

CHAPTER THREE

METHODOLOGY

3.0 Introduction

Chapter 3 discusses the data and methodologies used in the study. Firstly, the chapter starts with the discussion on the methodological position of the current study in Section 3.1. Section 3.2 provides detailed overviews on the selected non-financial firms, index and variables, firm characteristics and macroeconomic factors. Section 3.3 discusses the employed methods in accordance to the objectives of the study. Overall exposure level is analysed using the panel model with inclusion of both symmetric and asymmetric exposure. This is followed by further assessment of the exposure level at the firm level regression model. The Maximal Overlap Discrete Wavelet Transformation (MODWT) model is used to test for multiscale exposure. Further analyses on the corporate hedging practice are discussed. Finally, Section 3.5 concludes the chapter.

3.1 Research Paradigm

First of all, the section discusses the research paradigm that governs the whole system of thinking including the basic assumptions, the questions to be answered, the research techniques, and examples of good scientific research (Neuman, 2000). In this sense, paradigm helps the researcher to focus in acquiring the most important information pertaining the topic of interest. Basically, paradigm puts the researcher to view the research topic from both ontological and epistemological perspectives. In other words, it governs

how the researcher view the topic (ontological perspective) and the information and assumptions of the topic (epistemological perspective).

Ontology refers to assumptions about the nature of reality (Saunders et al., 2019). Positivism under the ontological perspective regards the nature of the world as real, external and in order. On the contrary, subjectivism regards the reality as nominal, socially constructed and chaotic. Meanwhile under the epistemological point of view, positivism is an epistemological philosophy that proposes the use of natural science methods to the study of social reality. According to Krauss (2005), positivism denotes independency between the object of study and the actors. That is to say, observation is used to acquire the knowledge of interest. In scientific study, positivism is widely used due to its assumption of independency between the data and its analysis. On the other hand, subjectivism is another philosophical position which perceives dependency between the people and the phenomenon (Hoddy, 2018). Therefore, subjectivism often requires the researcher to class the social actions based on the assumption surrounding the topic. This way, subjectivism directs the researcher towards the direction of where instances of a particular kind of inquiry can be found. It merely suggests a direction rather than providing a description of what to see in order to wholly comprehend the settings of the topic.

In this study, the objective of the research was maintained to be separated from being influenced by the actors. This condition is termed as positivism in which the ontological perspective is practiced in separating the phenomena and the people in it (Kaya,

2013). With this, the foreign exchange rate was viewed as influenced by the market forces and independent from the market participants. From the epistemological perspective, positivism in the study is manifested by the factual nature of the analysis. The assumptions on the foreign currency exposure employed in this study are adopted from mainstream past studies which exhibit observable phenomena involving numbers and facts. Furthermore, the contributions coming from the study are law-like rather than addressing specific individuals (Saunders et al., 2019).

3.2 Data

3.2.1 Selection of Non-financial Firms

Selection of the sample firms is based on the listed firms on the main board of the Bursa Malaysia. These listed firms are used for easier filtering process as these firms are excluded from any issues of insolvency, suspensions, and trading halts. In addition, listed firms are more reliable in terms of data availability, especially as this study requires high frequency data for a long period. The data were screened based on two criteria. Firstly, financial firms were excluded as financial firms are excluded as they are not directly involved with export-import activities (Allayannis & Ofek, 2001). Additionally, the extent of currency exposure of these financial firms is different from non-financial firms as most financial firms are also market makers in foreign currency market. With this, the data collection only involves non-financial firms that are listed on the Malaysia's Stock Exchange main board.

The firms span under 15 industries based on the classification made by Datastream. The industries are industrial engineering and transportation, travel and leisure, food and beverage producers, oil and gas producers and equipment, general industries, construction and materials, industrial metals and mining, chemicals, automobile and parts, general retailer, household goods and home construction, technology hardware, software, equipment and services, forestry and paper, personal and leisure goods, and electronic and electrical equipment. Secondly, firms with insufficient trading data within the stipulated study period were excluded. The study uses twenty-one years from 1995-2016 as the research sample to cover both AFC and GFC. Inclusion of the financial crises enables more meaningful analyses by extensively cover both periods of market tranquillity and turbulence. After screening the 1000 initial sample firms based on these two restrictions, the final sample for the study only comprises 207 firms while 793 firms are excluded. The flow of the data sampling procedures is depicted in Figure 3.1.

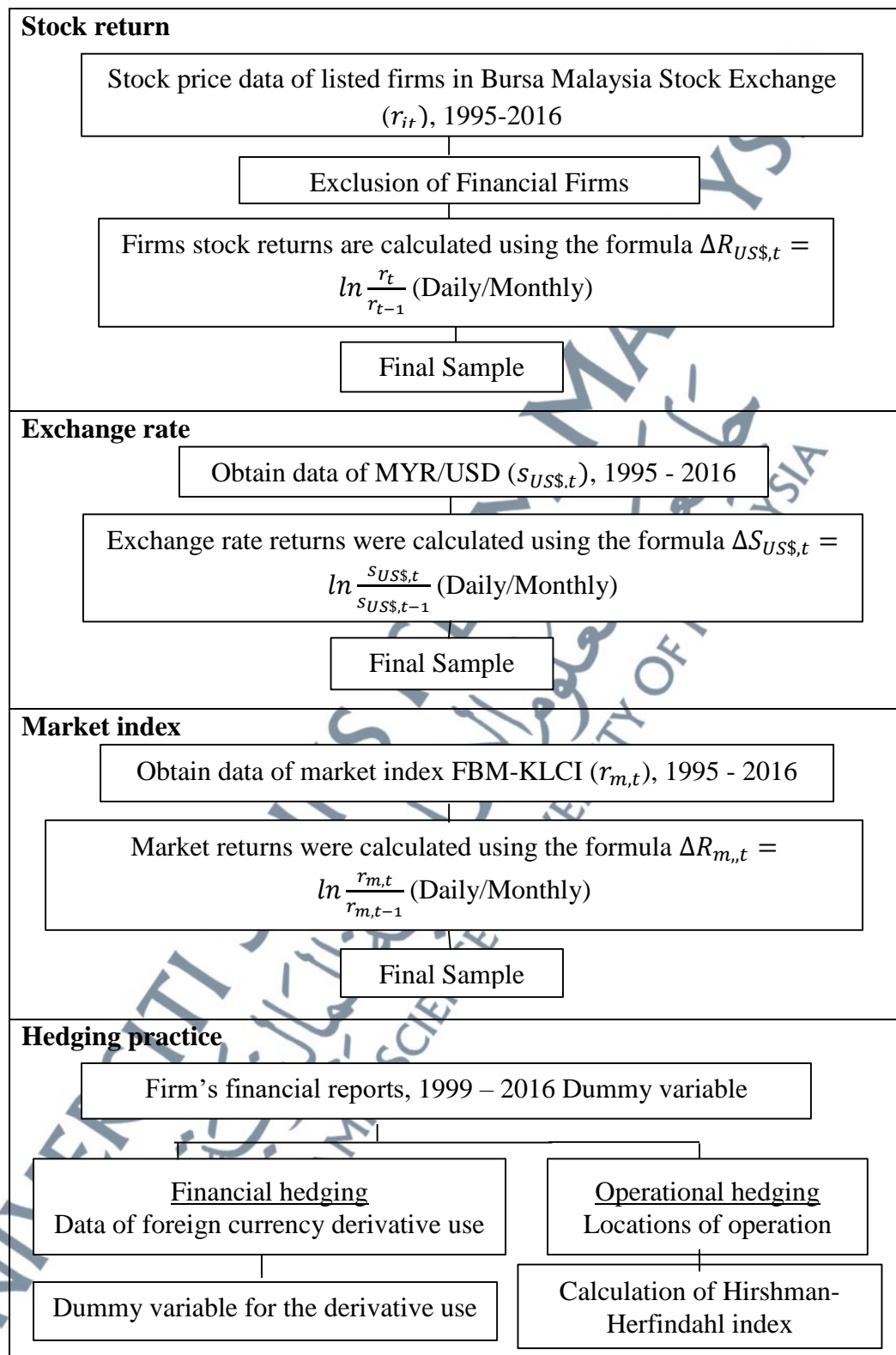


Figure 3.1: Data Sampling Procedures

3.2.2 Foreign Currency Exposure

3.2.2.1 Stock Returns

Stock returns data are collected from the Bloomberg Terminal. Monthly stock return data are used for the exposure analysis encompassing the asymmetric and time-varying components. The data run from January 1995 to December 2016 to capture the effect of Asian financial crisis and global financial crisis. On the other hand, daily data are collected to capture the multiscale dimension of the investment period. The returns are calculated using the model shown in Figure 3.1, in which the returns are logged difference at first level to solve for stationarity problem in trended series.

