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Malaysia: how much exchange rate misalignment is detrimental to exports?

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Abstract— **The purpose of this paper is to estimate an approximate threshold point at which exchange rate misalignment begins to deter exports. Based on the threshold autoregressive model, the sample is segregated into two regimes where the threshold point is unknown. The regimes are divided into low misalignment and high misalignment regimes. The estimated threshold point is 8 percent. Results show that below 8.88 percent, misalignment in terms of overvaluation has no statistically significant effect on exports. Misalignment in terms of overvaluation only affects exports in a negative manner when it is more than 8.88 percent. An important policy implication inferred from this study is that overvaluation of the exchange rate should be kept below 8.88 percent to ensure a conducive exchange rate environment for exports.**

Keywords-exchange rate misalignment; threshold autoregressive model; overvaluation; exports

I. INTRODUCTION AND BRIEF REVIEW OF LITERATURE

Exchange rate misalignment is one of the most conscientious topics in international economics. Both theoretical and empirical evidences suggest that misalignments can potentially lead to negative ramifications on exports, imports, foreign investment and savings. The major concern is that exchange rate overvaluation would undermine the competitiveness of exports and foreign investment into the country due to the added cost brought about by the exchange rate risk.

Majority of the literature focuses on exchange rate volatility to capture exchange rate risk. Studies by [1] [2] and [3] use the standard deviation of the growth of exchange rate with a moving average transformation to represent exchange rate risk. Other common methods include the ARCH and GARCH models [4][5], the standard deviation of the percentage change of the exchange rate or the standard deviation of the first differences of the logarithmic exchange rate [6], the variance of the spot exchange rate around its predicted trend [7] and autoregressive integrated moving average (ARIMA) model [8]. Theoretically, [9] demonstrate that the impact of exchange rate variability is ambiguous.

Misalignment is also used to capture exchange rate variability or the departure from its long run equilibrium exchange rate. The groundbreaking work of [10] marked the inception of literature on how exchange rate misalignment affects exports. The literature normally starts with the estimation of exchange rate misalignment and the calculated misalignment will then be used as a variable in the export model. Their point of departure lies in the way the exchange rate misalignment is estimated. [11] [12] [13] and [14] estimate misalignments based on the concept of purchasing power parity. [15] and [16] use the fluctuations between the dollar-yen exchange rates to capture exchange rate misalignment. [17] [18] [19] [20] among others, utilize model-based approaches such as the behavioural equilibrium exchange rate (BEER) and the fundamental equilibrium exchange rate (FEER). Other techniques include the estimation of misalignment using the monetary model [21] or self-derived model [22] [23] [24].

In this paper, we extend the aforementioned studies to provide an estimated point at which misalignments begins to significantly affect exports. We innovate in the following manner – instead of providing an estimation of how misalignment affects exports, we estimate a threshold point at which misalignment begins to significantly affect exports. Hence, policy makers would be better guided in the near future as to the ‘timing’ of when the exchange rate needs to be realigned to its equilibrium position to avoid negative consequences on exports.

The next section briefly overviews the theoretical and empirical export model augmented to incorporate exchange rate misalignment, followed by a section on the estimation of the exchange rate misalignment. Section IV describes the estimation technique, the threshold autoregressive model. The penultimate section discusses the results and the final section concludes.

II. THEORETICAL AND EMPIRICAL MODEL

[9] describe exports as a function of prices and capital stock,

$$X(t) = B(t)\left[\mu P(t)\right]^{\frac{\alpha}{1-\alpha}} K(t) \tag{1}$$

where $B(t)$ is a function of time and $P = P_x ER(t)$. The exchange rate is written in a Brownian process,

$$dER = \gamma ER dt + \sigma ER dz \tag{2}$$

where γ represents the deviation of the exchange rate from its equilibrium path (misalignment) and σ measures volatility of the exchange rate. γ and σ only depend on ER and time t. Suppose that f_1 and f_2 are overvaluation and undervaluation which are dependent on E and t, the processes followed by f_1 and f_2 are given as,

