Exchange rate fluctuations and industrial production in Malaysia: evidence from dynamic simulated ARDL analysis

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ABSTRACT – REZUMAT

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Contemporary literature argues that the exchange rate serves as an important instrument of industrial policy to boost economic growth. However, it is difficult to design effective exchange rate policies owing to the uncertainty shrouding the outcomes of the exchange rate movement for industrial growth. Therefore, this study uses a dynamic simulated autoregressive distributive lags approach to study the impact of positive and negative changes in the real effective exchange rate on industrial production of Malaysia for the period 1970–2022. We employ an extended production function to study this relationship by incorporating capital, labour and globalisation as additional explanatory variables. The findings suggest that positive (negative) changes in real effective exchange rate are followed by positive (negative) changes in economic growth in the long run. Furthermore, positive changes in capital affect economic growth positively and significantly in both the short and long run. Finally, positive (negative) movement in labour and globalization positively (negatively) and significantly affect industrial production in the long run respectively. Policymakers should depreciate currency to expand industrial production in Malaysia. Moreover, to boost industrial production, short-term loans should be introduced for capital accumulation.

Keywords: *exchange rate, industrial production, capital, labour, dynamic simulated ARDL simulations, textile industry, Malaysia*

Fluctuațiile cursului de schimb și producția industrială în Malaezia: studiu de caz empiric bazat pe analiza dinamică simulată ARDL

Literatura contemporană susține că, în general, cursul de schimb servește ca un instrument important al politicii industriale pentru a stimula creșterea economică. Cu toate acestea, este dificil să se elaboreze politici eficiente privind cursul de schimb din cauza incertitudinii care învăluie rezultatele mișcării cursului de schimb pentru creșterea industrială. Prin urmare, acest studiu de cercetare utilizează o abordare dinamică simulată a decalajelor distributive autoregresive pentru a studia impactul modificărilor pozitive și negative ale cursului de schimb real efectiv asupra producției industriale a Malaeziei pentru perioada selectată 1970–2022. În acest sens, utilizăm o funcție extinsă de producție pentru a studia această relație prin încorporarea capitalului, forței de muncă și globalizării ca variabile explicative suplimentare. Constatările empirice sugerează că modificările pozitive (negative) ale cursului de schimb real efectiv sunt urmate de modificări pozitive (negative) ale creșterii economice pe termen lung. În plus, schimbările pozitive ale capitalului afectează creșterea economică în mod pozitiv și semnificativ atât pe termen scurt, cât și pe termen lung. În cele din urmă, mișcarea pozitivă (negativă) a forței de muncă și globalizării afectează pozitiv (negativ) și în mod semnificativ producția industrială pe termen lung. Factorii decizionali ar trebui să deprecieze moneda pentru a extinde producția industrială în Malaezia. Mai mult, pentru a stimula producția industrială, ar trebui introduse împrumuturi pe termen scurt pentru acumularea de capital.

Cuvinte-cheie*: curs de schimb, producție industrială, capital, forță de muncă, simulari dinamice ARDL, industria textilă, Malaezia*

INTRODUCTION

Contemporary literature widely debates the role of exchange rate policies for macroeconomic development and highlights that exchange rate serves as an instrument of industrial policy to facilitate/hinder economic growth [1, 2] and helps in managing cyclical swings in external financing and terms of trade fluctuations [3, 4]. However, the uncertainty shrouding the outcomes of exchange rate movement for industrial production makes it difficult to design effective exchange rate policies. Countries usually choose to devalue their currencies or let them depreciate to gain competitiveness in international markets and boost exports. Nevertheless, a devaluation or depreciation raises the cost of imported inputs and increases production costs.

Hence, in line with the aggregate demand (AD) and aggregate supply (AS) model, the first channel will stimulate aggregate demand (by boosting exports) whereas the second channel will harm aggregate supply (by making imports dearer). If aggregate supply expands more than the decline in aggregate demand, depreciation will be expansionary.

Otherwise, it will be contractionary. As a result, the countries having higher dependence on imported inputs will experience contractionary devaluations, whereas, more export-oriented countries will undergo expansionary devaluations. This issue has attracted a large segment of researchers and it is well established that most emerging economies rely heavily on imports and a depreciation/devaluation of home currency leads to a decline in aggregate supply higher than an expansion in the aggregate demand, thereby causing a reduction in domestic production, hence decline in industrial production [5, 6].

Malaysia has the 38th biggest nominal GDP and the 26th largest PPP economy in the world [7]. The primary exports include palm oil, petroleum, liquefied natural gas, semiconductors and electronic products, machinery and chemicals and the imports include technology extensive commodities such as machinery, electrical & electronic products, plastics and vehicles. The country has excelled in knowledge-based industries and their major trading partners are Singapore, China, Japan and the United States. Malaysia is one of the world's top exporters of solar panels, electrical items, IT (information and communication technology) products, and semiconductor devices.

The Malaysian Ringgit was an internationalized currency, before 1997. The emergence of the Asian financial crisis in 1997 and resulting speculative activities caused 64% depreciation (in relation to USD) to Ringgit in a matter of weeks. The central bank, Bank Negara Malaysia (BNM), imposed capital controls to handle the outflow of home currency and made the Ringgit a non-internationalized currency pegging it to USD. After the same action by China, the fixed exchange rate was discontinued in July 2005 in favour of the flexible exchange rate. In 2014, owing to the 1MDB scandal and falling crude oil prices, the Ringgit faced sharp depreciation and although BNM took several steps, only partial recovery could be achieved, to date, in comparison to its 2014 level. However, per capital industrial production could not be excessively achieved. Therefore, the impact of the exchange rate on industrial production in Malaysia is questioned.

