CHAPTER 2:

LITERATURE REVIEW

2.0 Introduction

In this chapter, the literature review of stress testing approaches and the relevant concepts will be analyzed and discussed to support the conceptual model of this study. The discussion covers theoretical background, academics' arguments and the meaningful findings of previous studies. This chapter will be concluded with the conceptual framework applied for this research.

Stress testing is a tool to analyse the elasticity of a financial system under extreme shocks (Mizuho Kida, 2008). The concept of it is generally considered a way to identify those scenarios which could cause a significant loss or outside the regular market events (Kuo, *et al*., 2002). This test is important in assessing the stability of banking system (Deutsche Bundesbank, 2003).

Basically, there were a lot of definitions or perceptions of stress testing. Berkowitz, (1999) view stress testing as a subgroup of risk modelling focusing on "tail" events that is complementary to "standard" methods such as value at risk and should be included in a comprehensive risk model. Pesaran *et al* (2004) and Alves (2004) use vector autoregressive (VAR) model to assess the impact of macroeconomic variables on firms' probabilities of default. GDP, consumer prices, the nominal money supply, equity prices, exchange rates *vis-à-vis* the dollar and nominal interest rates for eleven countries/regions over the 1979-99 periods were included in Pesaran *et al's* VAR approach. The global VAR is used as an input into replication for firms' equity returns, which are then linked to the loss distribution of a corporate loan portfolio. A clear benefit of this approach is that it links the credit risk of internationally

diversified loan portfolios in a detailed macroeconomic model that allows for differences across countries.

However, Ingo Fender et al (2001) stated that since VAR models use average historical correlations among asset prices to make such statistical assessments, their ability is limited to capture the risks of exceptional market events, especially those in which asset prices move in ways that differ sharply from historical norms. In contrast, stress tests are designed to imitate specific large market shocks and independent of statistical relationships.

In addition, aggregate stress testing has different objectives from those of stress testing individual portfolios (Blaschke et al, 2001). He termed the stress test as a range of techniques used to assess the vulnerability of a portfolio to major changes in the macroeconomic environment or to exceptional, but plausible events. The Basel II framework (BCBS, 2006) also asks to investigate possible future scenarios that may threaten the solvency of banks. In the case of credit, this stress testing particularly includes an assessment of economic or sector-specific downturn events, which must be meaningful and practically conservative and thereby represent at least mild recession scenarios, but not necessarily a worst-case scenario (BCBS, 2006, para. 435).

On a broader view, stress testing the exposure of financial institutions to adverse macroeconomic events is an important tool in assessing financial stability (Hoggarth et al., 2003). Historical events with particular relevance to bank and security firm portfolios are Black Monday (1987), the Asian financial crisis (1997) and Russian

default (1998). The terrorist attack in the United States (2001) has also formed the basis for many historical and hypothetical scenarios. As a result, Oesterreichische Nationalbank, 2001 views that to deterioration in the average creditworthiness of the bank's borrowers are lead by the typical crisis scenarios examined in this context include stock market crashes, interest and exchange rate shocks, as well as a general economic recession. Shu (2002) observes the forces of macroeconomic developments on the asset quality of the Hong Kong banking sector and concludes that the increase in non-performing loans between 1995 and 2002 was largely attributable to changes in macroeconomic conditions.

In addition to regular surveillance of a set of macro-prudential indicators, a more quantitative tool for financial stability analysis has to be developed. In this respect, the joint IMF and World Bank financial sector assessment programmes (FSAPs) have played a catalytic role in many cases (Kimmo Virolainen.2004).

Moreover, Bank regulators consider stress tests to be an effective and necessary tool that complements statistical model for quantifying and monitoring risk, for instance Basel Committee on Banking Supervision and EU Directive; Stress tests were originally used in risk management by banks in order to determine how certain crisis scenarios would affect the value of their portfolios or sub-portfolios. (Oesterreichische Nationalbank, 2001). Basel Committee on Banking Supervision (1995) notes that stress testing to identify events or influences that could greatly impact banks is a key component of a bank's assessment of its capital position. Therefore, banks that use internal model approaches for meeting market risk capital requirement must have in place a rigorous and comprehensive stress testing program.

2.1 Stress Test Approaches

Macro Sorge (2004) distinguishes two main methodological approaches to macro stress-testing which are:

(i) a "piecewise approach" which evaluates the vulnerability of the financial sector to single risk factors. This evaluation will forecast several "financial soundness indicators" (such as non-performing loans, capital ratios and exposure to exchange rate or interest rate risks) under various macroeconomic stress scenarios;

(ii) an "integrated approach" which combining the analysis of the sensitivity of the financial system to multiple risk factors into a single estimate of the probability distribution of aggregate losses that could appear under any given stress scenario.

