover, the definitions of the publicly available data should be reviewed to ensure its accuracy with reliable international data sources and continuity in releasing complete data. To monitor any uncertainty in financial vulnerabilities, more specific and complete data is necessary to predict developments in the financial market. Utilising the FVI might provide more

accurate insights for policymakers and stakeholders, in the future, to foretell vulnerabilities in the Malaysian financial market.

5.3 Limitations of the Study

Spanning from 1997 to 2017, the present study productively investigated the fluctuations of the Malaysian financial market and predicted the early signals of financial market vulnerability using the Financial Vulnerability Indicator (FVI) constructed through the signals approach and the dynamic approximate factor model before exploring the effect of financial vulnerabilities by implementing the Markov Switching Bayesian Vector Autoregressive (MSBVAR) model. The implementation of the methodology used was based on data on a monthly basis to ensure better accuracy in forecasting of the financial vulnerabilities. Nevertheless, some of the data compiled on a monthly basis were interpolated as high-frequency data were not readily available. Due to that, the sensitivity of the empirical estimation might have been limited where the actual month-to-month fluctuations were absent.

Moreover, a property-related data constraint was a limitation to constructing a more precise indicator. For Malaysia, the production of property-related data only gained significant attention after the Asian Financial Crisis in 1997. In that sense, significant property-related data has been produced since then but not property-specific data. Therefore, property-specific data were not available at the time of this research.

Besides the unavailability of property-specific data, data limitations were also due to changes in the definition of some of the vital leading indicators for financial vulnerabilities to establish a more detailed definition. Updates on the definitions cause the previous data series to be discontinued and only a short data series of the new definition is available. Hence, an empirical estimation using other available modelling data to forecast the financial vulnerabilities in the Malaysian financial market might be difficult to implement due to the constraints stated. More complete general and property-specific data are essential to weigh the dynamism of the financial market for policy establishment.

Lastly, other than the data limitations, not all of the issues that have a probable effect on a country's financial vulnerability and economy have been considered in the present study of a warning mechanism. This includes issues, such as the nature of institutions and natural disasters, which may be relevant for a certain country at a particular time only. Such issues can only be considered with the availability of suitable data and information if it is relevant.

5.4 Room for Further Studies

The objectives of this research to investigate the fluctuations of the Malaysian financial market and predict the early signals of financial market vulnerability have been accomplished. However, room for further study remains feasible as financial vulnerabilities and crisis forecasting are an ever-changing topic. Further studies could be carried out from different perspectives on the financial market and the economy as a whole.

One area for further study is in modelling the financial vulnerabilities by means of a more advanced and dynamic model-based approach when more complete and vital indicators are available in the future. With that, higher sensitivity and more accurate financial vulnerabilities modelling can be achieved. In turn, this might provide more accurate and detailed insights for policymakers and stakeholders in the financial market. In that sense, more efficient policies can be established by policymakers while better decision-making in financial investment can be made by stakeholders based on the more precise information.

The second area for further study is to further enhance the precision of the present indicator in its forecasting performance. This can be carried out, in the future, by utilising more complete and specific data. The predictive power of the FVI can be enhanced to serve as a better forecasting instrument for the financial market in Malaysia. With that, the FVI would also supply more precise insights on financial market developments for its users, mainly policymakers and investors.

Last, the present research can also be adapted for other countries to construct the leading indicators for their respective financial markets. Considering that most of the construction of such indicators have implemented in developed countries, indicator construction for the financial market can also be employed for other developing economies that have a similar financial market structure as Malaysia. It is of importance to study financial market developments in developing economies, especially emerging economies, and it is even more crucial to understand its indicators to formulate more efficient and effective policies as such economies are also vulnerable to financial risk and crisis.

REFERENCES

- Abdymomunov, A. (2013). Regime-switching measure of systemic financial stress. *Annals of Finance*, 9(3), 455-470.
- Abiad, A. (2003). *Early warning systems: a survey and a regime-switching approach*. International Monetary Fund, IMF Working Paper, No. 32.
- Aboura, S., & van Roye, B. (2013). *Financial stress and economic dynamics: an application to France*. Kiel Institute for the World Economy, Kiel Working Papers, No. 1834.
- Abu Mansor, S., Puah, C. H., Liew, V. K. S., & Wong, S. S. L. (2015). An early warning indicator of economic vulnerability constructing for Malaysian economy. *Economic Annals-XXI*, 3-4(1), 37-41.
- Albulescu, C. T. (2010). Financial system stability using a stochastic simulation model. *Romanian Journal of Economic Forecasting*, 1, 81-98.
- Alessi, L., & Detken, C. (2018). Identifying excessive credit growth and leverage. *Journal of Financial Stability*, 35, 215-225.
- Andreou, I., & Zdzienicka-Durand, A. (2009). *Financial vulnerability in the central and eastern European countries*. Centre National de la Recherche Scientifique, Working Papers, No. 0907.
- Athukorala, P. C. (2010). *Malaysian economy in three crises*. The Australian National University, Working Paper No. 12.
- Balakrishnan, R., Danninger, S., Elekdag, S., & Tytell, I. (2009). *How linkages fuel the fire: The transmission of financial stress from advanced to emerging economies*. World Economic Outlook (April 2009). Washington, D.C.: International Monetary Fund.
- Balakrishnan, R., Danninger, S., Elekdag, S., & Tytell, I. (2011). The transmission of financial stress from advanced and emerging economies. *Emerging Markets Finance and Trade*, 47, 40-68.

- Banbura, M., & Modugno, M. (2010). *Maximum likelihood estimation of factor models on data sets with arbitrary of missing data*. European Central Bank, Working Paper Series, No. 1189.
- Banbura, M., & Modugno, M. (2014). Maximum likelihood estimation of factor models on datasets with arbitrary pattern of missing data. *Journal of Applied Econometrics*, 29(1), 133-160.
- Bank Negara Malaysia. (2008). *Bank Negara Malaysia Annual Report 2008*. Kuala Lumpur: Bank Negara Malaysia, Malaysia.
- Bank Negara Malaysia. (2013). *Financial Stability and Payment Systems Report 2013*. Kuala Lumpur: Bank Negara Malaysia, Malaysia.
- Bank Negara Malaysia. (2015a). *Bank Negara Malaysia Annual Report 2015*. Kuala Lumpur: Bank Negara Malaysia, Malaysia.
- Bank Negara Malaysia. (2015b). *Financial Stability and Payment Systems Report 2015*. Kuala Lumpur: Bank Negara Malaysia, Malaysia.
- Bhattacharya, B., & Roy, T. N. S. (2012). Indicators of banking fragility in India: an empirical test. *South Asia Economic Journal*, 13(2), 265-290.
- Braga, J. P., Pereira, I., & Reis, T. B. (2014). *Composite indicator of financial stress for Portugal*. Banco de Portugal, Financial Stability Papers, No. 1.
- Brugemann, A., & Linne, T. (2002). *Are the central and Eastern European transition countries still vulnerable to a financial crisis? Results from the signals approach*. IWH Discussion Papers, No. 157.
- Bussiere, M., & Fratzscher, M. (2006). Towards a new early warning system of financial crises. *Journal of International Money and Finance*, 25, 953-973.
- Cardarelli, R., Elekdag, S., & Lall, S. (2011). Financial stress and economic contractions. *Journal of Financial Stability*, 7, 78-97.
- Cecchetti, S. G., Mohanty, M. S., & Zampolli, F. (2011). *The real effects of debt*. Bank of International Settlement, Working Paper No. 352.
- Cevik, E. I., Dibooglu, S., & Kenc, T. (2013a). Measuring financial stress in Turkey. *Journal of Policy Modeling*, 35, 370-383.

