Analysing Time-Scales Currency Exposure Using Maximal Overlap Discrete Wavelet Transform (MODWT) for Malaysian Industrial

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Abstract. Based on dynamic nature of foreign exchange rate risk toward Malaysian firms across different time horizons, this paper is motivated to investigate the multiscale effect of currency exposure using wavelet analysis for 71 industrial products and services firms listed on the main market of Bursa Malaysia. The study employed Daubechies Least Asymmetric as a special wavelet filter in Maximal Overlap Discrete Wavelet Transform (MODWT) method to decompose a given time series into different time-intervals from January 2000 till December 2020. Specifically, the study found that there was non-monotonic exchange risk concentration from low to high time scale. As a result, as time horizon widened, the firm profitability becomes more sensitive to the foreign currency fluctuations. Besides, majority of the sample firms were negatively exposed to the Euro (EUR), and Japanese Yen (JPY) indicating that Malaysia industrial firms were benefited from depreciation of these currencies. Given the significant time scale effect of currency exposure, firm managers and investors should incorporate the length of transactions in foreign exchange risk assessment for greater accuracy and timely decision making in hedging strategies.

Keywords: Currency Exposure · Wavelet Analysis · Maximal Overlap Discrete Wavelet Transform (MODWT) · Industrial Products and Services

1 Introduction

In the context of the rapid globalization of financial markets, the heightened volatility of the foreign exchange market has had a significant impact on the growth, profitability, and operations of companies. Unexpected movements in exchange rates can affect not only companies operating in advanced economies, but also companies in emerging economies. In fact, since the post-Bretton Woods era, the issue of the sensitivity of firm value to the unpredictable exchange rate movements has begun to draw the attention of market participants and academicians. Due to increasing trade openness and lower hedging practices, the impact of exchange rate exposure is more pronounced in emerging economies than in advanced and advanced economies regarding on [2, 9, 19, 36], and [38].

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According to [14], different industries have varying business cycle variability and faced different risk attributes. Thus, firms in cyclical sectors might attribute to experience higher foreign exchange risk. Industrial products and services sector is one of the cyclical sectors that the firms value is sensitive to the global economic situation. In practice, [26] reported industrial sector contributed the major share of Malaysia's export and import composition since 2003 that comprised of electrical & electronic, chemicals and chemical products and machinery, appliances & parts. It showed that Malaysia's economy is highly dependent on the international trading especially industrial sector, and it could afflict to the heightened the exchange risk. All companies involved in international trade, even purely domestic companies in concept, are affected by changes in the value of the currency. Consequently, ongoing exchange rate volatility and increasingly globalized business activities make foreign exchange risk management a key component of the company's strategy in study [7].

Despite the fact that there have been numerous studies on exchange rate exposure under the context of Malaysia, the heterogeneity time scales' effect on the extent of currency exposure has been overlooked by previous studies [15] and [25]. This causing bias in the estimation of dynamic nature of foreign exchange rate risk. In this paper we aspire to assess the multiscale currency exposure of Malaysian industrial products and services firms. To do this, the first part of the study, we employed wavelet analysis using Maximum Overlap Discrete Wavelet Transform (MODWT) to decomposed domain time horizon into several time scales. Then, we regressed the two-factor model for each time scale using Ordinary Least Square, OLS together with Generalized Autoregressive Conditional Heteroskedasticity (1,1), GARCH (1,1) specification. Unveil scale-dependent foreign exchange exposure. Next subsections are literature review of currency exposure and wavelet analysis. Then followed by remaining sections which are data and methodology, results and discussions, and conclusions.

1.1 Currency Exposure

The firm's profitability is influenced by unexpected movement of the foreign exchange rate. The extensive studies on the effect of currency exposure on firm value have been discussed broadly and have become the major concern in the global economy since the Bretton Wood system crash in 1973. The definition of exchange rate exposure has been addressed in [1] and [24] as the volatility of exchange rate that affects a firm's cash flows, the real domestic currency value of assets, liabilities, or operating incomes and directly impact firm value.