Both of these approaches have their own pros and cons. The piecewise approach shows more intuitive results with low computational burden. Besides, it allows broader characterisation of stress scenarios. However, for the cons site, the parameter of this approach is instability over longer horizons and it has no feedback effects. Hence, the loan loss provisions and non-performing loans may be noisy indicators of the credit risk.

As for integrated approach, since the analysis is a combination of multiple risk factors into a single portfolio loss distribution, it integrates market and credit risks. It simulates shift in entire loss distribution driven by the impact of macroeconomic shocks on individual risk components and it has been applied to capture the nonlinear effects of macro shocks on credit risk. However, the cons of this approach are non-

additives of value-at-risk measures across the institutions. And most of the models so far have focused on credit risk only, which usually limited to a short-term horizon. In fact, the available studies have not dealt with feedback effects or parameter instability over a longer horizon

In year 2005, Glenn Hoggarth *et al* adopted a different approach to perform macroeconomic stress tests on the UK banking system and investigate whether the conclusions arising depend on the choice of stress test and on the fragility variable used. They attempted to account for the dynamics between banks' write-off to loan ratio and key macroeconomic variables using a parsimonious vector autoregression (VAR) model. They research distinct itself with most of the existing stress testing work on links between the business cycle and the fragility of the banking system, a direct measure of banks' fragility, which the write-off ratio on loans, is employed. The advantage of the VAR is that it estimates how write-offs change in the quarters following adverse business cycle shocks implying that the stress test is conditional on the historical correlation among the variables in the multivariate model.

Besides, according to Martin Cihak (2007), there are two other main approaches to interpret the macroeconomic shocks and scenarios into financial sector variables i.e. the bottom-up approach, where the impact is estimated using data on individual portfolios, and the top-down approach, where the impact is estimated using aggregated data.

Allen Kearns (2006) stated in details that top-down stress-testing is the process whereby the answer to the test is supplied by the supervisory authorities whereas the

obligation is on financial institutions' themselves to answer the test in the bottom-up process. The institutions' bottom-up answers will be driven by their own institutions past experiences in the outcome of the adverse shocks; In contrast, the regulator's answers will be driven by a model that summarises the reaction to past shocks of a sample of diverse credit institutions. Figure 2.1 below shows the differentiation between bottom-up and top-down approach.

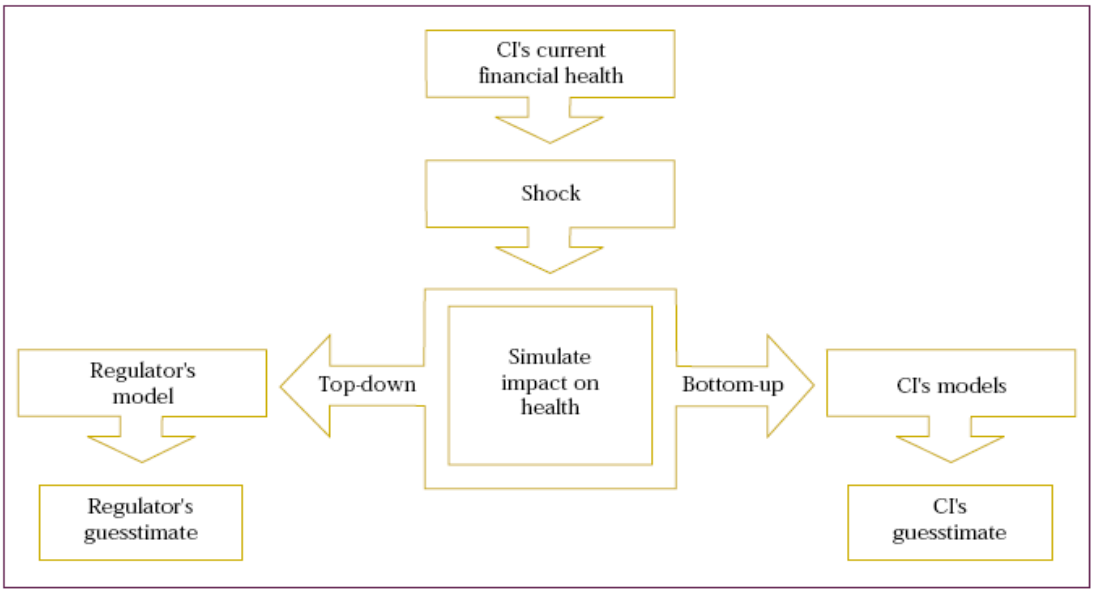


Figure 2.1: Stress-Testing Credit Institutions' (CI's) Financial Health[2]

Of course, in the bottom-up methodology, the issue of comparability is a relevant one since each intermediary may employ different methodologies and modelling assumptions, making the aggregation less reliable. Conversely, the top-down approach enhances the comparability of the results, but it is typically based on historical relations (IAIS, 2003).