- Cevik, E. I., Dibooglu, S., & Kutan, A. M. (2013b). Measuring financial stress in transition economies. *Journal of Financial Stability*, 9, 597-611.
- Chong, M. T., Pua, C. H., & Abu Mansor, S. (2018). Oil price dynamics forecasting: an indicator-pivoted paradigm. *International Journal of Energy Economics and Policy*, 8(3), 307-311.
- Chow, G., & Lin, A. (1971). Best linear unbiased interpolation, distribution, and extrapolation of time series by related series. *The Review of Economics and Statistics*, 53, 372-375.
- Christensen, I., & Li, F. (2014). *Predicting financial stress events: a signal extraction approach*. Bank of Canada, Working Paper, No. 37.
- Claessens, S., & Kose, M. A. (2013). *Financial crises: explanations, types, and implications*. International Monetary Fund, IMF Working Paper, No. 28.
- Dempster, A. P., Laird, N. M., & Rubin, D. B. (1977). Maximum likelihood from incomplete data via the EM algorithm. *Journal of the Royal Statistical Society, B39*, 1-38.
- Diebold, F. X., & Mariano, R. S. (2012). Comparing predictive accuracy. *Journal of Business & Economic Statistics*, 13, 253-263.
- Drehmann, M., & Juselius, M. (2014). Improving EWIs for banking crises – satisfying policy requirements. *International Journal of Forecasting*, 30(3), 759-780.
- Duca, M. L., & Peltonen, T. A. (2011). *Macro-financial vulnerabilities and future financial distress*. European Central Bank, Working Paper Series, No. 1311.
- Dumicic, M. (2015). *Financial stability indicators – the case of Croatia*. Croatian National Bank, Working Papers Series, No. 43.
- Duprey, T., Klaus, B., & Peltonen, T. (2016). *Dating systemic financial stress episodes in the EU countries*. Bank of Canada, Staff Working Paper, No. 11.
- Edison, H. J. (2000). *Do indicators of financial crises work? An evaluation of an early warning system*. Board of Governors of the Federal Reserve System, International Finance Discussion Papers, No. 675, 1-74.
- Edison, H. J. (2003). Do indicators of financial crises work? An evaluation of an early warning system. *International Journal of Finance and Economics*, 8, 11-53.

- El-Shagi, M., Knedlik, T., & Schweinitz, G. V. (2012). *Predicting financial crises – the statistical significance of the signals approach*. Halle Institute for Economic Research, Discussion Papers, No. 3.
- European Central Bank. (2017). *Financial Stability Review May 2017*. Frankfurt: European Central Bank, Germany.
- Feldkircher, M., Gruber, T., & Moder, I. (2014). *Using a threshold approach to flag vulnerabilities in CESEE economies*. National Bank of Austria, Foreign Research Division, 3, 8-30.
- Frankel, J. A., & Saravelos, G. (2012). Can leading indicators assess country vulnerability? Evidence from the 2008-09 global financial crisis. *Journal of International Economics*, 87, 216-231.
- Geweke, J. (1977). The dynamic factor analysis of economic time-series models. In Aigner, D. J., & Goldberger, A.S. (Eds.), *Latent variables in socio-economic models 1* (pp. 365-383). North Holland, Amsterdam.
- Giese, J., Andersen, H., Bush, O., Castro, C., Farag, M., & Kapadia, S. (2014). The credit-to-GDP gap and complementary indicators for macroprudential policy: evidence from the UK. *International Journal of Finance and Economics*, 19, 25-47.
- Glocker, C., & Kaniovski, S. (2014). A financial market stress indicator for Austria. *Empirica*, 41, 481-504.
- Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica*, 57, 357-384.
- Hartmann, P., Hubrich, K., Kremer, M., & Tetlow, R. J. (2013). *Melting down: systemic financial instability and the macroeconomy*. Beiträge zur Jahrestagung des Vereins für Socialpolitik 2013, Wettbewerbspolitik und Regulierung in einer globalen Wirtschaftsordnung - Session: Financial Stability, No. G02-V3.
- Hasan, Z. (2001). Recent financial crisis in Malaysia: response, results, challenges. *The Indian Economic Journal*, 49(1), 29-49.

- Hernandez, P. C., Moral-Benito, E., Koester, G. B., & Nickel, C. (2014). *Signalling fiscal stress in the Euro area: a country-specific early warning system*. Bank of Spain, Working Paper Series, No. 1418.
- Hollo, D., Kremer, M., & Duca, M. (2012). *CISS – a composite indicator of systemic stress in the financial system*. European Central Bank, Working Paper, No. 1426.
- Hubrich, K., & Tetlow, R. J. (2014). *Financial stress and economic dynamics: the transmission of crises*. European Central Bank, Working Paper Series, No. 1728.
- Huotari, J. (2015). *Measuring financial stress- a country specific stress index for Finland*. Bank of Finland, Research Discussion Paper No. 7.
- Illing, M., & Liu, Y. (2006). Measuring financial stress in a developed country: an application to Canada. *Journal of Financial Stability*, 2, 243-265.
- International Monetary Fund. (2012). *Dealing with household debt*. World Economic Outlook: Growth Resuming, Dangers Remain (April 2012). Washington, D.C.: International Monetary Fund.
- International Monetary Fund. (2014). *Financial sector assessment program*. IMF Country Report No. 99. Washington, D.C.: International Monetary Fund.
- International Monetary Fund. (2016). *Malaysia: 2016 Article IV Consultation – Press Release*. IMF Country Report No. 110. Washington, D.C.: International Monetary Fund.
- Islami, M., & Kurz-Kim, J. R. (2013). *A single composite financial stress indicator and its real impact in the Euro area*. Bundesbank Discussion Paper, No. 31.
- Kaminsky, G. L., & Reinhart, C. M. (1999). The twin crises: the causes of banking and balance-of-payments problems. *The American Economic Review*, 89(3), 473-500.
- Kaminsky, G., & Reinhart, C. M. (1996). *The twin crises: the causes of banking and balance-of-payments problems*. Board of Governors of the Federal Reserve System, International Finance Discussion Paper, No. 544.
- Kaminsky, G., Lizondo, S., & Reinhart, C. M. (1998). *Leading indicators of currency crises*. International Monetary Fund, IMF Staff Papers, 45(1), 1-48.