3.2.2.2 Foreign Exchange Rate

Direct quotation of exchange rate of MYR/USD is used to denote the foreign exchange rate. The USD is chosen for the analysis in consideration of the US' position as Malaysia's main trading partner. The nominal exchange rate is used for the main analysis while the real exchange rate is used for robustness test. In line with the stock return, the OLS and panel analyses use monthly foreign exchange rate for synchronisation purpose. Meanwhile, daily exchange rate is used for the wavelet analysis. Daily data are considered to provide high frequency data and cater the objective of the analysis to measure exposure across multiple time-scales. The shortest time-scale is between 2- 4 days, while the longest time-scale is between 128 – 256 days (one year).

3.2.2.3 FBM-KLCI

FBM-KLCI is used to represent the market index for Malaysian market. Inclusion of the index pivotally to control other external macroeconomic conditions and enhances the regression precision. As FBM-KLCI absorbs any influence that are correlated with the index, beta estimates will provide results that illustrate the residual exchange rate exposure level.

3.2.3 Corporate Hedging Practice

Hedging practice in this study revolves around two strategies namely the financial hedging and operational hedging. In this sense, the financial hedging is denoted by involvement of the particular firm with foreign currency derivative as a form to hedge their exposure. Meanwhile, operational hedging requires data of the country and region that the firm operates inclusive of Malaysia. Data for hedging practice are acquired from the annual financial reports of the respective firms. Information on the use of derivative hedging is found under the 'Foreign Currency Risk' section in the financial report, in which the firms clarify whether they enter any derivative contract to monitor their exposure to foreign currency risk for that particular year. However, inconsistency is observed as most of the sample firms do not clarify the types of the derivative that they entered into. Hence, the data are compiled into single variable rather than segregating them into different types of derivatives. The firms are also regarded as not entering into the derivative hedging should the firm stated they opted for natural hedging practice.

Meanwhile, enforcement of the financial disclosure by the Malaysian Accounting Standard Boards has facilitated the study to observe the hedging activities among the selected firms. Regulation of the disclosure of hedging information in Malaysian Financial Reporting Standards 7 (MFRS 7) has revolved from the previous IAS 39 to include an additional chapter on hedging accounting (Chong et al., 2014). The chapter specifies the qualifying hedging instrument and the hedged items, in which a derivative measure at fair value through profit or loss is regarded as a hedging instrument.

As per Table 3.1 below, the relevant variables for all the analyses in the study are listed. For all analyses on currency exposure, the data are acquired from the Bloomberg Terminal. Meanwhile, data for the hedging practice are collected from the firm's annual report.

Table 3.1: List of Relevant Variables

List of Variables	Frequency	Duration	Sources
Currency Exposure			
Stock Return	Monthly	1995-2016	Bloomberg Terminal
FBM-KLCI	Monthly	1995-2016	Bloomberg Terminal
Nominal MYR/USD Exchange	Monthly	1995-2016	Bloomberg Terminal
Real MYR/USD Exchange	Monthly	1995-2016	Bloomberg Terminal
Multiscale Exposure			
Stock Return	Daily	1995-2016	Bloomberg Terminal
FBM-KLCI	Daily	1995-2016	Bloomberg Terminal
Nominal MYR/USD Exchange	Daily	1995-2016	Bloomberg Terminal
Real MYR/USD Exchange	Daily	1995-2016	Bloomberg Terminal
Hedging Practice			
Foreign Currency Derivative Use	Annual	1995-2016	Annual Report
Operational Hedging	Annual	1995-2016	Annual Report

On the other hand, the financial periods data utilise the dummy variable. As the data in the study span from 1995-2016, inclusion of the financial periods is relevant considering the long-time horizon. With this, the financial periods included in the study are the Asian financial crisis, peg period, and global financial crisis. In this sense, the data will be 1 for the specific time-period and 0 otherwise.

3.3 Methodology

3.3.1 Symmetric and Asymmetric Foreign Currency Exposure

This section discusses the models used to analyse symmetric and asymmetric currency exposure. Investigating these exposure levels would answer the first objective of the study. This section comprises four analyses which are the overall symmetric exposure, overall asymmetric exposure, firm-level symmetric exposure, and firm-level asymmetric exposure. For this purpose, the study conducts panel analysis as well as firm-level analysis on the data for both symmetric and asymmetric approaches. This serves as a comparison between the overall and firm-level analyses to better gauge the currency exposure level in the Malaysian market.

3.3.1.1 Overall Symmetric Foreign Currency Exposure

In measuring currency exposure, the study utilises the symmetric model that is based on the Parsley and Popper's (2006) model. The model by Parsley and Popper (2006) is based on the mainstream study by Jorion (1990) that has been widely used in the study of currency exposure. This model provides better

measurement as it incorporates the market index into the analysis. This is in comparison to the total exposure model introduced by Modigliani and Miller (1958) which excluded the market index from the model. Hence, the residual model by Parsley and Popper is appropriate for the analysis because incorporation of the market index into the model disassociates the beta coefficient for the exposure from the potential market effect. On the other hand, the asymmetric model is based on the model by Clark and Mefteh (2011) in which the model enables simultaneous measurement of the different directions of the currency movements. In the first step of the analysis, the level of currency exposure across the whole market is assessed to provide the overall level of exposure using the panel model. In conducting the analysis, the following procedures were followed:

Step 1: Data for each variable were sorted as monthly return data.

Step 2: The data were then used to form the symmetric currency exposure model based on the model introduced by Parsley and Popper (2006)

The symmetric exposure model to measure the level of symmetric currency at the overall level is as follows:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \beta_{US\$} S_{US\$,t} + \mu_{it} \quad (3.1)$$

For each firm i at time t , the other denotations are as follow:

R_{it} = monthly stock return of firm i

R_{mt} = monthly return of the market index

$S_{US,t}$ = nominal monthly change in the USD exchange rates

μ_{it} = regression residual

Step 3: Preliminary Hausman specification test was conducting before running the panel analysis in order to select between Fixed or Random Effects models.