[2] Allan Kearns (2004). Loan Losses and the Macroeconomy: A Framework of Stress testing Credit Institution Financial Well- Being.

Several central banks regularly organise bottom-up stress-tests (e.g. Bank of Finland, Bank of Ireland, Banco d'Espana). De Nederlandsche Bank (DNB) uses a combination of bottom-up and top-down methods to perform their macro stress-tests. Both are found to complement to each other and it can be provided for a cross checks (Jan Willem van den End et al, 2006).

At 2007, the Deutsche Bundesbank takes a two-step approach: besides using aggregate data available in the Central Bank to analyse financial steadiness (top-down approach), it also uses information collected from single institutions through a survey method (bottom-up approach) (Petr Jakubik et al, 2008).

2.2 Types of stress testing

There are one or more types of analysis in stress testing:

a. Sensitivity Analysis

Sensitivity analyses assess the impact of large movements in financial variables on portfolio values without specifying the reasons for such movements (Lijia Guo, 2008). As per Muliaman et al, stated that sensitivity is also called univariate stress test and only a single risk factor was changed. Sensitivity tests can be considered in the same framework as a one-dimensional scenario (Matthew T. Jones et al, 2004).

The advantage of this test is that it can isolate the specific influence of individual risk factors from that of other factors. With this test, credit institutions can identify the weaknesses of their portfolio structure relatively accurately. The drawbacks, however, is that it ignores the interaction of various risk factors (Deutsche Bundesbank, 2004). In addition, this analysis also lacks of historical and economic content, which can

limit its usefulness for longer term risk management decisions (Lijia Guo, 2008). Therefore, it normally supplemented by multivariate stress-test or scenario analysis, in which more than one risk factor is changed at one time (Deutsche Bundesbank, 2004).

b. Scenario Analysis

Scenario analyses assess the resilience of financial institutions and the financial system to severe but plausible scenarios. It is more comprehensive test and includes simultaneous moves in a number of risk factors and is often linked to explicit changes in the view of the world (Muliaman *et al*). This scenario analysis can be based on historic events (e.g. the 1998 emerging market crisis) or on hypothetical assumptions (Jan Willem van den End *et al*, 2006). Historical scenarios reflect changes in risk factors that occurred in specific historical episodes. Hypothetical scenarios use a structure of shocks that is thought to be plausible, but has not yet occurred (IAIS, 2003).

Historical scenarios are the most spontaneous approach (Blaschke *et al*., 2001). It is frequently used for market shocks in order to increase the plausibility of these stress scenarios (Gabriel Bonti *et al*, 2005). Historical scenarios are developed more fully since they reflect an actual stressed market environment that can be studied in great detail, therefore requiring fewer judgements by risk managers (FRBSF Economic Letter, 2005). Historical stress testing is backward looking, hence, it consist of the drawback of losing relevance over time as markets and institutions change over time ((Blaschke *et al*., 2001). From FRBSF Economic Letter (2005), noted that the commonly used events for historical scenarios are the large U.S. stock market declines in October 1987, the Asian financial crisis of 1997, the financial market

fluctuations surrounding the Russian default of 1998, and financial market developments following the September 11, 2001, terrorist attacks in the United States.

Conversely, hypothetical scenario is a forward looking approach. According to Blaschke (2001), it can allow a more flexible formulation of potential events, as well as encouraging risk manager to be more forward looking. Besides, it may cover situations completely absent from the historical data. However, the disadvantage of this approach is the difficulty to determine the likelihood of an event occurring since it is beyond the range of expectation (Blaschke *et al*., 2001). Since some of the events may not be relevant to a specific portfolio, hypothetical scenarios that are directly relevant can be crafted, but at the cost of a more labor-intensive and judgmental process (FRBSF Economic Letter, 2005).

After all, it is essential to determine upfront whether the exercise should be based on historical scenarios, assuming that past shocks may happen again, or on hypothetical scenarios, that is on extreme but plausible changes in the external environment regardless of the historical experience (Blaschke *et al*., 2001; Hoggarth *et al.*, 2004).

Hence, some of the researcher combined the historical and hypothetical scenario. A combination of these scenarios includes not only scenarios that have a medium to high likelihood, but also those scenarios with low probabilities. A Monte Carlo method has been called in order to simulate the impact of many different combinations of variables. However, this simulation requires a high level of risk management expertise (Blaschke *et al*., 2001).

c. Extreme Value Theory

Longin (1995) stated that the computation of capital requirement for Financial institutions should be considered as an extreme value problem. Extreme value theory gives some interesting results about the statistical distribution of extreme returns as it extremes of a random process refer to the lowest observation (the minimum) and to the highest observation (the maximum) over a given time-period (Longin, 2000). It is a better way to capture the risk of loss in extreme, but possible event. Due to focusing on the tail of a probability distribution, it can be more flexible. However, it produces a problem if it adapts to a situation where many risk factors drive the underlying return distribution. Furthermore, the usually unstated assumption that extreme events are not correlated over time is questionable (BIS, 2000).