- Khan, M. H. (2002). *When is economic growth pro-poor? Experience in Malaysia and Pakistan*. International Monetary Fund, Working Paper No. 85.
- Kim, H., & Shi, W. (2015). *Forecasting financial market vulnerability in the US: a factor model approach*. Auburn University, Working Paper Series, No. 04.
- Kim, J. W. (2010). The effects of financial instability on real output growth. *KIET Industrial Economic Review*, 75(1), 55-68.
- Knedlik, T., & Scheufele, R. (2007). *Three methods of forecasting currency crises: which made the run in signaling the South African currency crisis of June 2006?* Halle Institute for Economic Research, Discussion Papers, No. 17.
- Krolzig, H. M. (2003). Constructing turning point chronologies with Markov-switching vector autoregressive models: the Euro-zone business cycle. In Eurostat (ed.) *Proceedings on Modern Tools for Business Cycle Analysis, Monography in Official Statistics*.
- Lee, W.L. (2010, September 07). Is the property market bubbling over? *The Malaysian Insider*. Retrieved from <http://www.themalaysianinsider.com/mobile/business/article/is-the-property-market-bubbling-over/>.
- Li, F. C., & Xiao, H. Y. (2016). *Early warning system of financial stress events: a credit-regime-switching approach*. Bank of Canada, Staff Working Paper, No. 21.
- Louzis, D. P., & Vouldis, A. T. (2012). A methodology for constructing a financial systemic stress index: an application to Greece. *Economic Modelling*, 29, 1228-1241.
- Malaysian Rating Corporation Berhad. (2016). *The 2015 Bank Negara Malaysia Annual Report*. Kuala Lumpur: Malaysian Rating Corporation Berhad, Malaysia.
- Matkovskyy, R. (2012a). *Forecasting the index of financial safety (IFS) of South Africa using neural networks*. Munich Personal RePEc Archive, MPRA Paper, No. 42153.
- Matkovskyy, R. (2012b). *The index of the financial safety (IFS) of South Africa and Bayesian estimates for IFS vector-autoregressive model*. Munich Personal RePEc Archive, MPRA Paper, No. 42173.

- Mazlan, N. (2014, March 12). An investigation on household debt in Malaysia. *International Centre for Education in Islamic Finance*. Retrieved from <http://www.inceif.org/research-bulletin/investigation-household-debt-malaysia/>.
- Megersa, K., & Cassimon, D. (2015). Assessing indicators of currency crisis in Ethiopia: signals approach. *African Development Review*, 27(3), 315-330.
- Milwood, T. A. T. (2012). *A composite indicator of systemic stress (CISS): the case of Jamaica*. Bank of Jamaica, Working Paper, November 2012.
- Mingione, F. (2011). *Forecasting with principal component analysis: an application to financial stability indices for Jamaica*. Bank of Jamaica, August 2011.
- Mishkin, F. S. (1991). *Anatomy of a financial crises*. National Bureau of Economic Research, NBER Working Paper Series, No. 3934.
- Morris, V. C. (2010). *Measuring and forecasting financial stability: the composition of an aggregate financial stability index for Jamaica*. Bank of Jamaica, August 2010.
- Nambiar, S. (2003). Malaysia's response to the financial crisis: reconsidering the viability of the unorthodox policy. *Asia-Pacific Development Journal*, 10(1), 1-23.
- National Property Informational Centre. (2005). *Property Market Status Report*. Putrajaya: Valuation and Property Services Department.
- Nguyen, T., & Duy, N. N. (2017). Developing an early warning system for financial crises in Vietnam. *Asian Economic and Financial Review*, 7(4), 413-430.
- Okposin, S. B., & Cheng, M. Y. (2000). *Economic crises in Malaysia: Causes, implications & policy prescriptions*. Selangor Darul Ehsan, Malaysia: Pelanduk Publications (M) Sdn Bhd.
- Organisation for Economic Co-operation and Development. (2012). *Financial contagion in the era of globalised banking? OECD Economics Department Policy Notes*, No. 14.
- Oyong, R. A., Didong, R., Safuan, S., & Warjiyo, P. (2018). Early detection of Indonesia's vulnerability to currency crisis. *International Journal of Economics and Financial Issues*, 8(1), 196-204.

- Park, C. Y., & Mercado, Jr., R. V. (2013). *Determinants of financial stress in emerging market economies*. Asian Development Bank, Working Paper No. 356.
- Pasricha, G., Roberts, T., Christensen, I., & Howell, B. (2013). Assessing financial system vulnerabilities: an early warning approach. *Bank of Canada Review*, Autumn 2013, 10-19.
- Percic, S., Apostoaie, C. M., & Cocris, V. (2013). *Early warning systems for financial crises – a critical approach*. CES Working Papers, 5(1), 77-88.
- Pranowo, K., Achsani, N. A., Manurung, A. H., & Nuryartono, N. (2010). The dynamics of corporate financial distress in emerging market economy: empirical evidence from the Indonesian stock exchange 2004-2008. *European Journal of Social Sciences*, 16(1), 138-149.
- Puah, C. H., Kuek, T. H., & Arip, M. A. (2017). Assessing Thailand's financial vulnerability: an early warning approach. *Business and Economic Horizons*, 13(4), 496-505.
- Puah, C. H., Kuek, T. H., Arip, M. A., & Wong, S. S. L. (2016). Forecasting property market dynamics: insights from the property cycle indicator. *INFORMATION*, 19(6(B)), 2225-2232.
- Reinhart, C., Goldstein, M., & Kaminsky, G. (2000). *Assessing financial vulnerability, an early warning system for emerging markets: Introduction*. Munich Personal RePEc Archive, MPRA Paper, No. 13629.
- Sarafrazi, S., Hammoudeh, S., & Balcilar, M. (2015). Interactions between real economic and financial sides of the US economy in a regime-switching environment. *Applied Economics*, 47(60), 6493-6518.
- Semmler, W., & Chen, P. (2014). Financial stress, regime switching and macrodynamics: theory and empirics for the US, the EU and non-EU countries. *Economics: The Open-access, Open-assessment E-journal*, 8, 1-42.
- Shiratsuka, S. (2003). *Asset price bubble in Japan in the 1980s: lessons for financial and macroeconomic stability*. Institute for Monetary and Economic Studies, Bank of Japan, Discussion Paper No. 2003-E-15.