Nonetheless, most of the existing studies suffer from aggregation bias or mostly use linear models and ignore the asymmetric nature of exchange rate linkages with industry [8]. This relationship may probably be asymmetric for various emerging economies owing to their weak institutional mechanisms. For instance, in general, a real depreciation resulting in a rise in net exports could be expansionary but, if adjustment lags on the part of exporters are slow due to the lags in decision-making, production, delivery etc., the effects of exports on domestic output may not be realized and depreciation could be contractionary. In such scenarios, dynamic simulated ARDL (DS-ARDL) are proficient in scrutinizing the influence of positive and negative changes in real exchange rates on industrial production.

This study contributes to the existing literature by using the extended Cobb and Douglas [9] model and employing DS-ARDL to explore the impact of positive and negative changes in exchange rates on industrial production in Malaysia. Malaysia is an important emerging economy of South East Asia, that relies on imported raw materials and therefore, we considered it a suitable case to test the ‘contractionary devaluation’ problem. Moreover, it is host to a variety of industrial sectors that faced various exchange rate regimes after independence from the British Empire. Additionally, it is an open economy and performs trade activities in multiple international markets having huge reliance on import inputs to run the economy. Finally, to the best of our knowledge and, in line with a survey of existing studies by Bahmani-Oskooee and Mohammadian [10], no study has explored this relationship for Malaysia by using the novel DS-ARDL of Jordan and Philips [11].

The rest of the work is as follows: 2nd section gives an overview of the economic trends of Malaysia. 3rd section presents a theoretical and empirical framework for the study. 4th section provides details of data and results. 5th section concludes the study.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Keynesian open-economy macroeconomists, while floating the idea that devaluation could boost domestic output, net exports and price level, ignored the significance of the aggregate supply side [5]. The advent of the oil crisis of the 1970s cast doubts on the effectiveness of devaluation prompting most of the emerging economies to continue with fixed exchange rate regimes. Central bank authorities of these countries, nevertheless, yielded to voluntary devaluation in response to external disturbances or upon the pressure of international agencies like the IMF with an overall objective of supporting their exports. If the devaluation initiative succeeds in increasing net exports through industrial production, it would be called “expansionary devaluation”. However, questions are raised on the effectiveness of exchange rates as instruments of economic policy due to the threat of failure to achieve the desired objective of the devaluation program. To begin with, it is likely that authorities may not achieve real devaluation and lead to spiralling devaluation. Moreover, even if the below-equilibrium exchange rates can be sustained, their effects on industrial production are still unknown. Instead of boosting production, the devaluation may result in a decrease in domestic demand owing to the increase in the input prices. As most emerging economies are dependent on imported inputs, they experience this ‘contractionary devaluation’ as evidenced by a well-established body of research.

The majority of empirical research on this topic examines the link between changes in exchange rates and domestic output using linear models while developing economies have not gotten much attention. Among the examples are Mills and Pentecost [12], Miteza [13] and Bahmani-Oskooee and Kutan [14]. However, further research has shown that this association is asymmetrical. For example, Bahmani-Oskooee and Mohammadian [6] conclude that, whereas a weak Yen has little effect, a strong Yen damages domestic output in Japan over time. Similarly, Bahmani-Oskooee, Halicioglu [15] observe asymmetric effects of movements in the exchange rate of the lira and find expansionary effects of appreciation as well as depreciation of the lira in the long run. Bahmani-Oskooee and Mohammadian [8] find that only the appreciation of the Australian Dollar affects output in the long run. Bahmani-Oskooee and Mohammadian [10] tested for this relationship for selected emerging economies and found it asymmetric for most of the countries in the sample. Finally, Bahmani-Oskooee and Mohammadian [16] performed bivariate NARDL analysis of the relationship of production and Real effective exchange rate, for 68 countries. Their findings, as reported in table 1, portray an interesting picture and reveal that for the majority of the countries, an increase in real effective exchange rate increases production whereas a decrease in real effective exchange rate also increases domestic production. The authors have merely tabulated the results without offering any analysis and possible justification of the findings. Therefore, it is difficult to discuss their findings in detail.

The above-mentioned study [16] only reports results, without offering detailed analysis linking findings with each country's distinguished environment. Moreover, they have not taken into consideration the important mediating variables (like monetary policy, fiscal policy and trade openness) that might exert a significant influence on the country's industrial production.

The dynamic implications of central bank decisions on production in Poland are examined by Anagnostou and Gajewski [17]. They demonstrate that regional differences in output responsiveness to budgetary shocks are more pronounced than those in inflation or unemployment. Hsing [18] find a positive relationship between China's production with real depreciation for the period 1990–2005 and a negative relationship between 2006 and 2016. Thus, from 1990 to 2005, real depreciation's advantages-such as increased exports outweighed its disadvantages, which included increased import prices, increased inflation, and a decrease in capital inflows. Real appreciation's positive effects, such as reduced import prices, lower inflation, and increased capital inflows, outweighed its negative consequences, such as decreased exports, between 2006 and 2016.

The above review suggests that there are not many studies exploring the effect of a real effective exchange rate on production, especially industrial production by using dynamic simulated ARDL in the case of Malaysia. We deemed it more appropriate to choose Malaysia as the example of an emerging country (having a positive balance of payment for most of the sample period) and test how devaluation might affect its industrial production. To the best of our knowledge, no study has explored the case of Malaysia by using novel DS-ARDL. The present work is aimed at filling this gap.