Longin (2000) has developed a parametric method based on extreme value theory to compute the Value at Risk (VaR) of a position. It considered the distribution of extreme returns instead of the distribution of all returns. As a result, he found that the extreme value method presents three main advantages which stated as follow:

(i) Out-of-sample VaR computations are possible for high probability values as the extreme value method is parametric. With the historical method the VaR cannot be computed for high probability values because of the limited number of observations.

(ii) The extreme value method does not assume a particular model for returns but the data may show that it fit the distribution tails; the model risk is considerably reduced. With the normal distribution or any given distribution of returns, the distribution tails may be badly fitted.

(iii) The event risk is explicitly taken into account as the extreme value method focuses on extreme events.

d. Maximum Loss Approach or Worst-Case Scenario

The objective of this worst case analysis is to identify scenarios that are most adverse for a given portfolio (Breuer and Krenn, 2000). The specification of worst case scenarios can either be based on expert judgement or quantitative techniques. The aggregated loss in these scenarios serves more as a benchmark to create some awareness of the current market situation rather than providing guidance for specific risk management actions (Gabriel Bonti, 2005).

Maximum Loss enables to actively manage risks since it clarifies the sources of risk, provides the ability to find the key drivers of a portfolio's profit and loss, helps to determine risk reducing transactions, and provides estimates of the incremental risk of single trades (Gerold Studer, 1997).

In year 2006, in the case of credit risk, this includes in particular an assessment of economic or industry sector specific downturn events, which must be chosen in a meaningful and reasonably conservative way and thus, represent at least mild recession scenarios, but not necessarily a worst-case scenario (BCBS, 2006, para. 435). Typically, a stress testing exercise would refer to plausible, but unlikely events. Nevertheless, the specific choice of the stress scenario lies in the prudence of the bank and has to be justified in respect of the supervisory body (Ferdinand Mager *et al*, 2008).

In order to identify worst-case scenarios, all possible future scenario scenarios should be considered and not only events which occurred at some point in the past (Muliaman *et al)*. Therefore, worst-case scenarios are also known as forward-looking scenario (Oesterreichische Nationalbank, 2001). In addition, historical scenarios pay little attention to the characteristics of the banks' portfolio. On the contrary, the portfolio plays central role in defining worst-case scenarios. Basle Committee on Banking Supervision and Austrian Regulation offer two fundamental options to identify worst-case scenarios, i.e. subjective search for worst-case scenarios and systematic search for worst-case scenarios (Oesterreichische Nationalbank, 2001).

In subjective search for worst-case scenarios, a bank may rely on the experience and economic expertise of staffs from as wide a range of field as possible, who use their knowledge of the market, of the portfolio and of the trading and hedging strategies of the bank in an attempt to identify market situation that could lead to high losses of the bank. On the other hand, in systematic search for worst-case scenarios, banks use their computers to systematically search for worst-case scenarios (Oesterreichische Nationalbank, 2001).

In year 2008, Thomas Breuer et al also used the worst case scenario among the macroeconomic scenarios which satisfying some plausibility constraint. This worst case scenario being determined as it caused the most harmful loss in loan portfolios. In the research, three advantages over traditional macro stress testing have been noted. Firstly, it ensures that no harmful scenarios are missed and therefore prevents a false illusion of safety which may result when considering only standard stress scenarios. Besides, it does not analyse scenarios which are too implausible and would therefore

jeopardize the credibility of stress analysis. Thirdly, it allows for a portfolio specific identification of key risk factors.

e. Contagion analysis

Contagion analysis seeks to assess the impact of transmitting from an individual financial institution to the rest of the financial system (IMF and World Bank, 2003). The values used by financial institutions for contagion effects are generally based on judgment and historical experiences rather than on formal models of market behaviour (BIS, 2000). In most stress test result, the analysis can be further improved by analyzing the contagion among banks and between non-bank and banks (Cihak, 2007).

2.3 Risk Factors

Risk, due to changes in the business environment, it is defined as the reductions in firms' value. Basically, there are few major sources of risks which identified as follow:[3]

(i) Market risk, which is the change in net asset value due to changes in underlying economic factors such as exchange rates, interest rates and equity and commodity prices.

(ii) Credit risk, the changes which caused by changes in the perceived ability of counter parties to meet their contractual obligation.