Many studies have been done to investigate the impact of exchange rate changes on firm value with mixed results. The past studies found that the sensitivity of a firm's performance to currency volatility was vastly investigated in the setting of the advanced and developed economy after the collapse of the Bretton Wood system. Through an investigation of exchange rate volatility on developed countries profitability, [6] and [17] found that less than 30% of the firms were exposed to foreign exchange rate fluctuation due to the wide utilization of financial hedging that led to the reduction of the industry-specific currency exposure. A recent study [8] adopted intraday data of 182 non-financial United States, US multinational firms from 2008 till 2014 found that 40% of the firms were positively significant to the currency exposure. The study revealed that most of the

US multinational firms were export-oriented firms that benefited from foreign currency appreciation. Regarding the incidence of currency exposure in developing economy settings, [5] reported that the exposure level of the firms in the emerging economy were higher than the studies in the advanced economy. In line with [5], recent studies [13, 27, 28] and [35] under the context of emerging market reported that the percentage of exposed firms to currency fluctuations is higher than 20%.

In the context of Malaysia, the studies of foreign currency exposure are limited, and the findings and result are still unclear and mixed. Over 16-years of research, [4] found out that 71% of 158 Malaysian firms that are listed under Bursa Malaysia are significantly exposed to the foreign currencies' movement. Out of 70 firms that exposed to US Dollar, USD, only two firms were positively significant during financial crisis. It showed that Malaysian firms are vulnerable to Malaysia Ringgit's (MYR) depreciation against USD. As overall analysis, the negative significant of USD exposure coefficient, indicated that most of Malaysian firms trading activities are focus on the import trading.

1.2 Wavelet Analysis

Mathematical techniques have been applied in solving various economic and financial problems in recent decades, including in the recent development of wavelet analysis. Many previous studies have used wavelet methods in various disciplines extensively, with growing interest in the finance and economy field of studies.

[10] found that there were several areas that the wavelet method is relevant in the economy and finance fields. The areas were exploratory analysis with time scales, density estimation and local heterogeneity, time series decomposition, and forecasting. Besides, the study found that the MODWT has the advantages for individual scale crystal to analyze time series and make statistical testing as it enables to decompose time series into any size of time scaling. [30] used M-GARCH-DCC, Continuous Wavelet Transforms (CWT), and MODWT to investigate the impact of investment horizon heterogeneity on portfolio diversification of 9 Islamic stock indexes which are from developed and developing markets that included Malaysia. The study emphasized that the investment horizon heterogeneity is significantly affecting the portfolio diversification strategies. The study also argued that investor should examine their stock exposures and holding positions over the period regularly. Using CWT and Markov switching models, [29] found that, the short-term time horizon exhibited a weak contagion signal and the direction of contagion remained vague. Thus, it showed that Islamic stocks are less exposed to short-term currency changes which are good news to The Association of Southeast Asian Nations, ASEAN currency hedgers.

Regarding [36], wavelet analysis found non-monotonic exposure across the time scales, indicating the multiscale presence among firms in 75 Malaysian non-financial firms based on daily basis data from 1995 to 2016. The exposure of exchange rate measured at various time scales indicated that at a longer period (higher frequency), the level of currency exposure increased. Through the application of Discrete Wavelet Transformation, [3] discovered that exchange rate exposure is more sensitive with low-frequency data (widened time interval) on electronics and electrical Malaysian corporations. The study argued that the impact of time scales should be taken into exchange risk pricing measurement and longer time intervals on investment should be prioritized in exchange risk management.

2 Data and Methodology

The study comprised secondary data of Kuala Lumpur Composite Index (KLCI) closing price indices, closing stock price for each firm and foreign exchange rate of MYR as domestic currency and selected foreign currency as base currency. As for foreign currency, the study focused on globally traded currencies which are USD, Euro (EUR), British Pound Sterling (GBP), Japanese Yen (JPY) and Chinese Yuan (CNY). These five currencies are among the top 5 widely held global reserves currencies. Based on the selected criteria, out of 783 firms trade in Bursa Malaysia, only 71 industrial firms are used as a sample. The selected firms' criteria were the firms have been listed on Bursa Malaysia' main market under industrial products and services sector continuously from 4th January 2000 until 31st December 2020 and owned at least a foreign subsidiary as a proxy of multinational companies in Malaysia.