Hausman Specification Test

Hausman test evaluates for endogenous regressor in a regression model. Presence of endogenous variables would cause bias estimation due to existence of correlation between the variables and error term. Hence, the Hausman specification test needs to be conducted to decide between the Fixed or Random Effects model. The test assumes no correlation between the independent variables and the error term in which the characteristics of the regressors are unique and not correlated with other individual regressors' characteristics. As the null hypothesis assumes no correlation between the regressors and the error term, rejection of the null hypothesis indicates more appropriate utilisation of the Fixed Effects model over Random Effects model. In other words, the Fixed Effects model is deemed as the more efficient model structure of the true population parameters. The hypotheses underlying the Hausman test are:

H_0 = There is no correlation between error term and regressors (Random Effects model is consistent)

H_α = There is correlation between error term and regressors (Random Effects model is inconsistent and Fixed Effects model is more appropriate)

The Fixed Effects and Random Effects symmetric exposure models are shown below:

The symmetric Fixed Effects model:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \beta_{US\$} S_{US\$,t} + \mu_{it} \quad (3.2)$$

The symmetric Random Effects model:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \beta_{US\$} S_{US\$,t} + \epsilon_i + v_t + \mu_{it} \quad (3.3)$$

For each firm i at time t , the other denotations are as follows:

- R_{it} = monthly stock return of firm i
- R_{mt} = monthly return of the market index
- $S_{US\$,t}$ = nominal monthly change in the USD
- ϵ_i = cross section error
- v_t = time series error
- μ_{it} = combined error component

The Hausman Specification Statistic is denoted by:

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})' [Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE})]^{-1} [\hat{\beta}_{FE} - \hat{\beta}_{RE}] \sim \chi^2(k) \quad (3.4)$$

Where k = number of parameters

Significance of the $\hat{\beta}_{FE}$ indicates consistency of Fixed Effects model structure. This criterion is used for all Hausman tests conducted throughout the study.

For overall level symmetric foreign currency exposure analysis, the following hypotheses are tested:

H_0 = There is no significant relationship between symmetric foreign currency exposure changes and the sample firms' stock return at the overall level analysis.

3.3.1.2 Overall Asymmetric Foreign Currency Exposure

In this section, currency exposure was measured at the overall level by incorporating the asymmetric factor. Before continuing with the analysis, the study firstly conducted a straightforward preliminary analysis to ensure the presence of asymmetric effect in the model by following the model introduced by Koutmos and Martin (2003). Specifically, the steps of the analysis for this section are:

Step 1: Data for each variable were sorted as monthly return data.

Step 2: Preliminary analysis was conducted to ensure the presence of the asymmetric effect in the model. The preliminary analysis followed the model by Koutmos and Martin (2003).

While most studies on asymmetric exposure tend to segregate the currency movements according to its direction, the model by Koutmos and Martin (2003) depended on the significance of the dummy variable to illustrate the presence of asymmetric effect. Hence, the model offers an advantage to the study by providing early indication on the existence of asymmetric in the model. To the best of our

knowledge, no improvement has been made on the model as most past studies resorted to the residual model by Parsley and Popper (2006) because the model by Koutmos and Martin (2003) only provides direct indication on the presence of asymmetric effect but did not specify the direction of effects. Still, the model is applicable in this study as a preliminary analysis to support our main model. For this reason, the model is adopted into the study in addition to the more rigorous and in-depth analysis of asymmetric exposure in the following section. The panel model proposed by Koutmos and Martin (2003) is as follows:

$$R_{it} = \theta_0 + \theta_1 R_{mt} + (\theta_{US\$} + \theta_{D,US\$} D_{it}) US\$_t + \varepsilon_{it} \quad (3.5)$$

Where:

- R_{it} = monthly stock return of firm i
- R_{mt} = monthly return on the market index
- $\theta_{US\$}$ = $\beta_{US\$,t}^P$
- $\theta_{D,US\$}$ = $\beta_{US\$,t}^P - \beta_{US\$,t}^N$
- D_t = 1 if the monthly change in the USD is less than 0 and zero otherwise.

Testing for asymmetric effect in the model is equivalent to testing statistical significance of the $\theta_{D,US\$}$, irrespective of the sign of the coefficient. Thus, presence of asymmetric exposure in the panel model is indicated by the significance of the dummy variable.

Step 3: The data were then used to form the symmetric currency exposure model based on the model introduced by Parsley and Popper (2006).

Once the presence of asymmetric effect is ascertained through the Koutmos and Martin (2003) model, the study continues to answer the second part of objective one by incorporating the asymmetric element of the currency exposure into the equations (3.1) and (3.2). Calculation of the asymmetric exposure takes into account the direction of MYR/USD movements. Appreciation of the currency is regarded as positive movement while currency depreciation denotes negative movement.

Step 4: Preliminary Hausman specification test was conducting before running the panel analysis in order to select between the Fixed or Random Effects models.

As this section involves panel analysis, Hausman test is conducted to determine the appropriate model for the analysis. The hypotheses underlying the Hausman test are:

H_o = There is no correlation between error term and regressors (Random Effects model is consistent)

H_a = There is correlation between error term and regressors (Random Effects model is inconsistent and Fixed Effects model is more appropriate)

The Fixed Effects and Random Effects models are shown below.

The asymmetric Fixed Effects model:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \beta_{US\$}^P S_{US\$,t}^P + \beta_{US\$}^N S_{US\$,t}^N + \mu_{it} \quad (3.6)$$

The asymmetric Random Effects model:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \beta_{US\$}^P S_{US\$,t}^P + \beta_{US\$}^N S_{US\$,t}^N + \epsilon_i + v_t + \mu_{it} \quad (3.7)$$

For each firm i at time t , the other denotations are as follow:

- R_{it} = monthly stock return of firm i
- R_{mt} = monthly return on the market index
- $S_{US\$,t}^P$ = positive nominal monthly change in the USD
- $S_{US\$,t}^N$ = negative nominal monthly change in the USD
- ϵ_i = cross section error
- v_t = time series error
- μ_{it} = combined error component

For the overall level asymmetric foreign currency exposure analysis, the following hypotheses are tested:

H_0 = There is no significant relationship between asymmetric foreign currency exposure changes and the sample firms' stock return at the overall level analysis.

3.3.1.3 Firm-level Symmetric Foreign Currency Exposure

Subsequent to the analysis on the overall exposure level, this section encompasses the model to examine the symmetric exposure at the firm-level. The steps involved for the analysis in this section are:

Step 1: Data for each variable were sorted as monthly return data.

Step 2: The data were then used to form the symmetric currency exposure model based on the model introduced by Jorion (1990).

Responding to the first part of objective one, the symmetric model is adopted from Jorion (1990) as follows:

$$R_t = \gamma_0 + \gamma_1 R_{mt} + \beta_{US\$} S_{US\$,t} + \mu_t \quad (3.8)$$

For each firm i at time t , the other denotations are as follow:

- R_t = monthly stock return of firm
- R_{mt} = monthly return of the market index
- $S_{US\$,t}$ = nominal monthly change in the USD
- μ_t = regression residual

Step 3: The results were tested using Breusch-Pagan Godfrey for heteroscedasticity problem.

Step 4 Firms that suffer from heteroscedasticity issue will be re-regressed using the GARCH(1,1) specification.

As this study deals with financial time series with non-constant variance, the study follows the precaution taken by Bacha et al. (2013) to add the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) (1,1) specification into equation (3.8). Prior to conducting the GARCH(1,1) estimation, each firm is tested

for heteroscedasticity using the Breusch-Pagan Godfrey test in Eviews. GARCH(1,1) is run for firms that suffered from heteroscedasticity problem.

Generalised Autoregressive Conditional Heteroscedasticity GARCH(1,1) Test

Heteroscedasticity problem arises when the conditional variance for the given past is non-stationary over time. Non-constant variance would inflict biased estimation results. In this study, Breusch-Pagan Godfrey test is conducted to test for heteroscedasticity problem. In the test, heteroscedasticity is assumed for firm with p -value that falls below the 0.05 threshold p -value ($p < 0.05$). Afterwards, the GARCH(1,1) model is employed in the firm-level analyses for data that suffer from the heteroscedasticity problem. For each firm i at time t , the GARCH(1,1) model is as follows:

$$h_t = \delta_0 + \delta_1 \mu_{t-1}^2 + \delta_2 h_{t-1} \tag{3.9}$$

Where:

h_t = conditional variance at time t

μ_t^2 = squared error term at time t

For firm-level symmetric foreign currency exposure analysis, the following hypotheses are tested:

H_0 = There is no significant relationship between symmetric currency exposure changes and the sample firms' stock return at the firm-level analysis.