$$\frac{df_1}{f_1} = \mu_1 dt + \sigma_1 dz \quad \text{and}$$

$$\frac{df_2}{f_2} = \mu_2 dt + \sigma_2 dz \tag{3}$$

where μ_1, μ_2, σ_1 and σ_2 are functions of *ER* and *t*. The *dz* in these processes are similar to that of equation (2). Conventional wisdom suggests that overvaluation would reduce the demand for exports. For this contention to hold, the necessary condition is,

$$\frac{\partial ER}{\partial \gamma} > 0 \tag{4}$$

For the purpose of empirical estimation, the theoretical discussion above is assimilated into the standard export demand-based framework to incorporate the impact of exchange rate misalignment. The main assumption in this model is that Malaysia's exports are relatively small compared to the world market. Hence, the baseline model is defined as,

$$\log X_t = \alpha_0 + \beta_1 \log Y_t - \beta_2 \log P_t \pm \beta_3 M_t + \mu \tag{5}$$

where X is the export volume, Y represents the world income, P is relative prices and M denotes exchange rate misalignment. Coefficients β_1 and β_2 represent the income and price elasticities of exports respectively.

III. Exchange Rate Misalignment

Exchange rate misalignment is the deviation of the actual real exchange rate from the equilibrium exchange rate. The equilibrium exchange rate is a hypothetical real exchange rate which is modeled using price-based approach (purchasing power parity, uncovered interest rate parity), model-based (BEER, FEER, natural equilibrium exchange rate) approach or based on black market premia. This paper adheres to the behavioural equilibrium exchange rate (BEER) proposed by [25] which underlines a few fundamental variables as the baseline to estimate the equilibrium exchange rate. These fundamental variables include productivity differentials, government spending, trade openness and net foreign assets. Productivity differentials are expected to appreciate the exchange rate since an increase in productivity in the tradable sectors would result in an increase in wages in both tradable and non-tradable sectors. The exchange rate would appreciate to keep the balance of payments in equilibrium. Hence, the sign is expected to be positive. On the other hand, the signs for government spending, openness and net foreign assets are ambiguous. [26] shows that large government spending is associated with exchange rate appreciation. On the other hand, large government spending leads to higher income and to restore the equilibrium position, the real exchange rate would have to depreciate. As for net foreign assets, high capital inflow appreciates the exchange rate. Likewise, high borrowing and outflow of capital depreciates the real exchange rate. Empirically, the equilibrium exchange rate is expressed as,

$$ERER = f(PROD, GOV, OPEN, NFA)$$

where ERER, PROD, GOV, OPEN and NFA represent the equilibrium real exchange rate, productivity differentials, government spending, openness and net foreign assets. If the real exchange rate and the fundamental variables move together in a systematic manner, the real exchange rate has a mean reversion property in the long run. To establish such relationship, the concept of cointegration is used where the mean is viewed as the equilibrium exchange rate. To reiterate, cointegration captures the steady state relationship between the real exchange rate and its fundamental variables. The estimated long run cointegrating equation or the equilibrium real exchange rate is given as,

$$ERER = -0.3610 + \underset{(6.6854)}{2.3113PROD} - \underset{(-4.4396)}{3.1996GOV}$$
$$+ \underset{(6.5172)}{0.8018OPEN} - \underset{(-7.2428)}{0.3365NFA}$$

where the variables are as previously defined and the *t*-statistics are in parentheses. Next, the degree of exchange rate misalignment is calculated based on the difference between the actual real exchange rate and the estimated equilibrium exchange rate above.

IV. Threshold Autoregressive Model

[27] [28] introduces the threshold autoregressive model (TAR) which breaks the sample into two regimes. In this non-linear approach, the unique behaviour in each regime can be captured individually instead of generalizing constant parameters in each data set. This technique allows the estimation of a specific point(s) at which exchange rate misalignments begin to affect exports.