- Sims, C. A., & Zha, T. (2006). Were there regime shifts in US monetary policy? *American Economic Review*, 96(1), 54-81.
- Sims, C. A., Waggoner, D. F., & Zha, T. (2008). Methods for inference in large multi-equation Markov-switching models. *Journal of Econometrics*, 146(2), 255-274.
- Sinenko, N., Titarenko, D., & Arins, M. (2013). The Latvian financial stress index as an important element of the financial system stability monitoring framework. *Baltic Journal of Economics*, 13(2), 87-112.
- Slingenberg, J. W., & Haan, J. D. (2011). *Forecasting financial stress*. Netherlands Central Bank, DNB Working Papers, No. 292.
- Stanga, I. M. (2011). *Sovereign and bank credit risk during the global financial crisis*. Netherlands Central Bank, DNB Working Papers, No. 314.
- Suidarma, I. M., Indrawati, Y., Diatmika, I. G. N. D., & Anggaradana, I. N. (2017). Financial system vulnerability indicators in Indonesia. *International Journal of Economics and Financial Issues*, 7(5), 299-306.
- Thakor, A. (2015). Lending booms, smart bankers, and financial crises. *American Economic Review: Papers and Proceedings 2015*, 105(5), 305-309.
- van Roye, B. (2011). *Financial stress and economic activity in Germany and the Euro area*. Kiel Institute for the World Economy, Working Paper, No. 1743.
- van Roye, B. (2014). Financial stress and economic activity in Germany. *Empirica*, 41(1), 101-126.
- Vermeulen, R., Hoeberichts, M., Vasicek, B., Zigràiova, D., Smidkova, K., & Haan, J. D. (2015). Financial stress indices and financial crises. *Open Economies Review*, 26(3), 383-406.
- Watson, M. W., & Engle, R. F. (1983). Alternative algorithms for the estimation of dynamic factor, mimic and varying coefficient regression models. *Journal of Econometrics*, 23, 385-400.
- Yap, J. T. (2002). *Monitoring economic vulnerability and performance: application to the Philippines*. Philippine Institute for Development Studies, Discussion Paper Series, No. 13.

- Yiu, M. S., Ho, A., & Jin, L. (2009). *Econometric approach to early warning of vulnerability in the banking system and currency market for Hong Kong and other EMEAP economies*. Hong Kong Monetary Authority, Working Paper, No. 08.
- Zhu, H. B. (2005). *The importance of property markets for monetary policy and financial stability*. Bank for International Settlements, BIS Paper No. 21, 9-29.

APPENDIX

Table 1 Summary of Review of Empirical Studies on Non-parametric Approach

Author (Year)	Variable	Sample & Methodology	Findings
Kaminsky et al. (1998)	• Exports • Deviations of the real exchange rate from trend • Ratio of broad money to gross international reserves • Output • Equity prices	• 15 developing countries • 5 industrial countries • Monthly data • Signals approach	Within the signals approach implementation using data in monthly basis, they discovered that exports, deviations of the real exchange rate from trend, the ratio of broad money to gross international reserves, output and equity prices were among the potential explanatory variables. Based on the individual indicators' performance, they noted that the signals approach is supportive as an early warning system and would be a useful tool for timely assessment of occurrence of crisis.
Reinhart et al. (2000)	• Current account balance over GDP • Short-term capital inflows over GDP • FDI over GDP • Overall budget deficit / GDP • Growth rate of general government consumption/GDP • Growth rate of central bank credit to the public sector/GDP • Growth rate of net credit to the public sector/GDP • Growth rate of the current account balance as a share of investment	• 25 countries from region of Africa, Asia, Europe and the Middle East, and Latin America • Monthly data • Signals approach	With the employment of signals approach for monthly data of 1970 to 1995, they found out that economy behaves differently before happenings of financial crises and this happens in recurrent systematic pattern. They added that this systemic pattern is brought about through evolution of economic and financial indicators.
Bruggemann and Linne (2002)	• Exchange rate • Exports • Currency reserves • Ratio of lending rate to deposit rate • Deposits of bank	• Central and Eastern European transition countries • Monthly data • Signals approach	Their findings showed that overvalued exchange rate, weak exports and dwindling currency reserves are among the variables that possess good predictive power on crisis vulnerabilities assessment besides indicators that are related to banking sector developments, such as ratio of lending rate to deposit rate and deposits of bank.

Table 1 continued

Author (Year)	Variable	Sample & Methodology	Findings
Yap (2002)	• M2 multiplier • Domestic credit • M2/reserves • Lending/deposit rate • Deposits • Real interest rate • Excess money balances • Exports • Imports • Real exchange rate • Reserves • Interest rate differential • Output growth • Stock market prices	• Philippines • Monthly data • Limited dependent variables estimation • Signals approach	They discovered that foreign borrowing and high domestic credit exposed the economy to vulnerability, but the transformation of vulnerability to weakness in economy was due to crisis contagion from other country.
Edison (2003)	• Real exchange rate (relative to trend) • Ratio of short-term debt to reserves • Ratio of M2 to reserves • Foreign exchange reserves • Equity prices	• 20 countries from Latin America, Asia and other region • Monthly data • Signals approach	In assessing numerous indicators, he listed out a number of important indicators, namely, marked appreciation of the real exchange rate (relative to trend), high ratio of short-term debt to reserves, high ratio of M2 to reserves, substantial losses of foreign exchange reserves and sharp decline in equity prices. He also added that early warning system is a useful diagnostic tool.
Pranowo et al. (2010)	• Debt service coverage	• Indonesia • Process integral financial distress	They employed the methodology of process integral financial distress and used debt service coverage to proxy corporate financial distress. The empirical outcome showed that shock of oil price and Subprime Mortgage Crisis impacted the financial performance of companies differently where its impacts varied across different industrial sectors.

Table 1 continued

Author (Year)	Variable	Sample & Methodology	Findings
Duca and Peltonen (2011)	• Spread of the 3-month interbank rate over the 3-month Government bill rate • Negative quarterly equity returns • The realised volatility of the main equity index • The realised volatility of the nominal effective exchange rate • The realised volatility of the yield on the 3-month Government bill	• 18 emerging market • 10 advanced economies • Quarterly data • FSI construction	Their constructed index consisted of the spread of the 3-month interbank rate over the 3-month Government bill rate, negative quarterly equity returns, the realised volatility of the main equity index, the realised volatility of the nominal effective exchange rate and the realised volatility of the yield on the 3-month Government bill. They found that in order to greatly improve the performance of the forecasting models, domestic and global macro-financial vulnerabilities could be jointly implemented.
El-Shagi et al. (2012)	• Real exchange rate (relative to trend) • Ratio of short-term debt to reserves • Ratio of M2 to reserves • Foreign exchange reserves • Equity prices	• Multiple countries • Signals approach • Bootstrap approach	The authors proved that the signals approach portraits advantages and favourable characteristics for early warning system. They added that the produced composite indicator contained promising forecasting predictive power, though many individual indicators might not be statistically significant.

Table 1 continued

Author (Year)	Variable	Sample & Methodology	Findings
Percic et al. (2013)	• M2 multiplier • Ratio of internal credit/nominal GDP • Real passive interest rate • Ratio of active/passive interest rates • M1 • Real time deposits • Ratio of M2 over currency reserves • Exchange rate deviation from trend • Imports • Exports • Terms of trade • Currency reserves • Interest rate differential • Industrial production • Stock exchange indicators • Consolidated budget deficit/GDP	• Review on early warning system • Signals approach • Logit/probit models	They found out that prediction on crisis occurrence within a time frame could be done using early warning system. They added that models based on both methodologies were representation of important stage in combating financial crises while financial stability of an economy could be ensured through early warning system.
Drehmann and Juselius (2014)	• Credit-to-GDP gap • Debt service ratio • GDP growth • Credit growth • Property price growth • Equity price growth • Property price gap • Equity price gap • Non-core liability ratio	• 26 countries • Quarterly data • ROC curve analysis	By employing ROC curve, they discovered that credit-to-GDP gap and the debt service ratio were among the outperforming measures. For longer time frame, credit-to-GDP gap would be the outperforming indicator while debt service ratio showed domination for shorter time frame.
Christensen and Li (2014)	• Real GDP growth • Exchange rate • Real short-term interest rate • Inflation • M2/foreign exchange reserves • Bank reserve/bank asset • Growth rate of real private credit • Return on stock market index • Return on house price index • Current account/GDP • Contagion indicator • Three-quarter moving average of FSI	• Belgium • Canada • Denmark • Finland • France • Germany • Italy • Japan • Netherlands • Sweden • Switzerland • United Kingdom • United States • Quarterly data • Signals approach	With the use of signals approach on 1981Q2-2011Q2 data, assessment on likelihood of an impending financial stress event was done. By incorporating different weightage for composite indicator construction, they discovered that weighted composite indicator outperformed other indicator approaches where this indicator signalled most of the financial stress events accurately.