3.3.1.4 Firm-level Asymmetric Foreign Currency Exposure

In the second part of the asymmetric analysis, the steps of the analysis in this section are:

Step 1: Data for each variable were sorted as monthly return data.

Step 2: Preliminary analysis was conducted to ensure the presence of the asymmetric effect in the model. The preliminary analysis followed the model by Koutmos and Martin (2003).

Similar to the precautionary step undertaken in the analysis of asymmetric panel model, a straightforward initial analysis is also conducted on the firm-level analysis to test for the presence of the asymmetric effect. The measurement follows the model by Koutmos and Martin (2003), in which the response of the dependent variable (R_{it}) is compared to the values of the coefficients $\theta_{US\$}$ and $\theta_{D,US\$}$. The significance of the $\theta_{D,US\$}$ denotes the presence of asymmetric exposure in the model. The equation by Koutmos & Martin (2003) is as follows:

$$R_t = \theta_0 + \theta_1 R_{mt} + (\theta_{US\$} + \theta_{D,US\$} D_t) US\$_t + \varepsilon_t \quad (3.10)$$

Where:

R_t = monthly stock return of firm

R_{mt} = monthly return on the market index

$\theta_{US\$}$ = $\beta_{US\$,t}^P$

$\theta_{D,US\$}$ = $\beta_{US\$,t}^P - \beta_{US\$,t}^N$

D_t = 1 if the monthly change in the USD is less than 0 and zero otherwise.

Step 3: The data were then used to form the symmetric currency exposure model based on the model introduced by Jorion (1990).

In continuation of the equation (3.10), the firm level analysis further incorporates the asymmetric information of exchange rate movements into equation (3.6). Similarly, the equation segregates the monthly nominal change of MYR/USD based on the direction of their changes (appreciation and depreciation). The firm-level asymmetric exposure model is shown below:

$$R_t = \gamma_0 + \gamma_1 R_{mt} + \beta_{US\$}^P S_{US\$,t}^P + \beta_{US\$}^N S_{US\$,t}^N + \mu_t \quad (3.11)$$

Where:

- R_t = monthly stock return of firm i
- R_{mt} = monthly return of the market index
- $S_{US\$,t}^P$ = positive nominal monthly change in the USD
- $S_{US\$,t}^N$ = negative nominal monthly change in the USD
- μ_t = regression residual

Step 4: The results were tested using Breusch-Pagan Godfrey for heteroscedasticity problem.

Step 5 Firms that suffer from heteroscedasticity issue will be re-regressed using the GARCH(1,1) specification.

This study also adds the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) (1,1) specification into equation (3.11) for firms that suffered from heteroscedasticity problem. Prior to conducting the GARCH(1,1) estimation, the firms are tested for heteroscedasticity using the Breusch-Pagan Godfrey test in Eviews.

Generalised Autoregressive Conditional Heteroscedasticity GARCH(1,1) Test

Heteroscedasticity problem arises when the conditional variance for the given past is not constant over time. Non-constant variance would inflict biased estimation results. Hence, the GARCH(1,1) model is employed in the firm-level analyses for data that suffer from the heteroscedasticity problem. For each firm i at time t , the GARCH(1,1) model is as follows:

$$h_t = \delta_0 + \delta_1 \mu_{t-1}^2 + \delta_2 h_{t-1} \quad (3.12)$$

Where:

h_t = conditional variance at time t

μ_t^2 = squared error term at time t

For firm-level asymmetric foreign currency exposure analysis, the following hypotheses are tested:

H_o = There is no significant relationship between asymmetric currency exposure changes and the sample firms' stock return at the firm-level analysis.

3.3.2 Time-varying Symmetric and Asymmetric Foreign Currency Exposure

In order to answer the second objective of the study, the section segregates the time-varying component into the symmetric and asymmetric models. This section comprises four analyses namely the overall symmetric time-varying exposure, overall asymmetric time-varying exposure, firm-level symmetric time-varying exposure, and firm-level asymmetric time-varying exposure. All the models are rooted from the model introduced by Jorion (1990) to measure exchange rate exposure. The study incorporates the time-varying factor to measure the variation of currency exposure across different financial periods such as the Asian financial crisis, peg period, and the global financial crisis. These financial timelines are discussed in detail in Chapter 2 under Section 2.2.5 and summarised in Table 2.2 in page 47. Following the timeline, this study comes out with 5 dummy variables to denote the financial events. The dummy variables represent their respective financial events, with each financial period is hypothesised to exert significant effects towards the firm's currency exposure levels at 10% significant level. The hypothesis of significant effect of the financial period is accepted for any p-value of the beta coefficient for the dummy variable that is lesser than 0.10. Determining the significance of the dummy variable implies significant effect of the time period and answers the research objective of different currency exposure effects and significances across different time periods. The result also provides insights on the financial events that exert the highest effect towards the firm's currency exposure level.

3.3.2.1 Overall Time-varying Symmetric Foreign Currency Exposure

Initially, the currency exposure is analysed at the overall symmetric level with inclusion of dummy variable to capture time-variation. The analysis on the overall exposure level utilises the panel estimation model, thus Hausman test is required to ascertain between Fixed and Random Effects models. Details of the time periods are explained in the denotation section below. In running the analysis, the effect of the currency exposure is hypothesised to be significant under all periods at 10% significant level. Testing the p-value for each sub-period against the 10% significant level would indicate the exact effect of the currency exposure towards the value of the sample firms in consideration of each financial event.

In conducting the analysis, the following procedures were followed:

- Step 1: Data for each variable were sorted as monthly return data.
- Step 2: The data were then used to form the symmetric currency exposure model based on the model introduced by Parsley and Popper (2006)

Following the model by Parsley and Popper (2006), the time-varying symmetric model is as follows:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \sum_{j=1}^5 \beta_{US\$} D_j S_{US\$,t} + \mu_{it} \quad (3.13)$$

For each firm i at time t , the other denotations are as follow:

- R_{it} = monthly stock return of firm i
 R_{mt} = monthly return of the market index

$S_{US\$,t}$ = nominal monthly change in the USD
 μ_{it} = error term
 D_j = time dummy for specific time period;
 D_1 = 1, middle Asian Financial Crisis (July 1997- June 1998)
 0, otherwise
 D_2 = 1, peg period (July 1998 – July 2005)
 0, otherwise
 D_3 = 1, de-peg period (August 2005 – August 2008)
 0, otherwise
 D_4 = 1, middle Global Financial Crisis (September 2008 – March 2009)
 0, otherwise
 D_5 = 1, post Global Financial Crisis (April 2009 – December 2016)
 0, otherwise
 Control period = Pre-Asian Financial Crisis (January 1995 – June 1997)

Step 3: Preliminary Hausman specification test was conducting before running the panel analysis in order to select between the Fixed or Random Effects models.

Hausman Specification Test

Hausman test evaluates for endogenous regressor in a regression model. Presence of endogenous variables would cause bias estimation due to existence of correlation between the variables and error term. Hence, the Hausman specification test needs to be conducted to decide between the Fixed or Random Effects model.