DATA AND METHODOLOGY

Production function

Cobb and Douglas's production function is a well-known phenomenon in economics which explains the relationship between input and output. Cobb and Douglas [9] established that output/production of an economy is a function of input, typically labour and capital:

$$Y = f(K, L) \quad (1)$$

The general form of production function is parameterized as follows:

$$Y = K^a L^a \quad (2)$$

Examining the impact of globalization and exchange rates on the production function of Cobb-Douglas in the context of Malaysia is the aim of this study. As a result, the Cobb-Douglas production function extension can be expressed as follows:

Table 1

SUMMARY OF REVIEW		
Partial coefficient	**Relationship**	**Countries**
Positive	Increase (+)	Antigua and Barbuda, Austria, Bahrain, Belgium, Bolivia, Cameron, South Africa, Canada, Chile, Paraguay, China, Colombia, Ecuador, Dominican Republic, Finland, Fiji, Iran, Malaysia, Japan, Pakistan, Malta, Philippines, Togo, Trinidad, St. Vincent and the Grenadines and Tobago, Tunisia, Turkey, United Kingdom
	Decrease (-)	Malawi, Norway
Negative	Increase (+)	Fiji, France, Ireland, Malawi, Malta, Norway, Pakistan, Paraguay, Singapore, Spain, Sweden, Switzerland, Turkey, Uganda
	Decrease (-)	Cameron, Japan

$$Y = f(K, L, REER, GL) \Rightarrow$$
$$Y = K^{\beta_1} \cdot L^{\beta_2} \cdot REER^{\beta_3} \cdot GL^{\beta_4} \quad (3)$$

where Y is industrial production, K is capital formation, L is a labour force and GL is a globalization. The respective production elasticities of capital, labour, exchange rate, and globalization are represented by β_1, β_2, β_3 and β_4 coefficients. Using a fresh paradigm for analysis, the long-term relationship is provided by the following formula:

$$Y_t = K_t^{\beta_1} \cdot L_t^{\beta_2} \cdot REER_t^{\beta_3} \cdot GL_t^{\beta_4} \quad (4)$$

where $t = 1, \ldots, n$. T refers to the period. The natural log form of equation-4 which is being estimated is displayed as follows:

$$\ln Y_t = \beta_0 + \beta_1 \ln K_t + \beta_2 \ln L_t + \beta_3 \ln REER_t + + \beta_1 \ln GL_t + \mu_t \quad (5)$$

Here, $\ln Y_t$ is a natural log of industrial production which is proxied by manufacturing value added (current US$), $\ln K_t$ – a proxy of capital, shows the natural log of fixed capital formation per capita (constant 2010 US$), $\ln L_t$ denotes natural log of labour proxy by total labour force, $\ln REER_t$ represents natural log of real effective exchange rate, $\ln GL_t$ represents the natural log of KOF globalization index and μ_t is an error term that is supposed to be normal distributed having zero mean and constant variance. The time series data from 1970–2022 is utilized to achieve the objectives of the study.

Combined cointegration

The econometrics literature, including works by Engle and Granger [19], Johansen [20], Phillips and Ouliaris [21], Boswijk [22] and Banerjee, Dolado [23], has several cointegration tests accessible.

Nonetheless, the outcomes of these tests show contradictions. To increase the strength of the cointegration test, Bayer and Hanck [24] presented a joint test statistic for the null hypothesis of no-cointegration based on the tests previously discussed. This test is known as the Bayer-Hanck test. The recently created combined cointegration test improves cointegration outcomes and yields more trustworthy results of cointegration. Before applying the combined cointegration, it is required to confirm that all series are stationary at 1st difference $I(1)$. The Fisher's formulae to compute F-statistics is as follows:

$$EG - JOH = -2\left[\ln (P_{EG}) + (P_{JOH})\right] \quad (6)$$

$$EG - JOH - BO - BDM = -2\left[\ln (P_{EG}) + + (P_{JOH}) + (P_{BO}) + (P_{BDM})\right] \quad (7)$$

Here, the statistic of Engle and Granger [19] is represented by EG, the statistic of Johansen [20] is denoted by JOH, the statistic of Boswijk [22] is displayed by BO and statistic of Banerjee, Dolado [23] is expressed by BDM. Likewise, the p-values of the underlying separate tests for cointegration are PEG, PJOH, PBO, and PBDM, in that order.

Autoregressive-distributed lag (ARDL) model

Pesaran, Shin [25] proposed the Autoregressive-Distributed Lag Model, which has additional flexibility because of its special characteristics. The results of ARLD bound analysis are used to verify the cointegration's robustness. In addition, ARDL may be used for mixed integration I(0)/I(1), where certain variables are static at the level and the remainder of the data set is stationary at the first difference, or for all variables static at the level I(0), the first difference I(1), or both. However, none of the series – that is, I(2) – should be integrated at the second difference. The following is the estimated long- and short-term ARDL model:

$$\Delta \ln Y_t = \beta_0 + \beta_Y \ln Y_t + \beta_K \ln K_{t-1} + \beta_L \ln L_{t-1} + + \beta_{REER} \ln REER_{t-1} + \beta_{GL} \ln GL_{t-1} + \sum_{j=0}^{q} \alpha_j \Delta \ln K_{t-j} + + \sum_{k=0}^{r} \alpha_k \Delta \ln L_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta \ln REER_{t-l} + + \sum_{m=0}^{t} \alpha_m \Delta \ln GL_{t-m} + \mu_t \quad (8)$$

In equation 8, Δ represents the first difference, and 't–1' indicates the best lags to use, as determined by the AIC criterion, indicating the variables' long-term association characteristics. The null and alternate hypotheses of ARLD bound testing are $\beta_Y = \beta_K = \beta_L = \beta_{REER} = \beta_{GL} = 0$ and $\beta_Y \neq \beta_K \neq \beta_L \neq \beta_{REER} \neq \beta_{GL} \neq 0$ respectively. In making the choice, cointegration is indicated if the computed F-statistic is greater than the upper critical bound (UCB). In a similar vein, cointegration is not present if the calculated F-statistics are smaller than the lower critical limit (LCB). Cointegration will not be decided if the calculated F-statistics lie between the higher and lower critical boundaries.