All collected data are daily basis over the period of 4th January 2000 to 31st December 2020. Compustat database from S&P Global Market Intelligence is utilized to collect the datasets. RStudio version 4.1.0 and EViews version 12.0 software are utilized in the study. All the data collected were analyzed accordingly with descriptive statistics and ordinary least square (OLS) method. Besides, a special wavelet filter class under MODWT known Daubechies transformation is used to investigate the degree of multiscale currency exposure.

2.1 Currency Exposure Model

The study adopts the two-factor model proposed by [1] and [21] to measure the sensitivity of firms value to currency exchange rate fluctuation. Therefore, the following is the OLS model specification used in this study to measure the degree of currency exposure;

$$\begin{aligned} R_{it} = \beta_0 + \beta_{mt} R_{mt} + \beta_{USDt} R_{USDt} + \beta_{EURt} R_{EURt} \\ + \beta_{GBPt} R_{GBPt} + \beta_{JPYt} R_{JPYt} + \beta_{CNYt} R_{CNYt} + \varepsilon_t \end{aligned} \quad (1)$$

where ε_t follows Generalized autoregressive conditional heteroscedasticity (GARCH(1,1)) process (in any event of heteroscedasticity) as follows;

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} + \upsilon_t \quad (2)$$

R_{it} indicates the firm's stock i return at time t; R_{mt} as the market index return of KLCI at time t; and R_{FXt} which represents exchange rate return at time t for MYR/USD (R_{USDt}), MYR/EUR (R_{EURt}), MYR/GBP (R_{GBPt}), MYR/JPY (R_{JPYt}) and MYR/CNY (R_{CNYt}) at time t respectively. The coefficient β_{mt} and β_{FX} refer to firm's exposure to local market risk and firm's exchange rate exposure for each foreign currency respectively. While ε_t is error term. GARCH(1,1) is embedded in the regression model (1) to address the non-constant variance in error term. GARCH(1,1) can be explained as the relationship between conditional variance (h_t) and the lagged square of error term (ε_{t-1}^2) and the lagged value of conditional variance (h_{t-1}). The α_1 and α_2 stand for the coefficient parameters. The regression models undergo heteroskedasticity test by applying Breusch-Pagan specification to determine if there is heteroskedasticity problem. If the regression suffered from heteroskedasticity problem, we run the model again with GARCH(1,1). The application of GARCH(1,1) in the model would effectively improve the efficiency of exchange rate exposure betas as supported by [2, 20] and [37].

For data smoothing and stationarity of the series, the study computed natural log return to all the series (stock price, KLCI market index and currency rate) [34];

$$\text{Firm } i\text{'s stock return at time } t, R_{i,t} = ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right) \tag{3}$$

$$\text{Market index return at time } t, R_{mt} = ln\left(\frac{x_t}{x_{t-1}}\right) \tag{4}$$

$$\text{Exchange rate return at time } t, R_{FXt} = ln\left(\frac{MYR/FC_t}{MYR/FC_{t-1}}\right) \tag{5}$$

where $P_{i,t}$ indicates the closing price of stock i at time t; x_t as KLCI closing price indices at time t and *MYR/FC* represents the currency pair indicated *FC* as foreign currencies (USD, GBP, EUR and JPY) as the base currency and MYR as the home currency at time t based on direct quotation.