The test assumes no correlation between the independent variables and the error term. Rejection of the hypothesis favours the utilisation of the Fixed Effects model over Random Effects model. The hypotheses underlying the Hausman test are:

H_0 = There is no correlation between error term and regressors (Random Effects model is consistent)

H_a = There is correlation between error term and regressors (Random Effects model is inconsistent and Fixed Effects model is more appropriate)

The time-varying symmetric Fixed Effects model:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \sum_{j=1}^5 \beta_{US\$} D_j S_{US\$,t} + \mu_{it} \quad (3.14)$$

The time-varying symmetric Random Effects model:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \sum_{j=1}^5 \beta_{US\$} D_j S_{US\$,t} + \epsilon_i + v_t + \mu_{it} \quad (3.15)$$

For each firm i at time t , the other denotations are as follow:

R_{it} = monthly stock return of firm i

R_{mt} = monthly return of the market index

$S_{US\$,t}$ = nominal monthly change in the USD

ϵ_i = cross section error

v_t = time series error

μ_{it} = combined error component

D_j = time dummy for specific time period;

D_1 = 1, middle Asian Financial Crisis (July 1997- June 1998)
0, otherwise

D_2 = 1, peg period (July 1998 – July 2005)
0, otherwise

$D_3 = 1$, de-peg period (August 2005 – August 2008)

0, otherwise

$D_4 = 1$, middle Global Financial Crisis (September 2008 – March 2009)

0, otherwise

$D_5 = 1$, post Global Financial Crisis (April 2009 – December 2016)

0, otherwise

Control period = Pre-Asian Financial Crisis (January 1995 – June 1997)

For overall level time-varying symmetric foreign currency exposure analysis, the following hypotheses are tested:

H_0 = There is no significant relationship between symmetric currency exposure changes and the sample firms' stock return across different time periods at the overall level analysis.

3.3.2.2 Overall Time-varying Asymmetric Foreign Currency Exposure

Following the previous symmetric analysis, this section analyses the time-varying currency exposure at the overall level while considering the asymmetric component of the MYR/USD movements.

Specifically, the steps of the analysis for this section are:

Step 1: Data for each variable were sorted as monthly return data.

Step 2: The data were then used to form the symmetric currency exposure model based on the model introduced by Parsley and Popper (2006).

The time-varying asymmetric model:

$$R_{it} = \alpha_{0i} + \alpha_1 R_{mt} + \sum_{j=1}^5 \beta_{j,US\$}^P D_j S_{US\$,t}^P + \sum_{j=1}^5 \beta_{j,US\$}^N D_j S_{US\$,t}^N + \mu_{it} \quad (3.16)$$

For each firm i at time t , the other denotations are as follow:

- R_{it} = monthly stock return of firm i
 R_{mt} = monthly return of the market index
 $S_{US\$,t}^P$ = positive nominal monthly change in the USD
 $S_{US\$,t}^N$ = negative nominal monthly change in the USD
 μ_{it} = error term
 D_j = time dummy for specific time period
 D_1 = 1, middle Asian Financial Crisis (July 1997- June 1998)
 0, otherwise
 D_2 = 1, peg period (July 1998 – July 2005)
 0, otherwise
 D_3 = 1, de-peg period (August 2005 – August 2008)
 0, otherwise
 D_4 = 1, middle Global Financial Crisis (September 2008 – March 2009)
 0, otherwise
 D_5 = 1, post Global Financial Crisis (April 2009 – December 2016)
 0, otherwise
 Control period = Pre-Asian Financial Crisis (January 1995 – June 1997)

Step 3: Preliminary Hausman specification test was conducting before running the panel analysis in order to select between the Fixed or Random Effects models.

As this section involves panel analysis, Hausman test is conducted to determine the appropriate model for the analysis. The hypotheses underlying the Hausman test are:

H_0 = There is no correlation between error term and regressors (Random Effects model is consistent)

H_a = There is correlation between error term and regressors (Random Effects model is inconsistent and Fixed Effects model is more appropriate)

The Fixed Effects and Random Effects models are shown below.

The time-varying asymmetric Fixed Effects model:

$$R_{it} = \alpha_0 + \alpha_1 R_{mt} + \sum_{j=1}^5 \beta_{j,US\$}^P D_j S_{US\$,t}^P + \sum_{j=1}^5 \beta_{j,US\$}^N D_j S_{US\$,t}^N + \mu_{it} \quad (3.17)$$

The time-varying asymmetric Random Effects model:

$$R_{it} = \alpha_{0i} + \alpha_1 R_{mt} + \sum_{j=1}^5 \beta_{j,US\$}^P D_j S_{US\$,t}^P + \sum_{j=1}^5 \beta_{j,US\$}^N D_j S_{US\$,t}^N + \epsilon_i + v_t + \mu_{it} \quad (3.18)$$

For each firm i at time t , the other denotations are as follow:

R_{it} = monthly stock return of firm i

R_{mt} = monthly return of the market index

$S_{US\$,t}^P$ = positive nominal monthly change in the USD

$S_{US\$,t}^N$ = negative nominal monthly change in the USD

ϵ_i = cross section error

v_t = time series error

μ_{it} = combined error component

- D_j = time dummy for specific time period
 D_1 = 1, middle Asian Financial Crisis (July 1997- June 1998)
 0, otherwise
 D_2 = 1, peg period (July 1998 – July 2005)
 0, otherwise
 D_3 = 1, de-peg period (August 2005 – August 2008)
 0, otherwise
 D_4 = 1, middle Global Financial Crisis (September 2008 – March 2009)
 0, otherwise
 D_5 = 1, post Global Financial Crisis (April 2009 – December 2016)
 0, otherwise
 Control period = Pre-Asian Financial Crisis (January 1995 – June 1997)

For overall level time-varying asymmetric foreign currency exposure analysis, the following hypotheses are tested:

H_0 = There is no significant relationship between asymmetric currency exposure changes and the sample firms' stock return across different time periods at the overall level analysis.

3.3.2.3 Firm-level Time-varying Symmetric Foreign Currency Exposure

In addition to the panel analysis, this section entails the firm-level analysis of the symmetric time-varying exposure. The exposure level is analysed for each firm with the dummy variable denoting the different time periods.

The steps involved for the analysis in this section are:

Step 1: Data for each variable were sorted as monthly return data.

Step 2: The data were then used to form the symmetric currency exposure model based on the model introduced by Jorion (1990).

The firm-level time-varying symmetric model is in the equation (3.19) as follows:

$$R_t = \gamma_0 + \gamma_1 R_{mt} + \sum_{j=1}^5 \beta_{US\$} D_{j,US\$} S_{US\$,t} + \mu_t \quad (3.19)$$

R_t = monthly stock return of firm i

R_{mt} = monthly return of the market index

$S_{US\$,t}$ = nominal monthly change in the USD

μ_t = regression residual

D_j = time dummy for specific time period

D_1 = 1, middle Asian Financial Crisis (July 1997- June 1998)
0, otherwise

D_2 = 1, peg period (July 1998 – July 2005)
0, otherwise

D_3 = 1, de-peg period (August 2005 – August 2008)
0, otherwise

D_4 = 1, middle Global Financial Crisis (September 2008 – March 2009)
0, otherwise

D_5 = 1, post Global Financial Crisis (April 2009 – December 2016)
0, otherwise

Control period = Pre-Asian Financial Crisis (January 1995 – June 1997)

Step 3: The results were tested using Breusch-Pagan Godfrey for heteroscedasticity problem.

Step 4 Firms that suffer from heteroscedasticity issue will be re-regressed using the GARCH(1,1) specification.

Undertaking the precaution taken by Bacha et al. (2013), the study run the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) (1,1) specification as the analysis deals with financial time series with non-constant variance. Prior to conducting the GARCH(1,1) estimation, each firm is tested for heteroscedasticity using the Breusch-Pagan Godfrey test in Eviews. GARCH(1,1) is run for firms that suffered from heteroscedasticity problem.

Generalised Autoregressive Conditional Heteroscedasticity GARCH(1,1) Test

Initially, Breusch-Pagan Godfrey test is conducted to test for heteroscedasticity problem. In the test, heteroscedasticity is assumed for firm with p -value that falls below the 0.05 threshold p -value ($p < 0.05$). Afterwards, the GARCH(1,1) model is employed in the firm-level analyses for data that suffer from the heteroscedasticity problem. For each firm i at time t , the GARCH(1,1) model is as follows:

$$h_t = \delta_0 + \delta_1 \mu_{t-1}^2 + \delta_2 h_{t-1} \quad (3.20)$$

Where:

h_t = conditional variance at time t

μ_t^2 = squared error term at time t

For firm-level time-varying symmetric foreign currency exposure analysis, the following hypotheses are tested:

H_o = There is no significant relationship between symmetric currency exposure changes and the sample firms' stock return across different time periods at the firm-level analysis.