Table 1 continued

Author (Year)	Variable	Sample & Methodology	Findings
Hernandez et al. (2014)	• Change in labour costs • Change in REER • Construction, % value added • Current account, % of GDP • Debt of households and non-financial corporations • GDP per capita • Leverage financial corporations • Net international investment position, % of GDP • Net saving of corporations • Net saving of households • Private sector credit flow, % of GDP • Real GDP growth • Real short-term interest rate • Short-term debt of non-financial corporations, % of GDP	• European countries • Annually data • Signals approach	In their study, they included both fiscal and financial variables for index construction where fiscal sustainability directly triggered fiscal stress while financial variables represented the vulnerabilities to fiscal stress. Based on their finding, it indicated that fiscal stress could be detected earlier with the use of early warning system based on country-specific signals approach.
Giese et al. (2014)	• Credit-to-GDP gap • Property price • Sectoral credit ratios • Leverage ratio or loan-to-deposit ratio	• 26 countries • Quarterly data • Area under the receiver operator characteristic curve (AUROC) • Minimum noise ratio • Maximum signal ratio	They discovered that credit-to-GDP gap signalled tightness in policy with timely-mannered and added that property prices, sectoral credit ratios and indicators on banks' balance sheets (leverage ratio or loan-to-deposit ratios) would be of important to picture different cyclical changes.

Table 1 continued

Author (Year)	Variable	Sample & Methodology	Findings
Feldkircher et al. (2014)	• Lending rate • Interaction of domestic credit growth and credit in % of GDP • Capital-to-assets ratio • Current account balance in % of GDP • Basic balance • Short-term external debt in % of external debt • Total external debt service in % of exports • External debt in % of exports • Annual change in export volumes • Exchange rate misalignments • Total reserves in months of imports • Risk premium on lending • Multiplication of gross debt by fiscal balance • Three-year average of YoY CPI inflation • Money growth • Deviation from real GDP trend growth • Structural balance in % of potential GDP	• 22 Central, Eastern and South-eastern European (CESEE) countries • Annually data • Signals approach	Using signals approach, they found 18 valuable indicators for indicator construction which had the ability to signal economy's vulnerability. Based on the empirical outcome, the constructed composite indicator reached about 73 percent in accurate crisis prediction whereas 70 percent was achieved for accurate non-crisis prediction.