2.2 Wavelet Analysis

In order to measure multiscale currency exposure, the study performed multiresolution analysis using MODWT to decompose a single time domain into different time scales. The decomposition method of traditional discrete wavelet transform (DWT) has been significantly improved under MODW [33]. Compared to DWT, the non-orthogonal MODWT estimate has invariability under time series circular shift. Based on [18], the wavelet transformation of time series, r_t up to j crystal scale with k coefficient is calculated as the summation of father and mother wavelet coefficients as;

$$r_t \approx \sum\nolimits_k s_{j,k}\phi_{J,k}(t) + \sum\nolimits_k d_{j,k}\psi_{j,k}(t) + \sum\nolimits_k d_{j-1,k}\psi_{j-1,k}(t) + \ldots + \sum\nolimits_k d_{1,k}\psi_{1,k}(t) \tag{6}$$

where, $s_{j,k}$ is known as smooth wavelet coefficient that captures the overall pattern of original signal, while $d_{j,k}$ refers to the detailed wavelet coefficient for specific time scale. $s_{j,k}$ and $d_{j,k}$ are derived as below;

$$s_{J,k} = \int \phi_{J,k}(t) r_t dt \tag{7}$$

$$d_{j,k} = \int \psi_{j,k}(t) r_t dt \tag{8}$$

where $j = 1, 2, \ldots, J$; while $\phi_{J,k}(t)$ and $\psi_{j,k}(t)$ are father and mother wavelet respectively. Father wavelet is known as low frequency part of series to capture the smooth

Table 1. Wavelet scales.

Scaling Type	Scale	Trading Horizon (daily frequency resolution)
Mother wavelet	D1	2–4 periods (2 days-4 days)
	D2	4–8 periods (4 days & approximately 1 weeks)
	D3	8–16 periods (Approximately 1 week-2 weeks)
	D4	16–32 periods (Approximately 2 weeks-1 month)
	D5	32–64 periods (Approximately 1–2 months)
	D6	64–128 periods (Approximately 2–4 months)
	D7	128–256 periods (Approximately 4 months-1 year)
Father wavelet	S7	128–256 periods (Approximately 4 months-1 year)

signals, while mother wavelet, is known as high frequency part of series to capture the details variable of the signals. $\phi_{J,k}(t)$ and $\psi_{j,k}(t)$ are obtained as;

$$\text{Mother wavelet,}\ \ \phi_{j,k}(t) = 2^{-j/2}\phi\left(\frac{t-2^{j}k}{2^{j}}\right) \tag{9}$$

$$\text{Father wavelet,}\ \ \psi_{j,k}(t) = 2^{-j/2}\psi\left(\frac{t-2^{j}k}{2^{j}}\right) \tag{10}$$

The study applied least asymmetric of length 8 (LA8) as a wavelet filter in MODWT that has been employed by [12] and recommended by [16]. Considering the standard trading days which is 256 days, the study decomposed the sample with maximum time series scale, $j = 7$ based on [36]. The wavelet scales definition is shown in Table 1.

Hence, the analysis of time series, r_t multiresolution from MODWT is obtained as follow;

$$r_t = \sum\nolimits_{j=1}^{J} d_{j,k} + s_{j,k} \tag{11}$$

After decomposed all series for each firm into different time scales, j, the study adopted model in Eq. (2) to analyse the effect of currency exposure under specific frequency domain as follows;

$$\begin{aligned} R_i^j = {} & \beta_0^j + \beta_m^j R_m^j + \beta_{USD}^j R_{USD}^j + \beta_{EUR}^j R_{EUR}^j \\ & + \beta_{GBP}^j R_{GBP}^j + \beta_{JPY}^j R_{JPY}^j + \beta_{CNY}^j R_{CNY}^j + \varepsilon_t^j \end{aligned} \tag{12}$$

where j is indicated as wavelet crystal scales, $j = 1, 2, 3, 4, 5, 6$ *and* 7. The study employed OLS regression for each firm on different decomposed crystal. The OLS approach is used to investigate the relationship between the fluctuation of foreign exchange rate on the firm's profit at different time scales, j. The OLS is a consistent and effective method for estimating the parameters of the market model under fairly broad assumptions. By exhibiting this relationship, the OLS estimation output benefited in explaining the degree of currency exposure on different time intervals.

3 Results and Discussion

Table 2 displays the descriptive statistics and stationarity-test respectively for all return series for KLCI indices and foreign exchange rates of USD, EUR, GBP, JPY and CNY. Descriptive statistics was employed to briefly analyses the distribution properties of all return series from 4th January 2000 until 31st December 2020.