Dynamic Simulated ARDL (DS-ARDL) Model

Dynamic ARDL simulations (DS-ARDL) are a novel kind of ARDL that was presented by Jordan and Philips [11]. This method has the ability to solve the issue with the outdated ARDL model while examining the various long- and short-term model requirements. Furthermore, while maintaining the stability of the other independent variables, it can be used to stimulate, approximate, and automatically plot forecasts of counterfactual changes in one explanatory variable and their impact on the dependent variable [11, 26, 27]. This innovative model can also automatically estimate, stimulate, and plot to anticipate graphs of positive and negative changes in the variables and show the short- and long-term links between them. Nevertheless, the conventional ARDL is limited to identifying long-term and short-term relationships. All series must be stationary at the same level of integration, either I(0) or I(1), to use the DS-ARDL model. The study's variables fit the requirements for a unique DS-ARDL model. According to the previous research [11, 26, 27], the DS-ARDL error correction equation is as follows:

$$\Delta \ln Y_t = \alpha_0 + \phi_Y \ln Y_t + \beta_1 \Delta \ln K_t + \phi_1 \ln K_{t-1} + \\ + \beta_2 \Delta \ln L_t + \phi_2 \ln L_{t-1} + \beta_3 \Delta \ln REER_t + \\ + \phi_3 \ln REER_{t-1} + \beta_4 \Delta \ln GL_t + \phi_4 \ln GL_{t-1} + \\ + \gamma ECM_{t-1} + \mu_t \tag{9}$$

Here, ϕ_1, ϕ_2, ϕ_3 and ϕ_4 show the long-run parameters of capital, labour, exchange rate and globalization respectively. Similarly, short-run parameters of capital, labour, exchange rate and globalization are represented by β_1, β_2, β_3 and β_4 respectively. The transition from short-term disequilibrium to long-term equilibrium is shown by the ECM(t–1). From a different angle, it symbolizes the rate at which things shift from out of balance to balance.

RESULTS AND DISCUSSION

Table 2 presents the time series' descriptive statistics. All of the series have a normal distribution with zero mean and constant variance, according to the Jarque-Bara test results. Furthermore, all series' standard deviation values are roughly near the mean, indicating little variation in the data. To determine if a time series is stationary at the level I(0) or first I(1) difference and to make sure that no series is stationary at the second difference I(2), time series analysts must analyse the characteristics of the data. Numerous classic unit root tests are available for this purpose, including ADF by Dickey and Fuller [28], P-P by Phillips and Perron [29], DF-GLS by Elliott, Rothenberg [30] and Ng and Perron [31]. ADF and PP unit root tests are used in this investigation, and table 3 presents the findings. According to the results of the ADF unit root test, all data series exhibit a unit root issue at level I(0), which goes away when the first difference I(1) is taken into account. The PP unit root results are likewise comparable.

Table 2

DESCRIPTIVE STATISTICS

Variables	$\ln Y_t$	$\ln K_t$	$\ln L_t$	$\ln REER_t$	$\ln GL_t$
Mean	8.592442	7.142261	15.84918	4.816186	4.153390
Median	8.710474	7.372145	15.86947	4.789930	4.200850
Maximum	9.431739	7.996965	16.56160	5.323985	4.404331
Minimum	7.557928	5.675031	14.86391	4.444330	3.752398
Std. Dev.	0.533841	0.660463	0.471938	0.268709	0.208440
Skewness	–0.213014	–0.535347	–0.316833	0.335364	–0.360064
Kurtosis	1.867560	2.150866	2.127572	1.643098	1.776331
Jarque-Bera	3.049833	3.890443	2.422216	4.103041	4.199892
Prob.	0.217639	0.142956	0.297867	0.10949	0.122463

Table 3

UNIT ROOT ANALYSISX

Variables	ADF Unit Root Test		Phillips-Perron Unit Root Test	
	T-statistics "Intercept and Trend"	Prob. Value	T-statistics "Intercept and Trend"	Prob. Value
$\ln Y_t$	–2.5831	0.2894	–2.6774	0.2501
$\ln K_t$	–2.7873	0.2089	–2.3997	0.3752
$\ln L_t$	–2.6878	0.2462	–2.4576	0.3378
$\ln REER_t$	–2.7022	0.2405	–2.5783	0.2915
$\ln GL_t$	0.1684	0.9971	–0.1431	0.9926
$\Delta \ln Y_t$	–6.0964*	0.0000	–6.0983*	0.0000
$\Delta \ln K_t$	–4.9647*	0.0010	–4.8885*	0.0013
$\Delta \ln L_t$	–4.9530*	0.0011	–5.9249*	0.0001
$\Delta \ln REER_t$	–4.8189*	0.0017	–5.8464*	0.0001
$\Delta \ln GL_t$	–5.5518*	0.0002	–5.5403*	0.0002

Note: * shows the significance at a 1% level of significance.

Table 4

LAG LENGTH CRITERIA						
VAR Lag Order Selection Criteria						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	217.9481	NA	1.16e–10	–8.691760	–8.498717	–8.618520
1	550.7093	584.0299*	4.07e–16*	–21.25344*	–20.09519*	–20.81400*

Note: * indicates lag order selected by the criterion.

Table 5

THE BAYER AND HANCK COMBINED COINTEGRATION ANALYSIS			
Estimated model	**EG-JOH**	**EG-JOH-BO-BDM**	**Cointegration**
$Y_t = f(K_t, L_t, REER_t, GL_t)$	55.4335*	57.6886*	Yes
Significance Level	EG-JOH	EG-JOH-BO-BDM	
1%	16.259	31.169	
5%	10.637	20.486	
10%	8.363	16.097	

Note: * represents a significant 1% level of significance. Lag length is based on the minimum value of AIC.

The findings of the same level of integration confirm that we may proceed to find the association between industrial production, capital, labour, exchange rate and globalization. For this purpose, we apply combined cointegration. The use of optimal lag plays an important role in determining cointegration. Therefore, we identify the optimal lags via lag length criteria and the results are reported in table 4.

The findings indicate that a lag of one is the ideal length, and this may be used in the analysis. Going forward, table 5 presents the combined cointegration findings. The results show that, over the years 1970–2019, there was a long-term link between industrial production, capital, labour, exchange rate, and globalization in Malaysia. The computed Fisher's values of EG-JOH and EG-JOH-BO-BDM are more than critical values. Table 6 presents the results of an ARDL bound testing used to assess the robustness of combined cointegration.