(iii) Operational risk, results from costs incurred through mistakes made in carrying out transactions such as failure to meet regulations

[3] David H.Pyle. (1997). *Bank Risk Management: Theory*. Research Program in Finance, working paper RPF-272.

(iv) Performance risk, losses resulting from the failure to properly monitor employees, or to use appropriate methods.

For stress testing, there were two types of risk factors that usually being used i.e. credit risk and market risk (systematic risk).

Credit risk is the main type of risk for financial institution. It refers to the default risk whereby borrowers are not able to fulfil their payment obligation. In a broader sense, the term denotes the risk of a deterioration in a borrower's creditworthiness (migration risk), which leads to a revaluation of the relevant assets (Deutsche Bundesbank, 2004). The importance of credit risk is also clearly reflected in the Basel II framework, which foresees wide-ranging instruments to measure and control credit risk, both under Pillar I, but also under Pillar II (Deutsche Bundesbank, 2008). In addition, Banks' balance sheets are shocked directly applied to non-performing loans (NPLs) or provisions and a link to the macro economy are not modelled explicitly (Marina Moretti *et al,* 2008). Loan losses are usually counter-cyclical because of the borrowers' ability to repay their debts and the collateral's value which may be recovered in the event of default.

Same with the theory above, market risk comprises interest rate, equity price, commodity price, exchange rate and volatility risk (Deutsche Bundesbank, 2004). As regards the coverage of the stress tests, it can be benefitted from a broader scope that would cover the credit risk, its interplay with market risk, and interbank contagion (Cihak, 2007). They investigate how much the value of a portfolio of securities or loans changes given an assumed shock in the risk parameters. And, these risk

parameters that come into consideration are, above all, interest curves, exchange rates, equity prices and borrowers' ratings. In terms of the number of risk factors used, a rough distinction can be made between univariate and multivariate stress tests. The concept of "value at risk" has now become established as a standard in the area of market risk. (Deutsche Bundesbank, 2004).

Each bank has its own portfolio and it varies between each other. Hence, it is important to choose the right risk factors. However, this is not easy as the procedure to select the risk factors are not clearly defined (Oesterreichische Nationalbank, 2001).

2.4 Macroeconomic relevance of Non-performing Loans and Household Debt

Macroeconomic steadiness as well as financial sector development and government policies have all played an important role in influencing the supply of and demand for household credit.

From Macro Sorge paper, noted that in Austrian banking system, Kalirai and Scheicher (2002) estimate a time series regression of aggregate loan loss provisions as a function of an extensive array of macroeconomic variables. The indicators includes general economic activity (GDP, output gap and industrial production), price stability (CPI inflation and money growth), income, consumption and investment in the household and corporate sectors, financial market indicators (interest rates and stock market indices) and finally variables affecting external solvency (exchange rates, exports and oil prices).

In 1987, Keeton and Morris shows that local economic conditions along with the poor performance of certain sectors explain the variation in loan losses recorded by the banks using the NPL net of charge offs as the measurement of loan loss. In addition, the aforesaid study reports the commercial banks have greater risk appetite to record higher losses.

In year 1991, Sinkey and Greenwalt details that depressed regional economic conditions explain the loss-rate of the commercial banks too. In addition, Jimenez and Saurina (2005) observe the Spanish banking sector using data from 1984 to 2003 and found that NPLs are determined by GDP growth, high real interest rates and relaxed credit terms.

In Guyana, Tarron and Sukrishnalall employs regression analysis and a 10 years panel dataset which from 1994 to 2004 to examine the relationship between non-performing loans and several key macroeconomic and bank specific variables. Tarron find evidence of a significant inverse relationship between GDP and non-performing loans.

In addition, from the study, its being found that Bunn and Redwood (2003) examine the determinants of failure among individual UK companies with probit model to assess risks arising from the UK corporate sector. Besides, in addition to firm-specific factors like profitability and financial ratios, Kimmo Virolainen (2004) explain the explanatory variables also include macroeconomic conditions (proxies by the GDP growth rate). GDP growth proves to have a negative effect on the failure rate even after controlling for the firm-level characteristics.

Mary Daly et al (2003) observe that the composite index does help explain bank conditions. The analysis is helpful in forecasting differences in bank risk by state. The composite index is the single-most important explanatory variable from the set of regional economic variables on interstate banks. While for intrastate banks, the composite index has the largest impact especially to those banks concentrate in certain types of lending like commercial real estate or business lending.

Laura and Alicia (2006) tested the long-run relationship linking of NPL to the macroeconomic variables for the group of considered euro area countries. They found the positive estimated coefficient which suggests a lower volatility has contributed to the better performance of the ratio of arrears. In addition, the role of financial wealth and housing wealth which proxied by the house price index tends to confirm the idea that wealth is used as a buffer in case of unpredicted shocks in the short-run. Besides, the unemployment rate displays a positive effect on arrears to indicate the uncertainty of household future income.