The return for all series shows consistency as the mean of the return close to zero. The currency of CNY and USD exhibit low volatility implying both countries have high foreign reserves and become the top 2 largest economy globally. All industry firm return series show higher standard deviation compared to market index and currency return series indicating industrial firms encountered higher fluctuation price across the period in the study. The return distribution for all series is slightly skewed from the center point and the kurtosis of dataset shows positive excess kurtosis with heavy tails of distribution presenting leptokurtic distribution.

This finding reveals that all the return series face high risk. Skewness and kurtosis results indicate that all the series are not normally distributed. This is supported by the results from Jarque-Bera test showing that all series are significantly failed to follow Gaussian distribution as the null hypothesis (H_0: The series is normally distributed) is rejected. ADF-test and PP-test are employed to test the stationarity of the dataset. All the data series are significantly stationary I(0*)* shown by the rejection of the null hypothesis of the presence of unit root at 1% significance level.

Table 3 presents the variance inflation factors (VIF) test on different time scales. Multicollinearity happens when there is high correlation between two or more independent variables with another independent variable. The large of standard error causes several variables that should be statistically significant become statistically insignificant and this supported by [11]. [22] and [31] stated that there is no multicollinearity problem if the *VIF* less than 10. Thus, there is no multicollinearity problem on all independent variables for all time-intervals as all VIF values are less than 10.

Next, the summary of exchange rate exposure coefficient for 71 industrial firms is displayed in Table 4. The results are obtained from Eq. (1) by utilizing OLS together with GARCH (1,1) specification. The table also shows the number and percentage of significant beta coefficients at 10% significance level.

Table 2. Descriptive statistics and stationarity test of variables.

Series	Mean	Median	Max	Min	SD	Skewness	Kurtosis	Jarque-Bera	ADF test	PP test
rKLCI	0.0001	0.0000	0.066	−0.0998	0.00797	−0.7662	14.2931	29645.66***	−65.45***	−65.68***
rUSD	0.0000	0.0000	0.023	−0.0256	0.00349	−0.1947	10.3644	12413.68***	−73.09***	−73.14***
rEUR	0.0000	0.0000	0.036	−0.0403	0.00585	0.0010	6.3812	2609.47***	−75.45***	−75.49***
rGBP	0.0000	0.0000	0.029	−0.0727	0.00564	−0.5911	11.0838	15234.60***	−71.52***	−71.50***
rJPY	0.0000	0.0000	0.061	−0.0476	0.00691	0.2726	8.7201	7535.94***	−77.55***	−77.60***
rCNY	0.0001	0.0000	0.021	−0.0354	0.00346	−0.4288	11.2489	15699.00***	−74.89***	−74.89***

Note: Max, Min, SD, ADF-test and PP-test denote maximum data, minimum data, standard deviation, Augmented Dickey Fuller test and Phillips Perron test respectively.
**** denotes the data is significance at 1% respectively.*

Table 3. Variance inflation factor *(VIF)* test.

	Overall	D1	D2	D3	D4	D5	D6	D7	S7
VIF_KLCI	1.1119	1.1004	1.1124	1.1222	1.1666	1.1763	1.1870	1.2620	1.6338
VIF_USD	1.8850	1.5475	2.2246	3.7388	4.6749	7.1037	6.1431	4.2633	3.8979
VIF_EUR	1.5952	1.5774	1.5585	1.6904	1.6695	1.7744	1.7595	1.9523	2.4526
VIF_GBP	1.5470	1.5395	1.5178	1.5783	1.5789	1.6725	1.7862	2.1881	2.7906
VIF_JPY	1.4396	1.4422	1.4560	1.4557	1.4530	1.4968	1.4759	1.4374	1.4153
VIF_CNY	1.5589	1.2305	1.8844	3.4712	4.4448	6.8575	5.8099	4.3503	3.4588

Table 4. Descriptive statistics of exchange rate exposure coefficient.