Table 2 Summary of Review of Empirical Studies on Indicator Approach

Author (Year)	Variable	Sample & Methodology	Findings
Illing and Liu (2006)	• Bank beta • Bank spread • Liquidity spread • Corporate bond spread • Covered interest rate spread • Yield curve (inverted) • Weighted dollar crashes • Stock market crashes • CP-Treasury bill spread	• Canada • Monthly data • Factor analysis • Credit aggregate-based weights • Variance-equal weights • Sample cumulative distribution functions transformation approach	Based on their findings, standard-variable version based on credit aggregate weighting technique contained better forecasting performance. They noted the accuracy in stress characterization is important in financial crises forecasting.
Albulescu (2010)	• Market capitalisation/GDP • Total credit/GDP • Interest spread • Banking reform and interest rate liberalisation • Inflation rate • General budget deficit • Current account deficit • REER excessive depreciation or appreciation • Non-government credit/total credit • Loans as a percentage of deposits • Deposit/M2 • Reserves/deposits over note & coins/M2 • Non-performing loans/total loans • Regulatory capital/risk weighted assets • Own capital ratio • Liquidity ratio • General risk ratio • Economic climate index • World inflation • World economic growth rate	• Romania • Quarterly data • Stochastic simulation model	The constructed AFSI, using aggregation of individual variables, consisted of potential indicators from financial development, financial vulnerability, financial soundness and world economic climate. Through the evolution of the constructed indicator, they found out that Romanian financial stability level was improved after 2000.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
Morris (2010)	• Market capitalisation/GDP • Total credit/GDP • Interest spread • Herfindahl-Hirschmann Index • Inflation rate • General budget deficit/surplus • Current account deficit/surplus • Change in REER • Non-government credit/total credit • Loans as a percentage of deposits • Deposit/M2 • Reserves/deposits over note & coins/M2 • Non-performing loans/total loans • Capital/ assets • Z-score • Liquidity ratio • Economic climate index • World inflation • World economic growth rate	• Jamaica • Quarterly data • AFSI construction procedure • Monte Carlo simulations	The author aggregated indicators representing banking sector performance from different perspective into a single AFSI while Monte Carlo simulations were used for one-year out-sample forecasting of financial stability. He discovered that deterioration of the forecasted index was due to seasonal increases in M2 where financial stability was affected.
Kim (2010)	• Beta of bank shares • Inverted term spread • TED spread • Corporate spread • Stock market volatility • Decline in stock market • REER volatility • FSI	• United States • Korea • Quarterly data • FSI construction procedure • Structural VAR	He discovered that real output growth would be impacted negatively wherever a national financial stress took place. Moreover, financial instability in the US could also affect other countries through the mass media, investor behaviour and other factors.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
van Roye (2011)	• TED spread • Money market spread • Beta of banking sector • Bank stock market returns • Banking equity risk index • Bank securities spread • Expected lending • Ifo-credit conditions • CDS on banking sector • Excess liquidity • ZEW Bank Index • Corporate bond spread • Corporate credit spread • Housing spread • CDS on corporate sector • CDS on 1Y government bonds • Consumer credit spread • VDAX • Percentage change of DAX • Slope of yield curve • Correlation of REX and DAX • Forward spread • REER volatility	• Germany • Euro area • Monthly data • Dynamic factor model • Bayesian VAR model	The empirical outcome illustrated that financial stress brought about negative impact on output growth and the inflation rate. Furthermore, he also concluded that indicator inclusion into the model improved the performance of out-of-sample forecasting to a greater extend.
Cardarelli et al. (2011)	• Slope of yield curve • TED spread • Beta of banking sector • Corporate bond spreads • Stock market returns • Time-varying stock return volatility • Time-varying volatility of nominal exchange rate	• 17 advanced economies • Quarterly data • FSI construction procedure • Variance-weighted average	The component series that made up the FSI consisted of the slope of yield curve, the TED spread, beta of banking sector, corporate bond spreads, stock market returns, time-varying stock return volatility and time-varying volatility of nominal exchange rate. Comparing to foreign exchange market stress, they concluded that banking distress had higher tendency in ending up with longer economic downturns.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
Slingenberg and Haan (2011)	• Real exchange rate • Import growth • Export growth • Terms of trade • Current account/GDP • Foreign exchange reserves growth • FDI/portfolio investment • M1 and M2 growth • M2 multiplier • Domestic total credit • Domestic business credit • Domestic household credit • Domestic interest rate • Lending and deposit rate spread • Commercial bank deposits • Ratio of bank reserves to assets • GDP growth • Inflation core • Inflation total • Investment/GDP • Savings/GDP • Residential real estate prices • Commercial real estate • Stock prices • Oil prices • World gold price • MSCI	• 13 OECD countries • FSI construction procedure	Six indicating perspectives were merged in the indicator construction procedure to capture the possible financial stress contributors, including current account, capital account, financial sector, real and public sector, asset prices, and foreign sector. They noticed that credit aggregates were among the best financial stress indicators with leading attribute.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
Mingione (2011)	• Capital/assets • Loans to capital • Deposits to loans • Deposits/assets • Deposit and repos/assets • Liquid assets to assets • Loan loss reserves/assets • Loan and security loss provision/assets • Non-performing loans/loans • Non-performing loans/assets • Financial institution loans/loans • Public sector loan/assets • Net income/assets • Non-interest income/assets • Implicit deposit interest rate • 12-month growth in deposits • Investments/assets • FX liabilities/FX assets • FX deposits/FX assets	• Jamaica • Quarterly data • Signals approach • Principal component analysis	He discovered that the ADL model with PCA factors performed better in forecasting and noted that inclusion of data from building societies, merchant bank and macroeconomic variables would improve the early warning system.
Louzis and Vouldis (2012)	• 10 year Greek government bond/German Bund spread • Yield realized volatility • Correlation between returns on Greek stocks to German Bund • Stock market prices • Realised volatility of banking index • Idiosyncratic risk of bank stock prices • Bank bond spreads • Deposit gap • Loan gap • Bank profitability • Stock market prices • Realised volatility • Earnings per share • 3-month Euribor/3-month German T-bill spread	• Greece • Monthly data • FSI construction procedure • Probit model	Variables of the index were selected from market data of banking sector, balance sheet data of banking sector, equity and money market. The empirical outcome indicated that the constructed index contained the ability in signalling crises periods accurately. They also suggested that suitable policies implementation could be made based on precise indication of nature in systematic stress with respect to detection of financial crisis.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
Frankel and Saravelos (2012)	• Reserves • REER • GDP • Credit • Current account • Money supply • Exports and imports • Inflation • Equity returns • Interest rate • Debt composition • Legal/business variables • Capital flows • External debt • Peg/financial openness • Regional/income dummy variables	• United States • Annually data • Multivariate regression	Six variables were included in their study, namely, drops in GDP and industrial production, currency depreciation, stock market performance, reserve losses, and participation in an IMF program. They concluded that level of reserves and real appreciation were the indicators which led in explaining crisis occurrence.
Islami and Kurz-Kim (2013)	• CDS spread on iTraxx Europe Crossover • CDS spread on iTraxx non-financials • Implied volatility of the EUR/USD exchange rate • Volatility of the future oil price • Earnings-price ratio • 3-month Euribor	• European region • Monthly data • FSI construction procedure	Five market segments were considered before constructing the FSI, namely, credit, foreign exchange, oil market, stock and interbank market. Based on their findings, the constructed FSI performed better than the Euro STOXX 50 volatility index in terms of predictive ability. They also added that the constructed FSI had the ability in signalling shocks from financial markets on the real economy by 1 to 4 months in advance.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
Pasricha et al. (2013)	• REER volatility • Stock market volatility • Stock market decline • Corporate spread • Inverted term spread • Interbank lending spread • Beta of banking sector	• Canada • Monthly data • FSI construction procedure (IMF) • Imbalance indicator model	The components of the FSI included REER volatility, stock market volatility, stock market decline, corporate spread, inverted term spread, interbank lending spread, and beta of banking sector. They showed that the model could indicate vulnerabilities in financial system without neglecting information from market intelligence as well as regular monitoring of economic and financial data.
Cevik et al. (2013b)	• Banking sector fragility • Time varying stock market return volatility • Sovereign debt spreads • Exchange market pressure index • Trade credit	• Bulgaria • Czech Republic • Hungary • Poland • Russia • Monthly data • Bivariate VAR	The constructed FSI was based on variables of banking sector fragility, time varying stock market return volatility, sovereign debt spreads, an exchange market pressure index, and trade credit. Based on the empirical findings from impulse response functions based on bivariate VARs, they noted that strong connection existed between financial stress and real economy. They also added that the constructed FSI contained valuable information on economic condition.
Cevik et al. (2013a)	• Stock market volatility • Exchange market pressure index • Bond spreads • Default probability of banking sector • Trade finance • Growth rate of short term external debt	• Turkey • Monthly data • Principal component analysis	The empirical analysis indicated that the index was a useful indicator with leading attribute for the economy and recessions in Turkey while linkage between FSI and the real economy existed.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
Sinenko et al. (2013)	• Decrease in the profitability of credit institutions • Increase in loan loss provision ratio • Sharp decline in lending • Deterioration of interbank lending • Widening of credit spreads on the interbank market • Deposit outflows • Increasing yields on government debt securities	• Latvia • Quarterly data • Aggregation with variance-equal weights • Aggregation using principal component analysis-based weights • Aggregation using equal or chained weights	The constructed FSI had the ability in signalling periods of stress, vigorous and imbalanced development of the Latvian financial system where it has become a monitoring framework for the Bank of Latvia after 2010.
Braga et al. (2014)	• Realized volatility of the 3-month Euribor rate • Interest rate spread • Portuguese monetary financial institutions' funding • Realised volatility of Portuguese 10-year benchmark government yields • Spread between Portuguese-German 10-year benchmark government yield • Spread between a non-financial corporation Iboxx yields index • Realised volatility of Portugal's non-financial sector market index • Maximum cumulated loss of non-financial sector stock market • Difference in CMAX of Portugal-Germany stock market index • Realised volatility of Portugal's financial sector stock market index • CMAX of Portugal's financial sector stock market index • Spread between a financial corporation Iboxx yields index • Realised volatility of euro exchange rate against US dollar • Realised volatility of euro exchange rate against the Japanese yen • CMAX of nominal EER of Portugal	• Portugal • Monthly data • FSI construction procedure	The authors discovered that the constructed composite indicator provided accurate identification of financial stress events which impacted its system since 1999 while added that a clear divergence from euro area composite stress indicators could be noticed.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
Dumicic (2015)	• Loan with interest within 1 year/total loans • Loans indexed to foreign currency/total loans • Foreign currency deposits/total deposits • Loans/deposits net of parent bank deposits • Corporate debt/GDP • Rate of change in corporate loans • Household debt/GDP • Rate of change in household loans • Public debt/GDP • Rate of change in government loans • External debt/GDP • Current account balance/GDP • Hedonic real estate price index • Share index CROBEX	• Croatia • Quarterly data • Principal component analysis	From the empirical findings, the author identified that strong lending activity was a great indicators for risk accumulation, particularly excessive credit growth and over-optimism in lending. The author also added that systemic risk could be materialised through escalation in non-performing loan ratio, which in turns impacted real sector development negatively.
Vermeulen et al. (2015)	• Stock price volatility • Volatility of monthly changes in the nominal effective exchange rate • Beta of banking sector • US long term interest rate • Inverse yield curve • TED-spread	• 28 OECD countries • Quarterly data • FSI construction procedure (non-weighted sum of the standardized indicators)	They discovered that the constructed FSI showed crisis occurrence to a varying degree, though the case on its relationship towards the crisis onset was weak. Therefore, they suggested the implementation of country-specific FSI for improved empirical estimation.
Kim and Shi (2015)	• Cleveland Financial Stress Index • Industrial Production • Capacity utilisation • Real personal income • Manufacturing index • Personal consumption expenditure • Consumer expectations/sentiment • Employment data • S&P common stock price index • Commercial and industrial loans • Housing permits • Adjusted monetary base	• United States • Monthly data • Factor model • Principal component analysis	Based on the empirical findings, they found out that the factor models outperformed other models in out-of-sample short term forecasting. They added that the first common factor of predicting financial vulnerability associated with real activity, but not nominal one.