Table 6

ARDL BOUND TESTING		
Statistics	**Value**	**K**
F-statistics	3.47**	4
Critical Bounds Values		
Significance Level	Lower Critical Bounds (LCB)	Upper Critical Bounds (UCB)
1%	3.845	5.150
5%	2.823	3.872
10%	2.372	3.320

The estimated F statistic is bigger than the upper critical limit at the 10 percent significance level, according to the results of the ARDL bound testing, suggesting that all the variables move together over time. This result demonstrates the robustness of our findings and is also in line with the results of combined cointegration. Following the confirmation of the long-term relationship between the variables of interest, we use the DS-ARDL model to assess the effects of globalization and exchange rates on industrial production, taking into account labour and capital as supporting variables from the production function. The findings are shown in table 7.

To begin with, the coefficient of the F-statistic is significant pointing out that model is a good fit. In addition, the value of R-square shows that 82 percent of industrial production is explained by the independent variables. Additionally, 5000 simulations are run to obtain the results of the DS-ARDL model. Moving forward, it is observed that a 1 percent depreciation of the exchange rate significantly increases industrial production by 0.06% in the long run. The nature of the relationship between exchange and industrial production depicts the similarity of J-curve phenomena. This finding shows that in the case of the Malaysian economy, contractionary devaluation does not hold. Therefore, our results are in contrast to Bahmani-Oskooee and Mohammadian [10] who show that an increase in exchange rates is coupled with an increase in output. Moreover, it is observed that capital, labour and globalization have positive and significant impacts on industrial production in the long run.

The estimated parameters of the long run show that a 1 percent increase in capital, labour and globalization will lead to a rise in industrial production by 0.00004%, 0.138% and 0.228% in the long run respectively. These findings are intuitive as an increase in both the factors of production namely labour and capital boosts industrial production. Similarly, increasing globalization opens the door to

Table 7

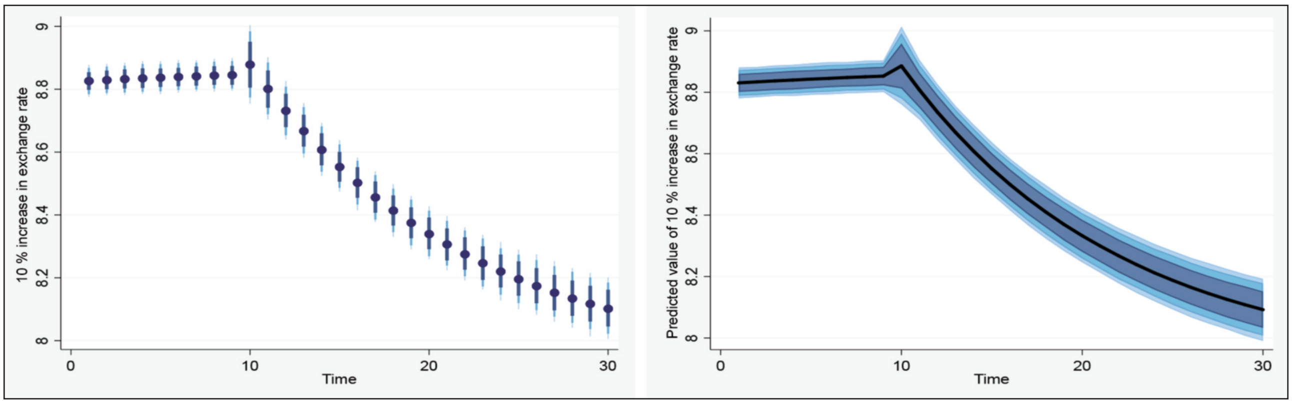
DYNAMIC SIMULATED ARDL MODEL				
Dependent Variable: ln Y_t				
Independent Variables	**Coefficient**	**Std. Error**	**T-Statistics**	**Prob.**
Constant	–0.139156	0.5511273	–0.25	0.802
ln K_t	0.0000473*	0.0000125	3.78	0.001
ΔK_t	0.1799359*	0.0247798	7.26	0.000
ln L_t	0.1384136**	0.056737	2.44	0.019
ΔL_t	0.2190782	0.152319	1.44	0.158
ln $REER_t$	–0.0696623**	0.0323899	–2.15	0.038
$\Delta REER_t$	0.0761668	0.0523059	1.46	0.153
ln GL_t	0.2283075***	0.1311673	1.74	0.090
ΔGL_t	–0.0851683	0.2419242	–0.35	0.727
$ECM_{(t-1)}$	–0.3159*	0.0943	–3.35	0.002
F-stat.	19.87*			
Prob.	0.0000			
N	49			
R-square	0.8209			
Simulations	5000			
Durbin-Watson (DW) D-statistics	1.9118			
Diagnostic Test				
Test Name	Statistics	Prob.	Conclusion	
Breusch-Pagan Heteroscedasticity	3.21	0.0730	No Heteroscedasticity Problem	
LM test	0.036	0.8503	No serial correlation Problem	
LM Serial Correlation test	0.707	0.4004	No ARCH effects	
Ramsey RESET test	0.597	0.4529	No omitted variables bias	
CUSUM	Stable			
CUSUM Square	Stable			

Note: *, ** and *** display the significant at 1%, 5% and 10% level of significance respectively.