In a two-regime threshold regression,

$$x_t = \theta_1' F_t + e_t, \qquad q_t \le \gamma, \tag{6}$$

$$x_t = \theta_2' F_t + e_t, \qquad q_t > \gamma, \tag{7}$$

where q_t is the threshold variable which is a continuous variable and is used to split the sample into two regimes, γ is the threshold value which is unknown and must be estimated, x_t represents exports, F_t represents a vector of explanatory variables and e_t is the error term assumed to be white noise and identically and independently distributed. If the threshold value is greater than the threshold variable, equation (6) is estimated and vice versa. In other words, regression parameters change with respect to q_t. Next, equations (6) and (7) are written in a single equation using a dummy variable is defined as $d(\gamma)=\{q_t \le \gamma\}$ where {.} is the indicator function, with $d=1$ when $q_t \le \gamma$ and $d = 0$, if otherwise; and set $x_t(\gamma)=x_t d(\gamma)$, hence (6) and (7) becomes:

$$y_t = \theta' x_t + \delta_n' x_t(\gamma) + e_t \quad (8)$$

where $\theta = \theta_2$ and $\delta = \theta_1 - \theta_2$. Equation (8) allows all the regression parameters θ, δ_n and γ to switch between the two regimes. The least square (LS) technique is used to estimate γ through minimization of the sum of squared errors function.

Given the aforementioned estimation technique, the first step is to examine the existence of a threshold effect in the model. A linear model is tested vis-à-vis the two-regime model, equation (8). The null hypothesis of no threshold effect is tested against an alternative hypothesis of the presence threshold effect. Since TAR models have a non-standard distribution, [29] develops a standard heteroscedasticity-consistent Langrange Multiplier (LM) bootstrap method to calculate the asymptotic critical values and the *p*-value.

Next, the significance of derived threshold value (γ) is tested by differencing the confidence interval region based on the likelihood ratio statistic $LR_n(\gamma)$, defined as:

$$LR_n^*(\gamma) = \frac{LR_n(\gamma)}{\hat{\eta}^2} = \frac{S_n(\gamma) - S_n(\hat{\gamma})}{\hat{\sigma}^2 \hat{\eta}^2} \quad (9)$$

and the adjusted confidence region becomes $\hat{\Gamma}^* = \{\gamma : LR_n^*(\gamma) \le c\}$ such that $\hat{\Gamma}^*$ is robust whether or not the heteroscedasticity condition holds. Simulation is set at 1000 replications as suggested by [27]. Also, $LR_n^*(\gamma)$ is not normally distributed hence, the valid asymptotic confidence intervals of the estimated threshold values in the no-rejection areas defined as $c(\alpha) = -2\ln(1-\sqrt{1-\alpha}$, where α is a given asymptotic level; and the no-rejection region of the confidence interval is $1-\alpha$. If $LR_1(\gamma_0) \le c(\alpha)$, then the null hypothesis of $H_0 : \gamma = \gamma_0$ cannot be rejected. In addition, to examine the possibility of a second threshold value, the same exercise is repeated. The augmented export model (5) is expressed as nonlinear equations under the two-regime threshold autoregression (TAR) model as follows,

$$\log X_t = (\alpha_{10} + \beta_{11} \log Y_t - \beta_{12} \log P_t \pm \beta 1_{13} M_t) d[q_t \le \gamma] + (\alpha_{20} + \beta_{21} \log Y_t - \beta_{22} \log P_t \pm \beta 1_{23} M_t) d[q_t > \gamma] + \mu_t \quad (10)$$