3.3.2.4 Firm-level Time-varying Asymmetric Foreign Currency Exposure

The fourth analysis in the section involves the firm-level analysis of currency exposure while taking into consideration of asymmetric movement of the MYR/USD and the effect of different time-periods.

In the second part of the asymmetric analysis, the steps of the analysis in this section are:

Step 1: Data for each variable were sorted as monthly return data.

Step 2: The data were then used to form the symmetric currency exposure model based on the model introduced by Jorion (1990).

The firm-level time-varying asymmetric exposure is analysed for each firm according to the following equation:

$$R_t = \gamma_0 + \gamma_1 R_{mt} + \sum_{j=1}^5 \beta_{j,US\$}^P D_{j,t} S_{US\$,t}^P + \sum_{j=1}^5 \beta_{j,US\$}^N D_{j,t} S_{US\$,t}^N + \mu_t \quad (3.21)$$

R_t = monthly stock return of firm i

- R_{mt} = monthly return of the market index
 $S_{US\$,t}^P$ = positive nominal monthly change in the USD
 $S_{US\$,t}^N$ = negative nominal monthly change in the USD
 μ_t = regression residual
 D_j = The dummy variable D_j in this model
 D_1 = 1, before Asian Financial Crisis (January 1995- June 1997)
 0, otherwise
 D_2 = 1, middle Asian Financial Crisis (July 1997 – June 1998)
 0, otherwise
 D_3 = 1, de-peg period (August 2005 – August 2008)
 0, otherwise
 D_4 = 1, middle Global Financial Crisis (September 2008 – March 2009)
 0, otherwise
 D_5 = 1, post Global Financial Crisis (April 2009 – December 2016)
 0, otherwise

Control period = peg period (July 1998 – July 2005)

Step 3: The results were tested using Breusch-Pagan Godfrey for heteroscedasticity problem.

Step 4 Firms that suffer from heteroscedasticity issue will be re-regressed using the GARCH(1,1) specification.

As in the previous firm-level analysis, this study also runs the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) (1,1) specification in the time-varying asymmetric analysis for firms that suffered from heteroscedasticity problem. Prior to conducting the GARCH(1,1) estimation, the firms are tested for heteroscedasticity using the Breusch-Pagan Godfrey test.

Generalised Autoregressive Conditional Heteroscedasticity GARCH(1,1) Test

Heteroscedasticity problem arises when the conditional variance for the given past is not constant over time. Non-constant variance would inflict biased estimation results. Hence, the GARCH(1,1) model is employed in the firm-level analyses for data that suffer from the heteroscedasticity problem. For each firm i at time t , the GARCH(1,1) model is as follows:

$$h_t = \delta_0 + \delta_1 \mu_{t-1}^2 + \delta_2 h_{t-1} \quad (3.22)$$

Where:

h_t = conditional variance at time t

μ_t^2 = squared error term at time t

For firm-level time-varying asymmetric foreign currency exposure analysis, the following hypotheses are tested:

H_0 = There is no significant relationship between asymmetric currency exposure changes and the sample firms' stock return across different time periods at the firm-level analysis.

3.3.3 Multiscale Foreign Currency Exposure

The subsequent objective encompasses the analysis on multiscale exposure of the selected non-financial firms. The analysis provides insight of the exposure level across different time-scales and accommodate diverse investment horizons in the market. This is an important consideration as the true dynamic structure of the relationship between variables tend to vary over different time scales associated with different horizons. In

wavelet method, the daily return data for each stock market and market index are used. Specifically, the measurement uses the maximal overlap discrete wavelet transformation (MODWT) under specific wavelet filter named the Daubechies transformation due to its ability to cater for unique phenomena in the data. In this sense, the transformation does not the frequency information, but also the time locality at which the frequency occurs. The MODWT transformation process is illustrated below:

Step 1: Sorting the data for each variable. Firstly, the initial stock return for stock price is as follows:

$$R_{it} = \ln\left(\frac{p_{i,t}}{p_{i,t-1}}\right) \text{ for stock } i \text{ at day } t \quad (3.23)$$

Meanwhile, the daily return for market index is:

$$r_{mt} = \ln\left(\frac{x_t}{x_{t-1}}\right) \text{ at day } t \quad (3.24)$$

Once the return series for every stock and market is generated, wavelet analysis is employed to separate the return series into its constituent multiresolution components. In this regards, the daily return series are segregated into different scale crystals; D1 (2-4 days), D2 (4-8 days), D3 (8-16 days), D4 (16-32 days), D5 (32-64 days), D6 (64-128 days) and D7 (128 – 256 days).

Step 2: Later on, the Daubechies wavelet transformation is used to obtain a multiscale decomposition of the return series, as follows;

$$r(t) \approx \sum_k s_{J,k} \phi_{J,k}(t) + \sum_k d_{J,k} \psi_{J,k}(t) + \sum_k d_{J-1,k} \psi_{J-1,k}(t) + \dots + \sum_k d_{1,k} \psi_{1,k}(t) \quad (3.25)$$

Where;

- j = the number of scale crystals (intervals of frequencies)
- k = the number of coefficients in the specified components
- $\phi_{J,k}(t)$ = father orthogonal wavelet pair that are given by;
 $\phi_{J,k}(t) = 2^{-\frac{j}{2}} \phi\left(\frac{t-2^j k}{2^j}\right)$ for $j = 1$ to J , which represents the low-frequency (smooth) part of the series.
- $\psi_{J,k}(t)$ = mother orthogonal wavelet pair that are given by;
 $\psi_{J,k}(t) = 2^{-\frac{j}{2}} \psi\left(\frac{t-2^j k}{2^j}\right)$ for $j = 1$ to J , which represents the high-frequency (detailed) part of the series.
- $s_{J,k}$ and $d_{J,k}$ = wavelet coefficients that are approximated by the following integrals. These coefficients represent the contributions of the corresponding wavelet function to the total series.
- $s_{J,k} \approx \int \phi_{J,k}(t) f(t) dt$ = the smooth coefficient that underlies the smooth behaviour of the series
- $d_{J,k} \approx \int \psi_{J,k}(t) f(t) dt$ = the detail coefficient that represent the scale deviations from the smooth process.

Step 3: Once the return series is decomposed into j crystals, crystal D_j are recomposed into a time domain. The entire return series is replicated in multiresolution decomposition of $\hat{r}^J = D_1 + \dots + D_j + S_j$. In this regard;

- D_j = the recomposed series in the time domain from the crystals D_j . It represents the contribution of frequency j to the original series.
- S_j = the recomposition of the residue

\hat{r}^j = The reconstituted return series contains the separate components of the original series at each frequency j

Step 4: After obtaining the recomposed series for each frequency, we run an OLS regression of each stock on each recomposed crystal of the market portfolio, R_m^j .

$$R_i = \alpha_i^j + \beta_i^j R_m^j + \beta_{US\$}^j R_{US\$}^j + \varepsilon_i^j = \alpha_i^j + \beta_i^j D_m^j + \beta_{US\$}^j D_{US\$}^j + \varepsilon_i^j \text{ for } j = 1 \text{ to } 5 \quad (3.26)$$

The coefficient β_i^j is the key variable to be examined. The value of the β_i^j is used to indicate the existence of multiscale tendency among the sample firms. The study expects the value of the β_i^j to change across different j scales and the beta is deemed as exhibiting multiscale tendency. The varying exposure levels indicate there are indeed differences on exposure measured based on monthly or weekly data. Hence, the return series must not be arbitrarily chosen especially during risk management decision making process.