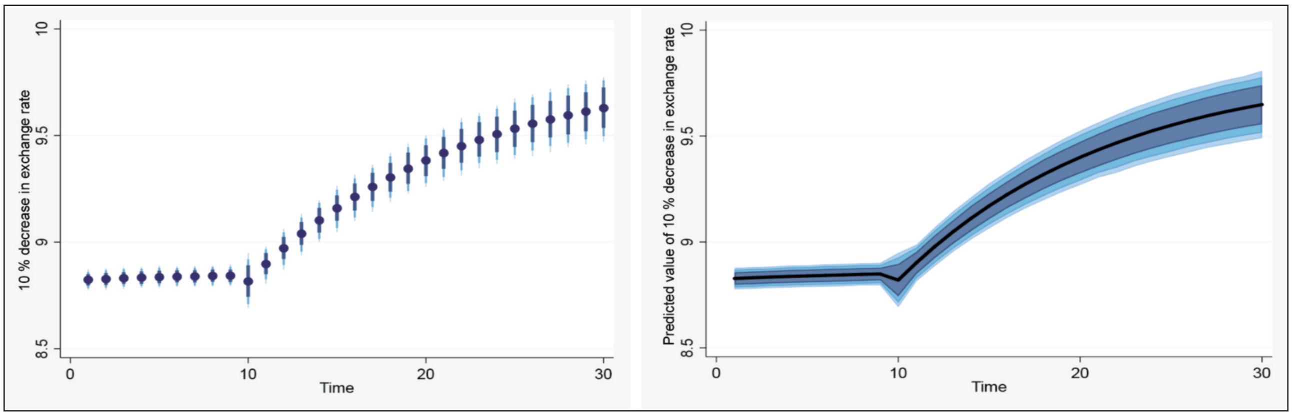
higher demand for domestic goods and results in an increase in industrial production. Furthermore, it is observed that in the short run, only capital has a positive and significant impact on industrial production and a 1 percent growth in capital leads to enhance the industrial production by 0.17%. This finding reveals that only capital has the ability to affect industrial production whereas the other variable requires a comparatively longer period to show their effect. Moving ahead, the lagged value of ECM is –0.31 is negative and significant implying that it requires approximately 3 years and 3 months to return to the equilibrium in the long run.

The lower part of table 7 shows the results of sensitivity analysis portraying no autocorrelation, no heteroscedasticity, no serial correlation, no ARCH effects and no omitted variables bias in our estimated model. Similarly, the CUSUM and CUSUM square tests of Brown, Durbin [32] show that estimated parameters are stable over a period of time.

The principal advantage of applying novel DS-ARDL simulations is its power to predict and forecast the positive and negative effects of one independent variable on the dependent variable over the selected time zone by controlling the effect of other independent variables. To find the true variance among individual variables and their impact on the regress and, the DS-ARDL graphs are often analysed. Forecasting and prediction aid in knowing how determinants will behave in the future and aid in the creation of policies. The graph's dots, which represent the average expected values of industrial production as a result of changes in independent variables, are displayed in the figures. The graph's dark blue to light blue lines represent the 75%, 90%, and 95% accuracy intervals. First, figure 1 shows the negative impact of the exchange rate on industrial production in the long run. It is observed that a 10 percent appreciation in the exchange rate (as displayed in figure 1, *a*) leads to a decrease in industrial production from the 10^{th} time horizon to the 30^{th} time horizon. Conversely, a 10 percent depreciation of the exchange rate (as displayed in figure 1, *b*) increases industrial production for the same time horizons. Second, figure 2 demonstrates the beneficial effects of capital on both short- and long-term industrial production. Figure 2, *a* illustrates how an increase in capital of 10% is expected to boost industrial production throughout the course of the 10^{th} through 30^{th} time periods.