Since the beginning of the 1990s, Malaysia has a rapid build-up of household debt, both in terms of ratio of debt to disposable income and, in terms of debt to GDP. Total household debt expanded by 9.4% to RM516.6bil or 76.6% of GDP (2008: RM472.1bil or 63.9% of GDP) as at end-2009.[4] In addition, from figure 2.2 below, 46.2% in 2009 were long term secured borrowings. This means that it is almost half of the household debts are to fund on the house acquisition.

[4] The Star Online, Business. 2010. *Household sector remains resilient.* http://biz.thestar.com.my/news/story.asp?file=/2010/3/25/business/5921818&sec=business

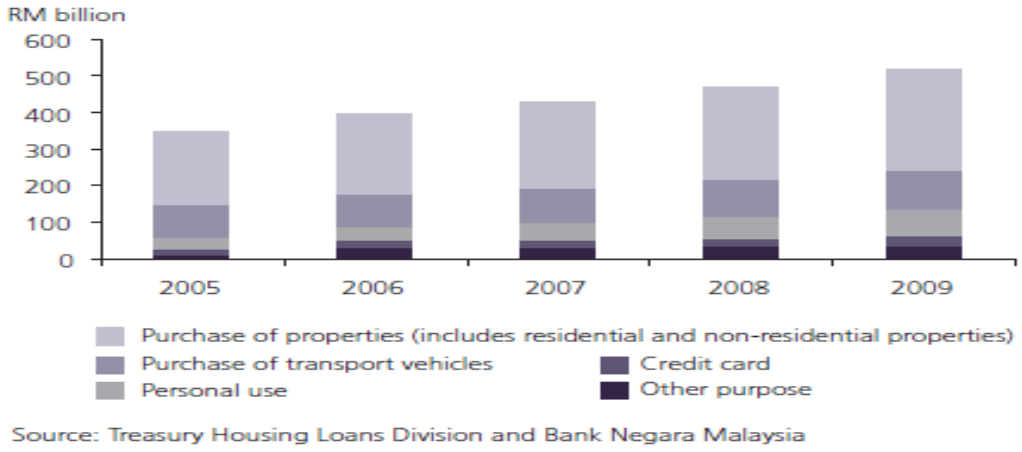


Figure 2.2: Composition of Household debt by purpose

(Source: Financial Stability Report, Central Bank of Malaysia)

Based on one of the publications and research from Bank for International Settlement, lending to the corporate sector had accounted for 67% of total loans outstanding at end of 1997. However, for consumer financing, it has expanded considerably from year 2000 onwards. From Figure 2.3 and 2.4 below, it shows that the average annual growth rate for the period 2001–07 was 14.8%. In addition, as at end-2007, household credit accounted for 56% of total outstanding bank loans and after six years of rapid growth, household debt grew at the more moderate pace of 7.9% in 2007.[5] With the shift towards high-volume, low-value loans, the banking sector has to diversify their credit risks and minimised the potential for large losses shooting from the failure of a few large borrowers. Since the lending to households becomes a larger segment of the financial system, it is fundamental for policymakers to be aware of the implications for monetary policy and financial stability.

[5] Norhana Endut and Toh Geok Hua. 2009. *Household debt in Malaysia, Bank for International Settlement.* http://www.bis.org/publ/bppdf/bispap46l.pdf