For the multiscale foreign currency exposure analysis, the following hypotheses are tested:

H_0 = There is no significant multiscale tendency of foreign currency exposure changes across different time crystals.

3.3.4 Corporate Hedging Practice

In line with the fourth objective, the section discusses the models used to examine the effect of corporate hedging practice towards the currency exposure level among the selected firms. The analyses are in accordance to the respective hedging strategies namely the financial and operational hedging. Additionally, an analysis is also conducted to incorporate the interaction term to investigate the effect of both hedging strategies towards these firms.

3.3.4.1 Financial Hedging Practice

In order to test for the effect of financial hedging practice, the exchange rate coefficient (β) values acquired in Section 3.3.1.1 was incorporated into the second stage cross-sectional regression against the dummy variable for hedging use in equation (3.27). The coefficient value denotes the dependent variable while the application of foreign currency derivative in the firm structure is the independent variable. The model hypothesises significant effect of financial hedging practice to mitigate the exposure level at 10% significant level. In order to overcome the potential issue of serial correlation and heteroscedasticity among time series data, Newey-West specification was also conducted into the analysis. The OLS model is depicted as below:

Step 1: Collection of financial hedging practice data from the financial reports.

Data of financial hedging practice are collected from the financial reports of the sample firms. The data were dichotomous in nature, with 1 denoting practice of financial hedging for the particular year and zero otherwise. However, the study resorts to use the average of dummy variables for the financial hedging practice due to stationarity issue. The average is calculated by dividing the sum of the total number of financial hedging practice with the number of sample period. For an example, if a firm implements financial hedging in its risk management strategy for the whole sample period of 21 years, the sum of the firm's dummy will be 21. As the study span for 21 years, dividing the sum of dummy with the number of sample period will give out an average of 1. On the other hand, if the firm only implements financial derivative hedging for 10 out of 21 years of sample study, the average will be $10/21=0.48$.

Step 2: The OLS model for the financial hedging practice is formed. For firm i , the equation for the residual measurement is:

$$\widehat{EXP}_i = \gamma_0 + \gamma_1 USE_i + \varepsilon_i \quad (3.27)$$

Where:

- \widehat{EXP}_i = estimated currency exposure for firm i from the symmetric foreign currency exposure model
- USE_i = average dummy variable for foreign currency derivative use for firm i
- ε_i = regression residual

Step 3: Newey-West specification is conducted to overcome autocorrelation issue.

Newey-West Specification

Newey-West (1987) variance estimator is an extension of the ordinary-least square regression that produces consistent estimation when there is autocorrelation in addition to possible heteroscedasticity problems. Specifically, the model is as follows:

$$\hat{\beta}_{OLS} = (X'X)^{-1}X'y \quad (3.28)$$

$$\widehat{Var}(\hat{\beta}_{OLS}) = (X'X)^{-1}X'\hat{\Omega}X(X'X)^{-1} \quad (3.29)$$

Coefficient estimates in Newey-West model are simply those of the initial linear regression. For any lag $l > 0$, the variance estimates are calculated using the Newey-West formula:

$$Q^* = \frac{1}{T} \sum_{t=1}^T e_t^2 x_t x_t' + \frac{1}{T} \sum_{l=1}^L \sum_{t=l+1}^T w_l e_t e_{t-l} (x_t x_{t-l}' + x_{t-l} x_t') \quad (3.30)$$

$$\text{with } w_l = 1 - \frac{l}{L+1}$$

Where:

Q^* = A matrix of Sum of Squares

x_t = The row of the X matrix observed at time t

L = Number of lag

w_l = Weight that represents the distance of between the disturbances

For the analysis on the effect of financial hedging practice, the following hypotheses are tested:

H_0 = There is no significant relationship between financial currency derivative practice and the level of foreign currency exposure among the sample firms.

3.3.4.2 Operational Hedging Practice

On the other hand, the exchange rate coefficient value in Section 3.3.1.1 is also used as the dependent variable in assessing the effect of operational hedging towards the firm value. While the coefficient of exposure (β) is used as the dependent variable likewise to equation (3.27), the following model uses the dispersion index of the firm as the independent variable. The model hypothesises significant effect of operational hedging practice to mitigate the exposure level at 10% significant level. The dispersion of firm operation is categorised into two levels of geographical dispersions namely the countries and regional dispersions. The countries and regional dispersion are considered based on the geographic dispersions of the sample firms. For this purpose, the study utilises the Hirshman-Herfindahl index as used by Allayannis et al. (2001). The Hirshman-Herfindahl index is commonly used to measure market concentration or competition (Le et al., 2021). Specifically, the index is calculated as the sum of squares of the market shares of each firm participating in a certain market. A striking advantage of the Hirshman-Herfindahl index lies in its simple measurement which only requires small amount of data. However, such simplicity also causes a drawback for the index as it hinders the index from taking into account the complexity of the various

market. Still, the measurement is pursued in this study as it fits the objective to provide an overview of the dispersion concentration of the respective sample firms.

The dispersion index is calculated as follows:

Step 1: Calculation of Hirshman-Herfindahl index to denote the level of operational hedging.

The Hirshman-Herfindahl index is measured as:

$$h\text{-index} = \sum_{i=1}^n \left(\frac{\text{number of subsidiaries in country } i}{\text{total number of subsidiaries}} \right)^2 \quad (3.31)$$

Step 2: Model to measure the effect of operational hedging incorporating the exposure level and dispersion index is formed.

Hence, the model for firm i is;

$$\widehat{EXP}_i = \gamma_0 + \gamma_1 disp_{index_i} + \theta_i \quad (3.32)$$

Where:

\widehat{EXP}_i = estimated currency exposure for firm i from the symmetric foreign currency exposure model

$disp_{index_i}$ = dispersion index measured as one minus the Hirshman-Herfindahl index $(1 - h\text{-index})$ of the number of countries/regions the firm i operates

θ_i = regression residual

The dispersion data are collected manually from the annual reports of the sample firm. The data are based on the geographical diversification undertaken by the firms to disperse their operation and production. The initial data are based on the countries that the firms have their operations in. Later on, the data are then grouped into seven regions namely the Eastern and East Asian, Latin America and the Caribbean, Australia and New Zealand, Western Africa, Western and Central Asia, Southern Asia and Europe.

Step 3: Newey-West specification is conducted to overcome autocorrelation issue.

Newey-West Specification

Likewise to the regression on the financial hedging, this section also implements the Newey-West specification to control for autocorrelation and heteroscedasticity problems in the model. Specifically, the model is as follows:

$$\hat{\beta}_{OLS} = (X'X)^{-1}X'y \quad (3.33)$$

$$\widehat{Var}(\hat{\beta}_{OLS}) = (X'X)^{-1}X'\hat{\Omega}X(X'X)^{-1} \quad (3.34)$$

Coefficient estimates in Newey-West model are simply those of the initial linear regression. For any lag $l > 0$, the variance estimates are calculated using the Newey-West formula:

$$Q^* = \frac{1}{T} \sum_{t=1}^T e_t^2 x_t x_t' + \frac{1}{T} \sum_{l=1}^L \sum_{t=l+1}^T w_l e_t e_{t-l} (x_t x_{t-l}' + x_{t-l} x_t') \quad (3.35)$$

with $w_l = 1 - \frac{l}{L+1}$

Where:

Q^* = A matrix of Sum of Squares

x_t = The row of the X matrix observed at time t

L = Number of lag

w_l = Weight that represents the distance of between the disturbances

For the analysis on the effect of operational hedging practice, the following hypotheses are tested:

H_o = There is no significant relationship between operational hedging practice and the level of foreign currency exposure among the sample firms.