Descriptive Statistics	β_{USD}	β_{EUR}	β_{GBP}	β_{JPY}	β_{CNY}
Mean	0.06175	−0.0384	0.052036	−0.06515	−0.05252
Median	0.023381	−0.04417	0.054414	−0.05888	−0.0375
Maximum	0.739186	0.844962	0.42394	0.164637	0.383556
Minimum	−0.44805	−0.28258	−0.3262	−0.82728	−0.66498
Standard Deviation	0.20656	0.152052	0.113333	0.132062	0.177232
(+ sign) Significant: Number of exposed firms	11:42	5:21	18:50	3:20	4:27
(– sign) Significant: Number of exposed firms	6:29	17:50	3:21	24:51	9:44
Percentage of exposed firms (+ sign significant)	15%	7%	25%	4%	6%
Percentage of exposed firms (– sign significant)	8%	24%	4%	34%	13%
Percentage of total exposed firms significantly	24%	31%	30%	38%	18%

Note: This table show the distribution of exchange rate exposure coefficient using OLS with specification of GARCH (1,1) by employing below regression model in Eq. (1)
+ sign and – sign denote as positive coefficient and negative coefficient respectively.
The coefficients are significant when p-value less than 0.10.

The study reports that most of the industrial firms are significantly exposed to the fluctuation of JPY followed by EUR and GBP with percentages of total exposed firms are 38%, 31% and 30% respectively.

Most of the exposed firms to JPY were significantly negative. This finding was in line with [3, 23], and [32], as the study stated majority of the firms are benefited from depreciation of JPY. Besides, JPY exposure shows highest coefficient with negative sign of -0.06515, it means that 1% depreciation of Japanese yen would lead firms to gain

Table 5. Exchange rate exposure by different time scales.

	Scale	D1	D2	D3	D4	D5	D6	D7	S7	Overall
β_{USD}	f	25	25	34	49	65	69	71	70	17
	%	35%	35%	48%	69%	92%	97%	100%	99%	24%
	Mean (+)	0.1960	0.2663	0.3474	0.6235	0.7140	0.8410	0.9463	0.9674	0.1848
	Mean (−)	−0.1883	−0.2421	−0.3529	−0.3323	−0.9180	−1.0644	−0.9721	−0.9983	−0.1165
β_{EUR}	f	24	29	41	52	59	66	71	71	22
	%	34%	41%	58%	73%	83%	93%	100%	100%	31%
	Mean (+)	0.0779	0.1290	0.1509	0.1368	0.1360	0.2835	0.4579	0.6495	0.1123
	Mean (−)	−0.1397	−0.1617	−0.1933	−0.2131	−0.3100	−0.4036	−0.7134	−0.5188	−0.1017
β_{GBP}	f	23	25	41	47	57	68	70	70	21
	%	32%	35%	58%	66%	80%	96%	99%	99%	30%
	Mean (+)	0.1334	0.1179	0.1820	0.1951	0.2964	0.4220	1.0120	0.7345	0.1046
	Mean (−)	−0.0988	−0.1298	−0.1684	−0.1417	−0.1200	−0.3165	−0.2868	−0.5332	−0.0730
β_{JPY}	f	27	33	50	58	58	66	69	71	27
	%	38%	46%	70%	82%	82%	93%	97%	100%	38%
	Mean (+)	0.0923	0.0871	0.1572	0.1691	0.1157	0.2238	0.3864	0.3633	0.0590
	Mean (−)	−0.1065	−0.1319	−0.1859	−0.1926	−0.1861	−0.2687	−0.3117	−0.2821	−0.1138
β_{CNY}	f	26	23	38	46	63	66	70	70	13
	%	37%	32%	54%	65%	89%	93%	99%	99%	18%
	Mean (+)	0.1236	0.2448	0.3845	0.4440	0.9791	0.9642	0.9525	1.0456	0.1096
	Mean (−)	−0.2270	−0.2059	−0.3446	−0.3904	−0.5584	−0.9164	−1.2750	−1.2281	−0.1520
R-Squared (R^2)		0.0501	0.0646	0.0891	0.1279	0.1558	0.1810	0.2045	0.2812	0.0653

Note: This table shows the estimation results of exchange rate exposure using OLS with GARCH (1,1) specification by employing the following regression models:
i. Regression model from Eq. (1) for overall time interval.
ii. Regression model from Eq. (12) for different wavelet crystal scales (D1, D2, D3, D4, D5, D6, D7 and S7).
f, %, Mean (+) and Mean (−) denote the number of significant exposed firms at 10% significant level, percentage of exposed firm, mean positive coefficient, and mean negative coefficient respectively.