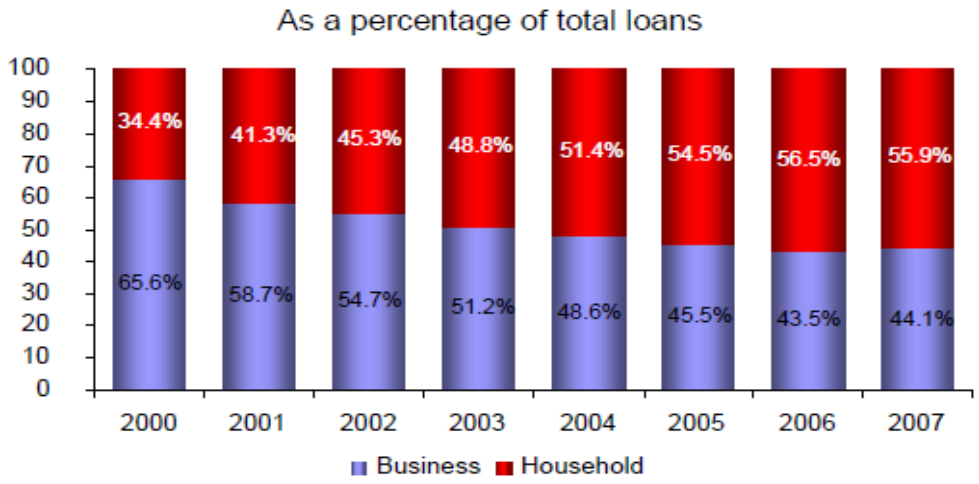
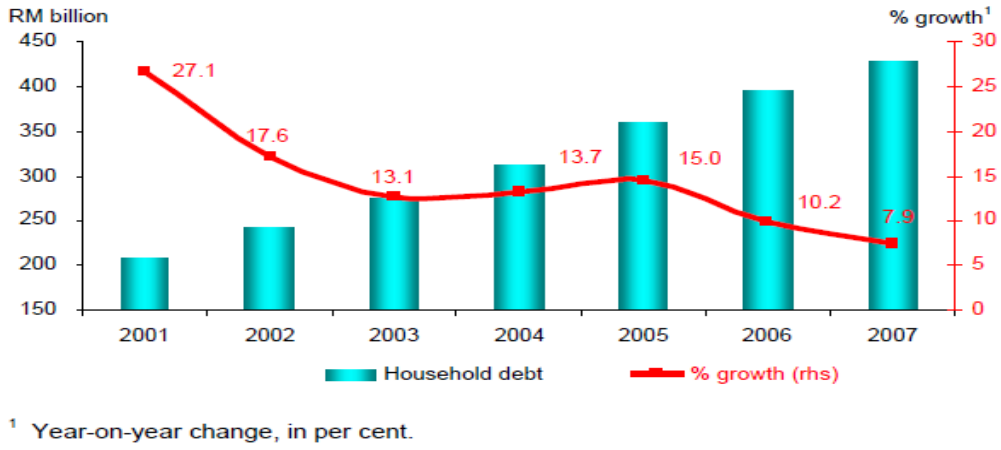


Figure 2.3: Breakdown of Malaysia Banking System Loan



[1] Year-on-year change, in per cent.

Figure 2.4: Household Indebtedness

(Source for Figure 2.3 & 2.4: Bank International Settlement, which sourced from Central Bank of Malaysia)

As a result of heavy borrowing by Malaysian households, the total household debt expanded by 9.4% to reach RM516.6 billion or 76.6% of GDP (2008: RM472.1 billion or 63.9% of GDP) as at end-2009. With this, it resulted in the gradual increase in total household debt-to-personal disposable income from 114.9% in January 2009 to 136% in December 2009.[6]

[6] Bank Negara Malaysia. 2009. *Financial Stability Report, Risk Assessment of the Financial System*, Pg 19.

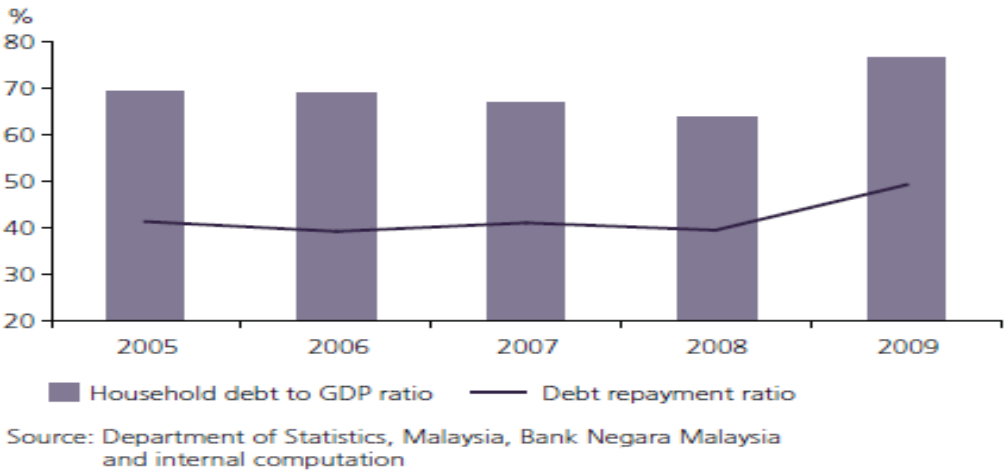
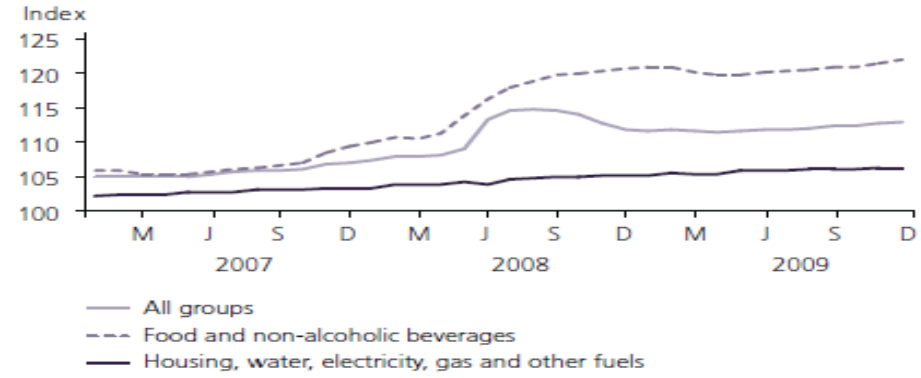