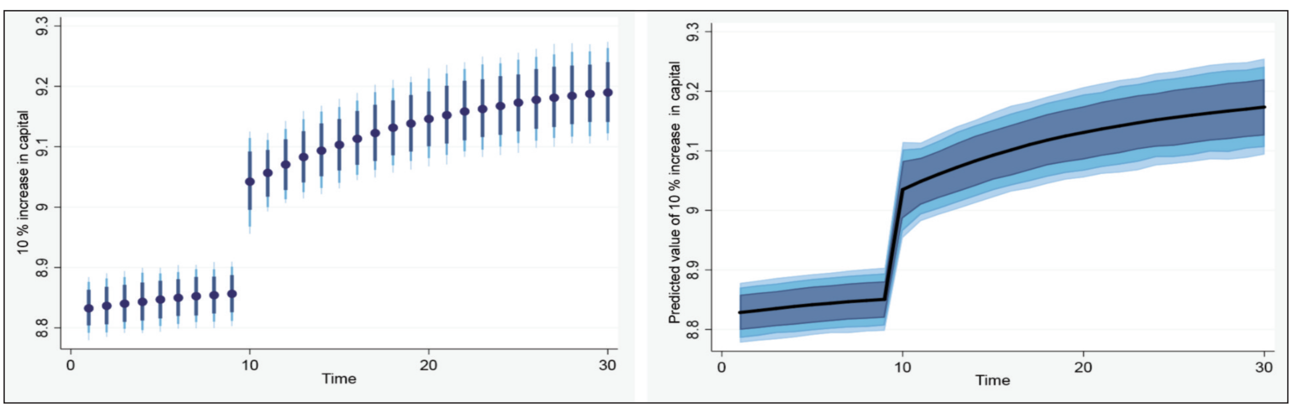


a

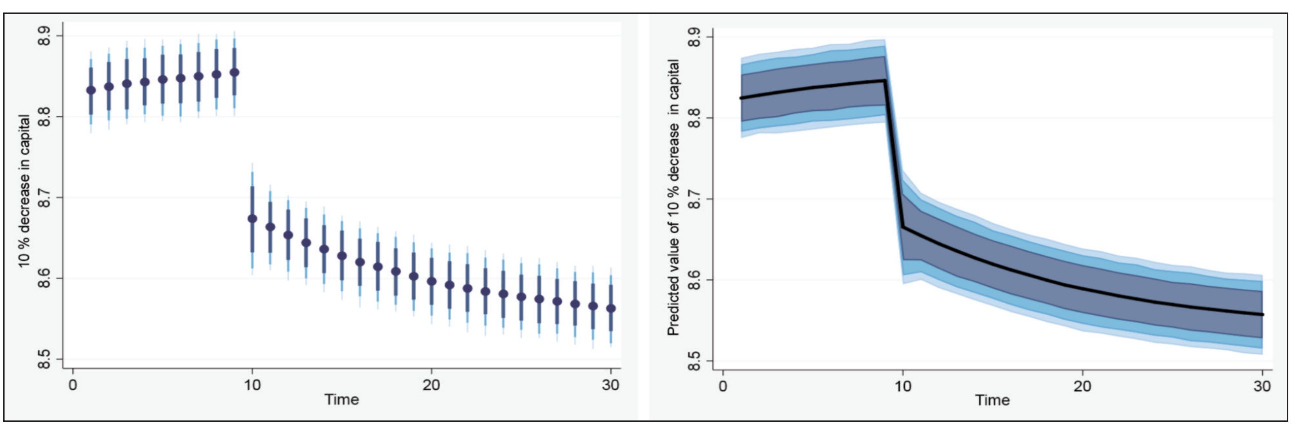


b

Fig. 1. The average predicted values of industrial production due to change in the exchange rate:
a – 10% increase in the exchange rate; *b* – 10% decrease in the exchange rate

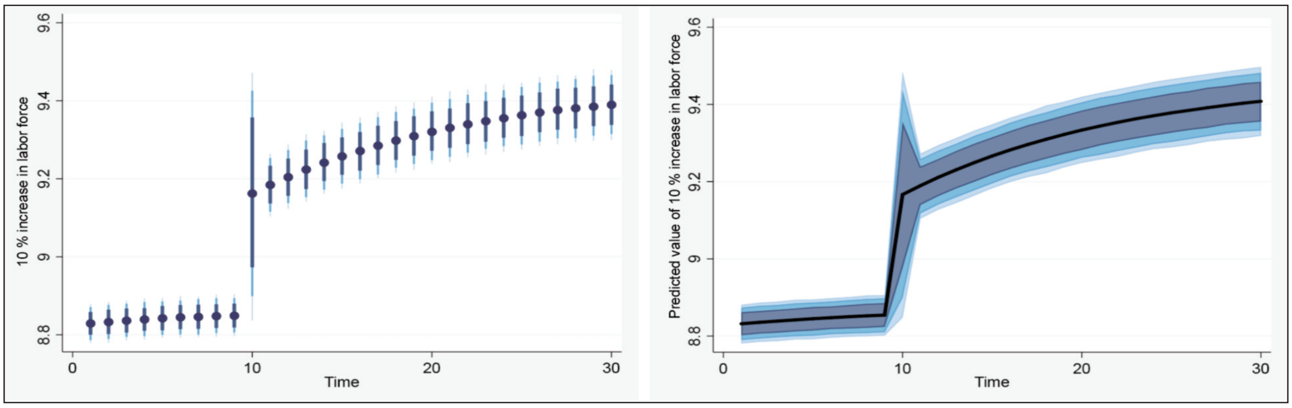


a

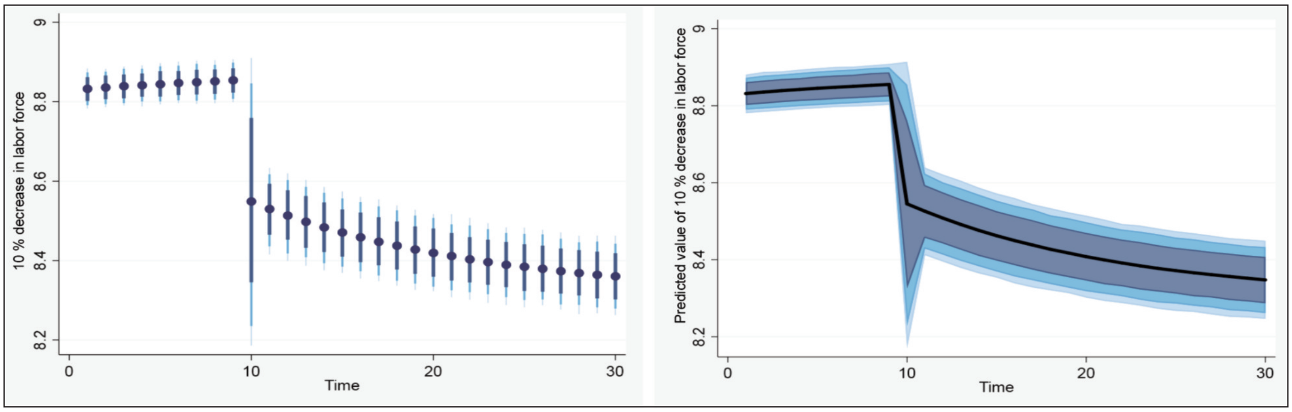


b

Fig. 2. The average predicted values of industrial production due to change in capital:
a – 10% increase in capital; *b* –10% decrease in capital