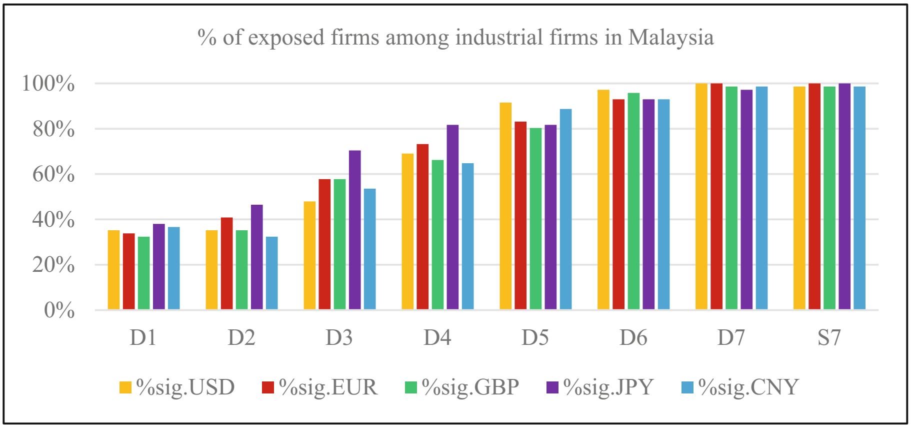

Fig. 1. Percentage of exposed firms (10% significance level).across industrial firms in Malaysia at different time horizons.

0.065% return. Next, we find that the industrial firms are less sensitive to CNY and USD fluctuations. This results in contrast with [4], which indicated majority of firms were vulnerable to the USD movement with negative significant. Surprisingly, even though US and China are prominence as Malaysia's main trading partners, the results indicate less than 25% of exposed firms are sensitive to the dollar and yuan volatility.

The results of regression with multiscale period are shown in Table 5. Table 5 shows that the value of R-square is rising with the widening of time-scale. This implies that the unexpected movement of foreign exchange rate on a higher time-scale be able to explain the incidence of foreign exchange risk.

Figure 1, Fig. 2 and Fig. 3 represent the output from Table 5. Based on the bar chart in the Fig. 1, we capture an ascending pattern on the number of exposed firms for all foreign exchange rates that correspond with the increasing width of time scales. Besides, beginning with D4 (16–32 days) to D7 (128–256 days), the number of exposed firms to all five foreign currencies increased by more than 50%, compared to D1 (2–4 days) which is just less than 40%. At D7 (128–256 days), almost all firms are exposed to all foreign currencies (USD, EUR, GBP, JPY and CNY). As for EUR, GBP, JPY and CNY, majority of the firms are exposed at long term time horizon (S7) with 99% to 100% firms sensitive to those 4 currencies. In contrast with EUR, GBP, JPY and CNY, the highest percentage of exposed firms to USD is at D7 (128–256 days).

Figure 2 and Fig. 3 indicate the level of currency exposure (average positive and negative beta) across different time scales. Both charts clearly demonstrate uptrend movement for the average positive coefficient and downtrend movement for the average negative coefficient. The increment of foreign currency exposure concentration starts from high frequency (short time interval) to low frequency (long time interval) which corresponds to the enhanced percentage of exposed firms at higher time scale as shown in Fig. 1. This suggests the effect of unpredictable movement of foreign currency on firm profitability is prone to be negligible at lower interval. The results are significant in terms of the risk-trading interval relationship. This result in line with [15] and [25].