Table 2 continued

Author (Year)	Variable	Sample & Methodology	Findings
Oyong et al. (2018)	• Current account • Credit • Exchange rate • Exports • M2 • Real exchange rate • Terms of trade	• Indonesia • Monthly data • Logistic regression • Fuzzy logic	They noted that vulnerabilities detection is more effective to offer more time for policymakers in establishing right policy to manage and avoid crisis. Besides, the constructed vulnerability index can also be applied in monitoring economic condition.

Table 3 Summary of Review of Empirical Studies on Other Innovative Approach

Author (Year)	Variable	Sample & Methodology	Findings
Abiad (2003)	• Deviations of RER from trend • Current account balance/GDP • Export growth rate • M2/reserves, level • M2/reserves, growth rate • Reserves growth rate • Growth rate of real domestic credit • Industrial production • Real GDP • Stock market performance • Real interest rate • LIBOR • Bank assets/GDP • Short-term debt to reserves • Cumulative non-FDI flows/GDP • Portfolio flows • Bank reserves/total bank assets • CB credit to banks/total bank liabilities • Bank deposits/M2, level • Bank deposits/M2, growth rate • Loans/deposits, level • Loans/deposits, growth rate	• Indonesia • Republic of Korea • Malaysia • Philippines • Thailand • Monthly data • Markov-switching model	Using Markov-switching model, the author discovered that signalled vulnerabilities of countries could be observed due to decline in competitiveness and slowdown in exports. The author also added that external factors to crises occurrence, such as volatility of global equity market and high-yield bond spread, could be considered as a result of financial globalisation.
Bussiere and Fratzscher (2006)	• Overvaluation • Lending boom • Ratio of short term debt and reserve • Ratio of current account over GDP • Financial contagion • Growth	• 20 open emerging market • Monthly data • Multinomial logit model	The key indicators were inclusive of overvaluation, leading boom, ratio of short term debt and reserve, ratio of current account over GDP, financial contagion and growth. They noted that the early warning system was enhanced in term of predictive performance with the use of proposed models of three regimes. Most of the crises in emerging markets were also accurately forecasted using the model.

Table 3 continued

Author (Year)	Variable	Sample & Methodology	Findings
Knedlik and Scheufele (2007)	• Budget deficits • Domestic interest rate • Foreign debt • Gold price • Industrial production • Lending/deposit rates • Credit/GDP • Bank deposits • Exports • M2 • Inflation differential • International liquidity position • Interest differential • Imports	• South Africa • Monthly data • Signals approach • Probit approach • Markov-switching approach	They noted that Markov switching approach was a better forecasting methodology as it signalled most accurate pre-crisis calls and allowed out-of-sample crisis forecasting.
Yiu et al. (2009)	• M2/international reserves • Real GDP growth • Default of probability of listed commercial banks • REER deviation • Real domestic private credit growth • Z-score • Trade integration with China • Real property price gap • Real equity price gap • Inflation • Trade balance over GDP • Short-term external debt/foreign reserves	• 11 EMEAP countries • Quarterly data • Panel probit models • Simultaneous probit equation system	For indicators to banking distress and currency pressure, asset-price misalignments, default risk of commercial banks and the non-financial corporate sector, and growth of real credit to the private sector were showing leading attributes. In addition to that, they discovered that the country behind for stabilising role was China where currency pressure might be lowered with a greater trading relationship with the Chinese.
Andreou and Zdzienicka-Durand (2009)	• Current account balance in percentage of GDP • FDI in percentage of total investments • CPI-based inflation • Real effective exchange rates • Bank credit to the private sector • YoY changes of GDP • Gross external debt in percentage to GDP	• 4 Central and Eastern European countries • Quarterly data • Principal component analysis	The authors discovered that the developed model through panel probit modelling was well-performed and it could be a useful forecasting tool for financial vulnerabilities assessment in transition countries.

Table 3 continued

Author (Year)	Variable	Sample & Methodology	Findings
Stanga (2011)	• Sovereign CDS spreads • Bank CDS spreads • Measure of business cycle	• Ireland • Spain • Monthly data • Restricted VAR	Based on the empirical estimation, the outcomes indicated that transfer of financial risk to the sovereign sector resulted in escalation in the credit risk though it was only for a short period of time.
Milwood (2012)	• Realised volatility of 30-day private market rate • Interest rate spread • Realised volatility of domestic government bond (1-year maturity) • Realised volatility of domestic government bond (3-year maturity) • Realised volatility of the main JSE index • CMAX of JSE index • Realised volatility of JMD/USD • Bid-ask spread	• Jamaica • Monthly data • Cumulative distribution function • Threshold VAR	The author confirmed that the constructed indicator impacted the economy differently where the impact was sustainable in regime of high stress than that in low stress.
Matkovskyy (2012a)	• Money in circulation/M2 • Money in circulation/GDP • M1/M2 • M2/GDP • M2/M0 • PPI/WPI • Money market interest rate • GDP/M2 • M2/money in circulation • Monetary base/reserves • Coverage of import by reserves • Total domestic credit/GDP • M2/market capitalisation • Change of share price index % to previous quarter • REER	• South Africa • Quarterly data • Neural network • Bayesian VAR	Based on the empirical outcome, it indicated that the proposed model with the application to South African index of financial safety contained sufficient predictive ability compared to the other model.