3.3.4.3 Interaction Terms

In order to examine the effect of both financial and operational hedging towards the sample firms, interaction terms are included in the previous (3.27) and (3.32) models.

Step 1: The model to measure the effects of both financial and operational hedging practices are as the following:

$$\begin{aligned} \overline{EXP}_i = & \gamma_0 + \gamma_1 disp_{countries,i} + \gamma_2 disp_{regions,i} + \gamma_3 USE_i + \gamma_4 disp_{countries} * \\ & disp_{regions,i} + \gamma_5 USE * disp_{countries}_i + \gamma_6 USE * disp_{regions}_i + \theta_i \end{aligned} \quad (3.36)$$

Where:

\overline{EXP}_i	=	currency exposure for firm i from the symmetric foreign currency exposure model
$disp_{countries}$	=	dispersion index based on countries for firm i
$disp_{regions}$	=	dispersion index based on regions for firm i
$disp_{countries} * disp_{regions}$	=	interaction term of countries and regions indexes for firm i
USE_i	=	average dummy variable for foreign currency derivative use for firm i
$USE * disp_{countries}$	=	interaction term of countries index and foreign currency derivative use for i
$USE * disp_{regions}$	=	interaction term of regions index and foreign currency derivative use for firm i
θ_i	=	regression residual

In overall, these models correspond to the fourth objective of the study to provide an overview on the effectiveness of corporate hedging practice among the sample firms in Malaysia. The analyses comprehensively include two main components of corporate hedging namely the financial and operational hedging practices. Simultaneous consideration of both corporate hedging aspects provides an insight on the effectiveness of the current hedging practices under concurrent implementation.

Step 3: Newey-West specification is conducted to overcome autocorrelation issue.

Newey-West Specification

An extension from the regression in equation 3.34, Newey-West variance estimator was also used to produce consistent estimation when there is autocorrelation in addition to possible heteroscedasticity problems. Specifically, the model is as follows:

$$\hat{\beta}_{OLS} = (X'X)^{-1}X'y \quad (3.37)$$

$$\widehat{Var}(\hat{\beta}_{OLS}) = (X'X)^{-1}X'\widehat{\Omega}X(X'X)^{-1} \quad (3.38)$$

Coefficient estimates in Newey-West model are simply those of the initial linear regression. For any lag $l > 0$, the variance estimates are calculated using the Newey-West formula:

$$Q^* = \frac{1}{T} \sum_{t=1}^T e_t^2 x_t x_t' + \frac{1}{T} \sum_{l=1}^L \sum_{t=l+1}^T w_l e_t e_{t-l} (x_t x_{t-l}' + x_{t-l} x_t') \quad (3.39)$$

$$\text{with } w_l = 1 - \frac{l}{L+1}$$

Where:

- Q^* = A matrix of Sum of Squares
- x_t = The row of the X matrix observed at time t
- L = Number of lag
- w_l = Weight that represents the distance of between the disturbances

For the analysis on the effect of financial and operational hedging practices, the following hypotheses are tested:

H_o = There is no significant relationship between financial and operational hedging practices and the level of foreign currency exposure among the sample firms.

3.4 Robustness Test

It is important to ensure that our estimations are robust. The robustness procedure is crucial to examine whether our results estimated on previous models are consistent under the real setting. Hence, examination on the currency exposure using the real exchange rate is conducted for robustness testing purpose. Past studies have mostly dedicated to include the nominal exchange rate in the analysis of exchange exposure. The scarcity of using real exchange rate may arise due to the considerably low variation in inflation rate across different periods. In order to access the potential influence of purchasing power, the real exchange rates data are collected from the Bloomberg Terminal.

The overall estimations of symmetric, asymmetric and multiscale exposure are replicated for the real exchange rate variable. The results are then compared to examine the consistency of the beta estimates between the models. The robustness estimations are conducted for the overall symmetric currency exposure, overall asymmetric currency exposure, and multiscale exposure. In addition, the effect of corporate hedging practice is also tested using the beta coefficients obtained from the analyses using the real exchange rate data. Similarities in term of significance and direction of effect are scrutinised to ensure consistency among the models.

3.5 Summary of Chapter

The following Table 3.2 provides a short overview of the methodologies and data that are used to answer the research objectives and questions.



Table 3.2: Summary of the Sections According to the Research Objectives

<p>Objective 1: To measure the level of currency exposure of Malaysian non-financial firms.</p> <p>Research Question 1: What is the level of currency exposure of Malaysian non-financial firms?</p>		
Topic	Data	Data Analysis
Overall Symmetric Currency Exposure	- Monthly Stock Return - Monthly FBM-KLCI - Nominal MYR/USD Exchange Rate	Panel Model
Overall Asymmetric Currency Exposure	- Monthly Stock Return - Monthly FBM-KLCI - Nominal MYR/USD Exchange Rate	Panel Model
Firm-level Symmetric Currency Exposure	- Monthly Stock Return - Monthly FBM-KLCI - Nominal MYR/USD Exchange Rate	OLS and GARCH(1,1)
Firm-level Asymmetric Currency Exposure	- Monthly Stock Return - Monthly FBM-KLCI - Nominal MYR/USD Exchange Rate	OLS and GARCH(1,1)

<p>Objective 2: To analyse the variation of currency exposure of Malaysian non-financial firms across different financial events.</p> <p>Research Question 2: What is the level of currency exposure of Malaysian non-financial firms across different financial events?</p>		
Topic	Data	Data Analysis
Overall Time-varying Symmetric Currency Exposure	- Monthly Stock Return - Monthly FBM-KLCI - Nominal MYR/USD Exchange Rate	Panel Model
Overall Time-varying Asymmetric Currency Exposure	- Monthly Stock Return - Monthly FBM-KLCI - Nominal MYR/USD Exchange Rate	Panel Model
Firm-level Time-varying Symmetric Currency Exposure	- Monthly Stock Return - Monthly FBM-KLCI - Nominal MYR/USD Exchange Rate	OLS and GARCH(1,1)
Firm-level Time-varying Asymmetric Currency Exposure	- Monthly Stock Return - Monthly FBM-KLCI - Nominal MYR/USD Exchange Rate	OLS and GARCH(1,1)

Table 3.2: Summary of the Sections According to the Research Objectives (cont.)

<p>Objective 3: To investigate the level of currency exposure of Malaysian non-financial firms across different time-scales. Research Question 3: What is the level of currency exposure of Malaysian non-financial firms across different time-scales?</p>		
Topic	Data	Data Analysis
Overall Multiscale Currency Exposure	<ul style="list-style-type: none"> - Daily Stock Return - Daily FBM-KLCI - Nominal MYR/USD Exchange Rate 	Wavelet
Industry Level Multiscale Currency Exposure	<ul style="list-style-type: none"> - Daily Stock Return - Daily FBM-KLCI - Nominal MYR/USD Exchange Rate 	Wavelet

<p>Objective 4: To investigate the impact of corporate hedging practice on the level of currency exposure of Malaysian non-financial firms. Research Question 4: What is the impact of corporate hedging practice on the level of currency exposure of Malaysian non-financial firms inclusive of financial and operational hedging practices?</p>		
Topic	Data	Data Analysis
Financial Hedging	<ul style="list-style-type: none"> - Currency Exposure - Foreign Currency Derivative Use 	OLS with Newey-West specification
Operational Hedging	<ul style="list-style-type: none"> - Currency Exposure - Hirshman-Herfindahl Index 	OLS with Newey-West specification
Interaction Term	<ul style="list-style-type: none"> - Currency Exposure - Foreign Currency Derivative Use - Hirshman-Herfindahl Index 	OLS with Newey-West specification
Multiscale Corporate Hedging Practice	<ul style="list-style-type: none"> -Multiscale Currency Exposure -Foreign Currency Derivative Use - Hirshman-Herfindahl Index 	OLS with Newey-West specification