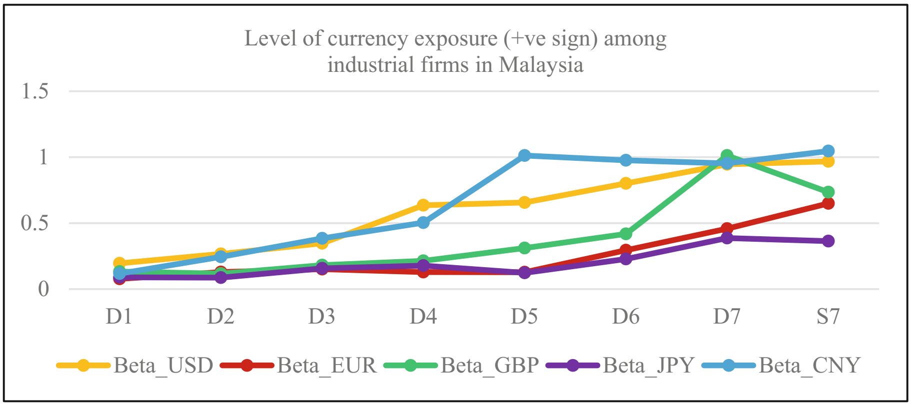

Fig. 2. Time-scales of currency exposure (positive coefficient) among industrial firms in Malaysia.

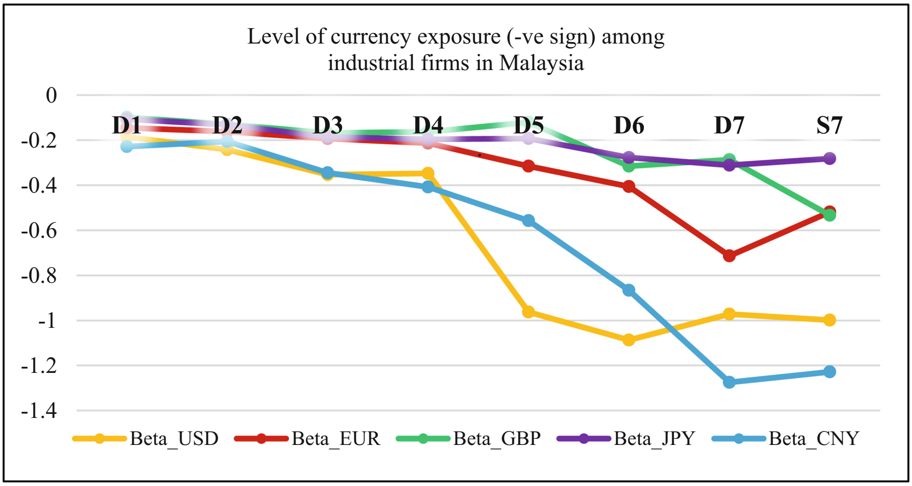

Fig. 3. Time-scales of currency exposure (negative coefficient) among industrial firms in Malaysia.

This result is economically sensible because firms that hold long-term investment tend to be highly susceptible to higher systematic risk to meet high return expectation.

4 Conclusion

The purpose of this paper was to analyse the multiscale currency exposure of 71 industrial firms in Malaysia from 4th January 2000 till 31st December 2020 by adopting MODWT to decompose a single time series domain into different time-scales. Then, we applied two factor model for each time scale to measure the multiscale of currency exposure level. Based on the results, most of the exposed firms are negatively significant to Japanese yen, indicating that the exposed firm earn profitability from the depreciation of yen. Besides, there was non-monotonic changes detected on the mean for beta coefficient of currency exposure across different time-scales. In line with [3, 25, 36] and [39], our results indicated that the level of currency exposure is heterogenous across time scales. Specifically, the level of currency exposure increases as the length of time-interval increases. The longer the investment holding period, the higher the degree of foreign currency exposure. Upcoming research may add the causes of gradual increase of currency exposure across different time scales. For policy implication, this study highlights the importance of wavelet technique (specifically MODWT) to firm managers and investors in pricing foreign exchange risk with greater accuracy and assisting in timely decision making for hedging strategies.

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