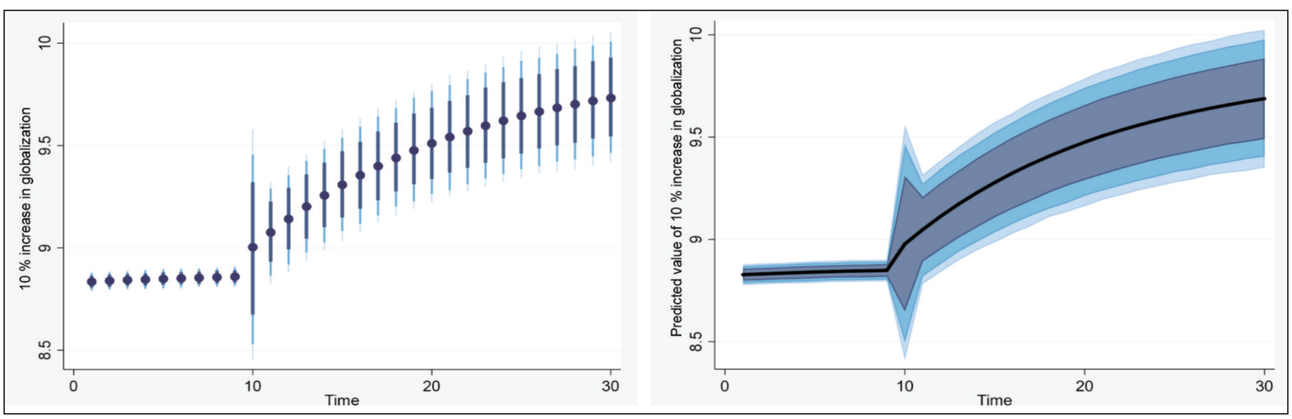


a

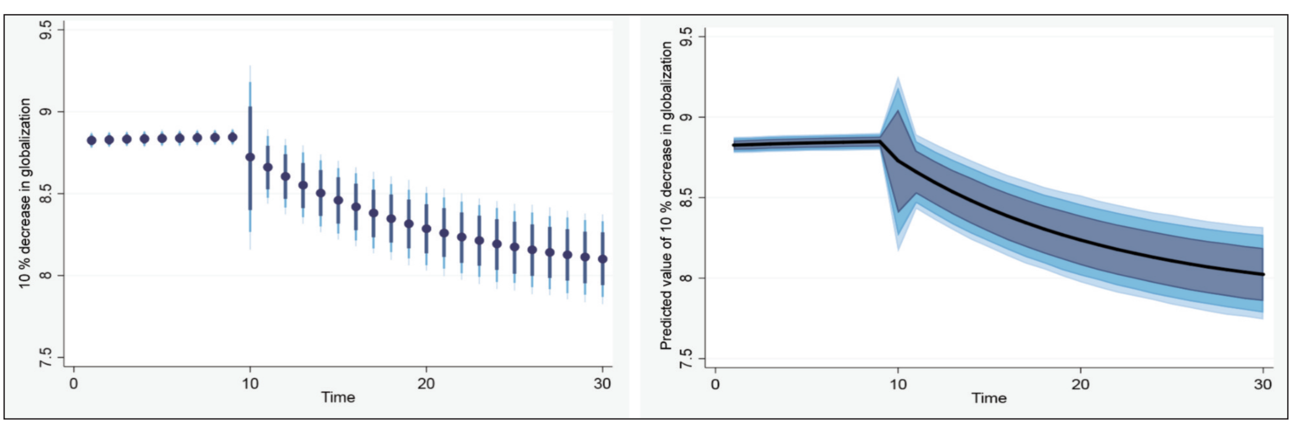


b

Fig. 3. The average predicted values of industrial production due to change in the labour force:
a – 10% increase in the labour force; *b* – 10% decrease in the labour force



a



b

Fig. 4. Predicting changes in industrial production due to changes in globalization:
a – 10% increase in globalization; *b* – 10% decrease in globalization

Comparably, figure 2, *b* shows that a 10% drop in capital causes industrial production to slow down from the 10th to the 30th time horizon. Thus, a constant rise or fall in capital consistently raises or lowers industrial production throughout the long and short terms. Finally, figure 3 projects both the positive and negative effects of labour on industrial production, demonstrating that a ten percent increase or decrease in labour is eventually favourably (or negatively) correlated with industrial production. Figure 4 shows how globalization and industrial production are positively correlated. This clear relationship between globalization and industrial production explains why, throughout a 30-year time frame, a 10% rise or decrease in globalization progressively boosts or reduces industrial production. We verify that the variables we predicted fall within the 95% confidence range.

CONCLUSION AND POLICY IMPLICATIONS

Existing literature on the impact of exchange rate movements on industrial production is inconclusive as most of the studies ignore the asymmetric nature of this relationship. More precisely, while determining the impact of currency depreciation on net exports and industrial production, they do not take into account the effects of depreciation on the variables related to production function namely capital and labour. The present work endeavours to explain the overall effects of exchange rate changes on industrial production while incorporating the contractionary effects of currency depreciation and uses a novel DS-ARDL approach of Jordan and Philips [11] for the estimation. The variables are found to be cointegrated. It is observed that in the long run, a depreciation of the real exchange rate is found to be expansionary. The other variables of interest namely capital, labour and globalization also seem expansionary.

This study has certain policy implications for decision-makers:

First, Malaysian policymakers may use voluntary devaluations due to their expansionary effect on industrial production. Nevertheless, they require a longer period to achieve the desired results. Second, to enhance production in the short run, Malaysia can consider easing capital controls to attract more capital and boost production in the short run. Third, Malaysian authorities should promote domestic labour as well as encourage cheap labour from other countries to promote industrial production in the long run. Fourth, the Malaysian regulators need to promote globalization of their economy to boost home industrial production.

Moreover, the study incorporates capital, labour, and globalization as explanatory variables but excludes other significant factors such as technological advancements, government policies, political stability, and external economic shocks, which can also impact industrial production. Additionally, while the study demonstrates a correlation between exchange rate changes and industrial production, establishing causality remains a challenge, as other underlying factors could drive both exchange rate movements and industrial production changes.

Future research should include additional variables like technological progress, political stability, government policies, and external shocks. Comparative studies across different countries and the use of advanced econometric techniques to explore non-linear relationships are needed. Sector-specific analyses within Malaysia and distinguishing between short-term and long-term effects will provide targeted insights. Examining policy case studies and the roles of globalization and technological advancements, especially within Industry 4.0, will offer valuable perspectives for effective policy development.

In another train of thought, the impact on the textile industry is a key aspect that must be revealed. For instance, Wang and Zakaria [33] argued that the apparel and garment industry in Malaysia has a significant influence on economic growth and sustainable development. Gazzola et al. [34] suggested that the impact of the apparel industry in Malaysia is around the important amount of USD 1.3 trillion. Other research studies [35, 36] also applied ARDL analysis to the emerging economy of India.

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