V. RESULTS

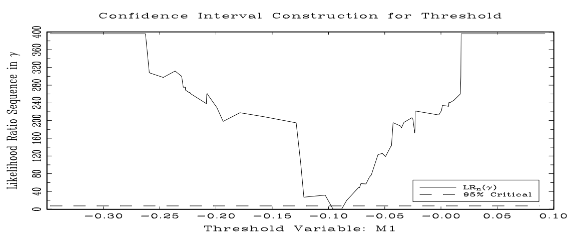
The benchmark models constitute one baseline model (Model 1) and two other models to check for the sensitivity of the estimated threshold value and coefficients (Model 2 and 3). Volatility (V) and foreign investment (FI) are added into Model 2 and Model 3 respectively. The existence of a threshold effect is examined by employing the heteroscedasticity-consistent Lagrange-multiplier (LM) test based on Hansen (1996). γ is tested under the null hypothesis of no threshold effect and the *p*-values are calculated using a bootstrap analog which generates the dependent variable from the distribution $N(0, \hat{e}_t^2)$, where $\hat{e}_t$ is the OLS residuals from the estimated threshold model. With reference to Table 1, the bootstrap *p*-values of Models 1, 2 and 3 are significant at 5, 1 and 10 percent respectively after 1000 bootstrap replications.

TABLE I. THRESHOLD EFFECTS FOR THE BENCHMARK MODELS

	Model 1	**Model 2**	**Model 3**
First Sample Split			
F-Stats	25.40	26.54	25.69
Bootstrap *p*-Value	0.04	0.01	0.08
Threshold Estimates	-8.88%	-8.88%	-8.88%
95% Confidence Interval	-9.20%, -6.65%	-9.61%, -7.55%	-9.61%, -8.57%
Second Sample Split			
F-Stats	5.24	6.95	3.22
Bootstrap *p*-Value	0.69	0.71	0.48

Note: H_0: No threshold effect. The threshold is based on the minimized sum of squared residuals

The graph of the normalized likelihood ratio sequence $LR_n^*(\gamma)$ as a function of the threshold in exchange rate misalignment is showed in Figure 1. The estimated γ is the value which minimizes these graphs at $\hat{\gamma}$ =8.88%. The dotted lines on the graphs present the 95% critical values. The results suggest that there is ample evidence for a two-regime specification. As for the possibility of a second sample split, the bootstrap *p*-values are insignificant, rendering no additional regime split (Table I).



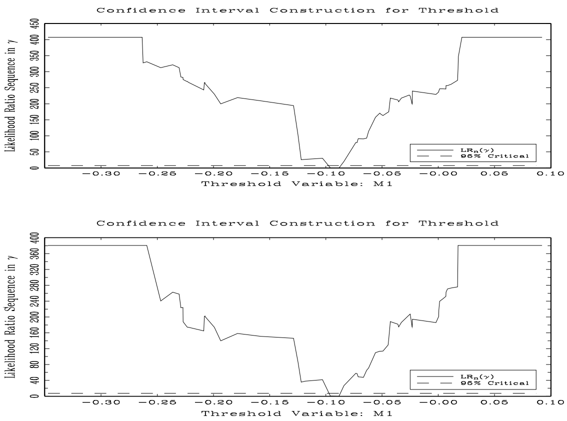


Figure 1. Confidence Interval Construction for Threshold

The benchmark regressions results are presented in Table II. For comparison purposes, this paper provides the linear OLS model without the threshold effect and a two-regime model which accommodates the threshold effect. Basically, the variables confer the correct signs in line with the prediction of the theory. Misalignment has a negative and significant effect on exports in the high misalignment regime. Income is significant in all models. Prices on the other hand, are not significant in all models. Volatility is only significant in the linear model. Foreign investment provides an interesting insight, where it is significant in the linear model and is only significant in the high misalignment regime. This is consistent with the work of [30] where the real exchange rate was overvalued by massive influx of foreign direct investment and portfolio investment prior to the 1997 crisis. Hence, splitting the sample gives a more indepth view of the effects of these basic variables on exports. To reiterate, sample splitting allows the examination of whether the significant effect is present in both regimes or otherwise.