Figure 2.5: Household Indebtedness and Debt Repayment Ratio

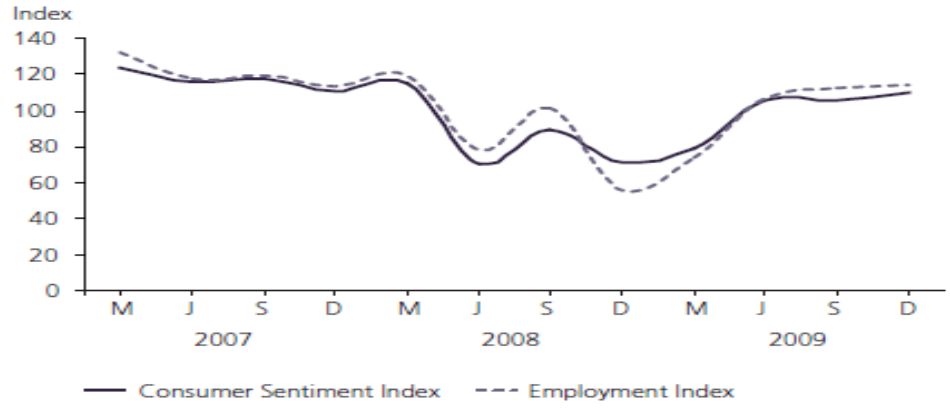
(Source: Financial Stability Report, Central Bank of Malaysia)

Household always adopted a cautious attitude of spending especially during crisis period. This can be clearly seen from Consumer Price Index (figure 2.6) below, which reveals that for first half of 2009, household is concerns on the surrounding of the uncertainty as to the direction of the domestic economy and employment prospects. In addition, figure 2.7 which adopted from BNM 2009's Financial Stability report, it shows the consumer sentiments in early 2009 reached a low level before the sharp turnaround in the second half of the year in line with more visible signs of improvement in the macroeconomic environment and employment outlook.



Source: Department of Statistics, Malaysia

Figure 2.6: Consumer Price Index



Source: Malaysian Institute of Economic Research

Figure 2.7: Consumer Sentiment Index and Employment Index

(Source for Figure 2.6 & 2.7: Financial Stability Report, Central Bank of Malaysia)

2.5 Univariate vs. Multivariate Regression model

As mentioned in the earlier section, univariate stress tests, which also known as sensitivity test, can isolate the specific influence of individual risk factors from that of other factors. This approach ignores the interaction of various risk factors that exists in reality (Deutsche Bundesbank, 2004). Hence, it has been supplemented by multivariate stress tests nowadays and these multivariate analyses are predominantly based on historical scenarios (Deutsche Bundesbank, 2004).

The macro stress testing in Finland was conducted through Wilson's model where it can be seen as a multifactor model for determining industry-specific average default rates. Subsequently, they simulated the future values of joint industry-specific default rates with a Monte Carlo method in order to determine the loss distributions for specific credit portfolios. The result of the test were appear a positive default correlation through joint sensitivity to the macro factors, and to the existence of large credit exposures in the portfolio.

In September 2008, there was a paper from Financial Stability Institute, which stress testing performed to compare the Credit Risk of the Czech Republic and Germany. The outcome that the multivariate impact of the stress test is much more severe for the Czech Republic may also be perceived at the resulting stress values of each of the macroeconomic variables of the two respective corporate models: in the German case, they are not diverging away too much from the actual value, while the stress level in the Czech case results in more substantial differences using multivariate.

As for IMF which experience in Financial Sector Assessment Program (FSAP), they have been evolving from single-factor sensitivity analysis from early days to multi-factor scenario. However, the result of the testing was not share to the public.

In Italy, Mario Quagliariello (2004) carried out both single factor stress tests, which are only a rough attempt to quantify the aggregate effects of GDP changes, and scenario analyses, which replicate the recessionary conditions of 1993 and the following recovery in 1994. The result shows that the econometric outcomes confirm

that banks' loan loss provisions, bad debts and profits are affected by the evolution of the business cycle i.e. the flow of new bad debts and the provisions against loan losses tend to increase when economic conditions deteriorate. This generally support the idea where the result of interaction between the general economic condition and banks' risk management.