Table 3 continued

Author (Year)	Variable	Sample & Methodology	Findings
Bhattacharya and Roy (2012)	• Real GDP • Headline in inflation rate • Spread between policy rate and short term risk-free rate • Broad money supply to foreign exchange reserves ratio • Overvaluation of REER from trend • Trade balance to GDP ratio	• India • Monthly data • Multivariate probit regression • Signals approach	The indications of fragility in Indian banking sector were real GDP slowdown, escalation in headline inflation rate, escalation in spread between policy rate and short term risk-free rate, escalation in broad money supply to foreign exchange reserves ratio, overvaluation of REER from trend, and decline in trade balance to GDP ratio. The authors noted that banking stress indicators with leading attributes provided timing for policy adjustment.
Matkovskyy (2012b)	• Money in circulation/M2 • Money in circulation/GDP • M1/M2 • M2/GDP • M2/M0 • PPI or WPI • Money market interest rate • GDP/M2 • M2/money in circulation • Monetary base/reserves • Coverage of import by reserves • Total domestic credit/GDP • M2/market capitalisation • Change of share price index % to previous quarter • REER	• South Africa • Quarterly data • Bayesian VAR	By implementing a Bayesian VAR model on the constructed indicator, the author showed that fluctuations in the financial system could be identified through the indicator while the model itself contained ability in forecasting dynamism in the indicator.

Table 3 continued

Author (Year)	Variable	Sample & Methodology	Findings
Aboura and van Roye (2013)	• TED spread • Money market spread • Beta of banking sector • Banking sector equity index • Expected lending • CDS on banking sector • Banking sector volatility • Term spread • Corporate credit spread • Housing credit spread • Consumer credit spread • CAC 40 log-returns • Stock market historical volatility • Government bonds spread • CDS on corporate sector • CDS on 10-year government bonds • Nominal synthetic exchange rate volatility	• France • Monthly data • Dynamic approximate factor model • Markov-switching Bayesian VAR model	With the application of Markov-switching Bayesian VAR model, the authors found out that high financial stress is associated with lower economic activity and added that the developed index can be employed to signal early warning to systemic risk in the French financial sector.
Hartmann et al. (2013)	• GDP growth • Inflation • Interest rate • Loans • Composite indicator of systemic stress	• European region • Monthly data • Markov-switching VAR model	With the adoption of Markov-switching VAR model, they noticed the alteration of parameters in transmission and variances of shocks during high stress period. They added that escalation in financial stress brought about stronger negative output effects after regime change compared to during tranquil times.
Abdymomu n-ov (2013)	• TED spread • Return on the NYSE index • Capital-weighted CDS spread for large banks	• United States • Weekly data • Multivariate SWARCH model	The author noticed that during high volatility regime, the TED spread, return on the NYSE index, and capital-weighted CDS spread for large banks were associated with financial stress periods while discovered that stressful episodes were detected using probability of the joint regime of high volatility.

Table 3 continued

Author (Year)	Variable	Sample & Methodology	Findings
Glocker and Kaniovski (2014)	• Money market spread • Realised stock price volatility • Idiosyncratic volatility of bank stock prices • Cross-section dispersion of bank stock returns • National excess stock price volatility • Bond securities spread • Country risk premium • Correlation between returns on stocks and government bonds • Spread between lending rates and bank bond returns • Lending rate yield curves • Deposit rate yield curves • Excess reserve liquidity • Exchange rate volatility	• Austria • Monthly data • Principal component analysis • Threshold VAR • Markov-switching VAR model	By employing bivariate threshold VAR and Markov-switching VAR model, they discovered that the effects of threshold existed in the stress transmission from financial system to real output during high stress period for the Austrian economy. They added that the threshold value provided indication on stress level which was also a warning on impending downturn.
Hubrich and Tetlow (2014)	FSI • AA rate-Treasury spread • BBB rate-Treasury spread • Federal funds rate • 10-year Treasury bond implied volatility • Private long-term bond implied volatility • 10-year Treasury on-the-run premium • 2-year Treasury on-the-run premium • S&P 500 earnings/price • S&P 100 implied volatility Linkages • Monthly growth of personal consumption expenditure • CPI • Nominal federal funds rate • Growth in the nominal M2 monetary aggregate • FSI	• United States • Monthly data • Markov-switching Bayesian VAR model	According to the author, the definition of stress event was a period where variances of shock and coefficients of the model of the latent Markov states were contrary. They found out that stressful events tailed subsequently with financial events where a shift to a stressful event impacted real economy prospects adversely.

Table 3 continued

Author (Year)	Variable	Sample & Methodology	Findings
Semmler and Chen (2014)	IMF's FSI • Bank beta • TED spread • Inverted term spread • Corporate bond spread • Stock market return • Stock market volatility • Exchange rate volatility Linkage • FSI • Growth of industrial output	• United States • EU countries • Non-EU countries • Multi-regime VAR model	During high stress regime, financial shock could impact the real economy insistently while during low stress regime, this shock could have no lasting effects. Based on the empirical findings, asymmetric effects existed between financial stress shocks and output shocks where it relied on the regime of the economy.
Sarafrazi et al (2015)	• Real private capital stock per capita • Real industrial production per capita • Total nonfarm employment • Crude oil spot price (WTI) • Financial stress indicator • Real interest rate • VIX	• United States • Monthly data • Markov-switching VECM model	From the empirical evidence, it suggested that during stressful time, the significance of the financial system towards real economy intensified and added that more fluctuations could be noticed, particularly, during high volatility regime.
Duprey et al. (2016)	FSI • Monthly realised volatility of real stock price index • CMAX of stock market • Monthly realised volatility of 10-year government bonds • Cumulative difference of real government bond spread/Germany's • Increase in the 10-year yield to the minimum • Volatility of REER • Cumulative change of REER Linkage • FSI • Annual industrial production growth	• EU countries • Monthly data • Markov-switching model	Based on the empirical evidence, the authors concluded that patterns of recurring financial stress events could be identified, namely, financial stress led to real economic stress, recession lasted more than 6 months and addition decline in output by three percentage points if that was due to stress from financial market, and systemic financial stress impacted few countries at once.

Table 3 continued

Author (Year)	Variable	Sample & Methodology	Findings
Li and Xiao (2016)	• Spread between yield of Canadian bonds and that of government bonds (FSI) • Spread between yields on Canadian non-financial corporate bonds and government bonds • Inverted term spread • Beta of financial institutions (total return index) • Trade-weighted dollar volatility • Stock market volatility • Difference of Canadian and US short-term borrowing rates • Average bid-spread on treasury bills • Spread between Canadian commercial paper rates and treasury bill rates • Credit/GDP (Linkage) • Household credit • Business credit • Stock market index • Housing prices/personal disposable income • New house prices • Investment/GDP • CPI core inflation • Exchange rate depreciation • Real GDP • Real investment • M2++ • Household disposable income • FSI • US federal funds rate • Crude oil prices • World gold prices • US commercial credit growth	• Canada • Quarterly data • Credit-regime-switching model • Signals approach	Based on the empirical evidence, the model based on credit-regime-switching approach contained higher predictive ability compared to the benchmark models based on a linear regression and signals approach.
Suidarma et al. (2017)	• Credit to GDP • Exchange rate • Interest rate differentials • Current account • Fiscal deficit • Interest rate spread • Credit to deposit ratio • Inflation • Capital transaction	• Indonesia • Monthly data • Markov switching VAR	They noticed early signs of vulnerability through growth of credit to GDP, spread of interest rate, fiscal deficit, current account, exchange rate and differentials in interest rate. They also highlighted the importance of early warning system to mitigate the financial crisis through effective policy establishment.