The results show that below the threshold value of 8.88 percent exchange rate misalignment in terms of overvaluation may be negative but are not statistically significant. However, above the 8.88 percent threshold level, overvaluation exerts both negative and significant impact on exports. A 1 percent increase in misalignment (overvaluation) suppresses exports by approximately 0.38 – 0.52 percent. The negative effect of exchange rate misalignment on exports is consistent with the findings of previous literature. [10] argue that an apparent currency misalignment persistent over some length of time renders added cost hence undermining the competitiveness of our exports. The added cost comes in the form of higher relative production costs as a result of such misalignment. If the ringgit is thought to be overvalued relative to its estimated equilibrium level, then importers may be discouraged by the prospect of reduced profit in the near future.

TABLE II. BENCHMARK REGRESSION RESULTS: THE EFFECT OF MISALIGNMENT ON EXPORTS (1991:Q1-2008:Q3) DEPENDENT VARIABLE: EXPORTS (X)

Model 1	**Linear Model**	**Threshold**	
	OLS	**Regime 1 ≤ 8.88%**	**Regime 2 > 8.88%**
Y	1.62***	2.19***	1.14***
	(0.08)	(0.11)	(0.07)
P	-0.69	0.91	-0.40
	(0.35)	(0.81)	(0.27)
M	-0.02	-0.45	-0.39***
	(0.14)	(0.33)	(0.11)
C	-2.60***	-8.24***	-2.72***
	(0.96)	(2.07)	(0.61)
Obs	71	31	40
R^2	0.95	0.96	0.87
Model 2	**Linear Model**	**Threshold**	
	OLS	**Regime 1** ≤ 8.88%	**Regime 2 > 8.88%**
Y	1.66	2.18***	1.14***
	(0.94)	(0.12)	(0.08)
P	-0.52	0.92	0.39
	(0.34)	(0.82)	(0.27)
M	-0.04	-0.45	-0.38***
	(0.14)	(0.33)	(0.12)
V	-0.04**	-0.02	-0.003
	(0.02)	(0.07)	(0.008)
C	-3.15***	-8.25***	-2.68***
	(0.94)	(2.07)	(0.69)
No. of Obs	71	31	40
R^2	0.96	0.96	0.87
Model 3	**Linear Model**	**Threshold**	
	OLS	**Regime 1 ≤ 8.88%**	**Regime 2 > 8.88%**
Y	1.59***	2.15***	1.11***
	(0.09)	(0.13)	(0.07)
P	-0.38	0.95	-0.32
	(0.29)	(0.81)	(0.27)
M	-0.19	-0.48	-0.52***
	(0.14)	(0.33)	(0.12)
V	0.04***	-0.03	-0.03
	(0.01)	(0.07)	(0.07)
FI	0.45***	0.12	0.40***
	(0.16)	(0.17)	(0.13)
C	-3.19***	-8.20***	-2.52***
	(0.80)	(2.06)	(0.64)
No. of Obs	71	31	40
R^2	0.96	0.96	0.90

Notes: *** and ** denote 1% and 5% significance respectively. Standard errors are in parentheses.

VI. CONCLUSION AND POLICY IMPLICATIONS

Malaysia's economic growth has been heavily dependent on exports. Ensuring competitiveness of exports necessitates careful monitoring of the exchange rate and its misalignments. Previous studies suggest that misalignments negatively affect exports especially in the long run. Misalignments in terms of overvaluation represent an added cost on exports. In this paper, the exact point where misalignment in terms of overvaluation negatively affects exports is estimated using the threshold autoregressive model. Results indicate that exports is negatively affected only when misalignments in terms of overvaluation is greater than 8.88 percent. Hence, intervention is only necessary when overvaluation is more than 8.88 percent. At the very least, the governing authorities should periodically check that the exchange rates reflect the fundamentals of the economy.

Nevertheless, apart from the exchange rates, policy makers need concerted efforts to improve the type and the quality of the export products, continue to diversify and venture into new exports destinations. With the emergence of export powerhouse like China, India and Indonesia, Malaysia can no longer compete in low technology-labour intensive industries and urgently needs to embark on high value-added, innovative products and high-technology industries.

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