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Muhammad Aiman Haziq Norehan, Abdul Rahim Ridzuan, Shafinar Ismail, Mohamad Idham Md Razak, Mohd Shahidan Shaari

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Dynamic Linkages between Foreign Direct Investment Inflows, Economic Growth and Information and Communication Technology: Evidence from China and Malaysia

Muhammad Aiman Haziq Norehan
Sales Department, CIMB Bank Berhad, Malaysia
Email: Aiman.norehan@cimb.com

Abdul Rahim Ridzuan
Faculty of Business and Management, Universiti Teknologi MARA, Malaysia
Institute for Big Data Analytics & Artificial Intelligence, Universiti Teknologi MARA, Malaysia
Accounting Research Institute, Universiti Teknologi MARA, Malaysia
Institute for Research on Socio-Economic Policy, Universiti Teknologi MARA, Malaysia
Centre for Economic Development and Policy, Universiti Malaysia Sabah, Malaysia
Email: Rahim670@uitm.edu.my

Shafinar Ismail, Mohamad Idham Md Razak[1]
Faculty of Business and Management, Universiti Teknologi MARA, Malaysia
Email: shafinar@uitm.edu.my, iedham@uitm.edu.my

Mohd Shahidan Shaari
Faculty of Applied and Human Sciences, Universiti Malaysia Perlis, Malaysia
Email: shahidanshaari@unimap.edu.my

Abstract
Information and communication technology (ICT) is one of the key sectors promoting economic growth in the modern era of globalisation. Most economic activities, including international trade and foreign direct investment (FDI), largely depend on various modern ICT sources. This study examines the dynamic relationship between economic growth and FDI inflows toward ICT development in China and Malaysia from 1980 to 2017. The study applied an ARDL bound test to analyse the long-run and short-run relationship among the variables. The findings show that economic growth, FDI inflows and capital significantly influence China's ICT development in the long run. While human capital and labour were found insignificantly influence China's ICT development. For Malaysia, only capital and human

[1] Corresponding author

capital significantly influence ICT development in the long run. From the results, we emphasise that focusing on improving economic growth and FDI inflows will provide better ICT development in the country. From a policy perspective, policymakers should focus on improving economic growth and tailor their policies according to foreign investors' needs by improving the current regulatory performance to attract more foreign investors.

Keywords: ICT Development, Economic Growth, FDI Inflows, ARDL Bound Test

Introduction

Information and Communications Technology (ICT) refers to technologies that provide access to information through telecommunications. It is similar to information technology but focuses more on communication technologies, such as the Internet, wireless networks, telephones, and other communication technologies. High-speed Internet simplifies the company's business strategy, innovation and transformation. According to UNCTAD (2015), a 10 per cent increase in internet speed will increase economic growth by 1.3 per cent. In the past few decades, through ICT, people have established connections, improved living standards, created opportunities for people, promoted modernisation, and increased global productivity, resulting in a worldwide revolution (Mago and Mago, 2015). It has been highlighted that how ICT can improve everyone and the community will bring positive ways and improve daily work. In this region, ASIA economies have benefited from the impact of ICT development. They have continuously led to tremendous changes in their economic growth.

As illustrated in Figure 1, the population of individuals using the Internet in Malaysia and China shows an increasing trend. However, China shows a more drastic increasing trend. This positive trend has been supported by China's spending of more than $182 billion to boost their high-speed 4G mobile network (Staff, 2015). This also proves that China has achieved its goals where almost 80% population in China uses the Internet.

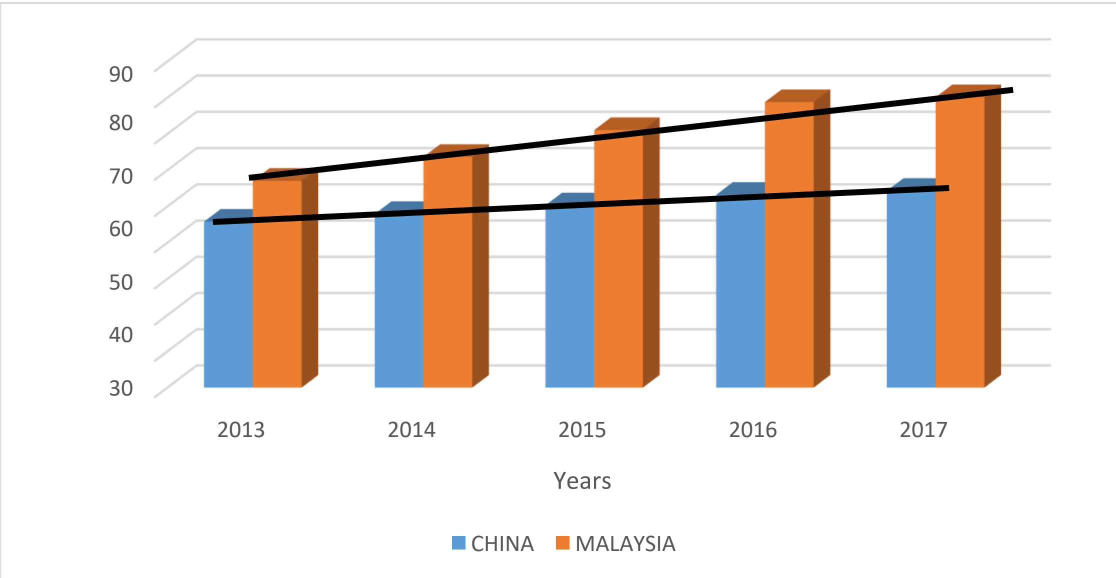


Figure 1: Individuals using the Internet (% of population)
Source: World Development Indicator (2017)

According to Thompson et al (2017), based on Akamai Technologies report China has a better average internet speed than Malaysia, which is 9.3 Mbps in China while only 4.4 Mbps for Malaysia. China notices that high-speed Internet has been the main component of economic development and social change. The slow increasing trend of individuals using the

Internet in Malaysia also has been caused by the cost of internet charges in Malaysia are still considered expensive. According to UNCTAD (2018), Malaysia ranked 74 of 167 countries in terms of price per Mbps for fixed broadband. This is due to a lack of competition among Internet providers in Malaysia, mostly dominated by Telekom Malaysia (TM), which held 92.2 per cent of the market share in 2017.

China has been struggling to penetrate its national ICT infrastructure as the world's largest economy. For example, according to the MOFA PRC (2019), in 2019, 97% of primary and secondary schools in China were connected to the Internet. The proportion of schools with multimedia classrooms has increased from 40% in 2019 to 93%. In addition, China now looks forward to implementing 5G technology in its country. The ICT gap between China and Malaysia proves that China is moving faster in every aspect of the production line, which will affect its economic growth.

Despite the fastest penetration of ICT Development, it has been supported by positive inflows of Foreign Direct Investment (FDI) in China and Malaysia. According to UNCTAD (2020), FDI flows in Asia increased by 4 per cent in 2018 to reach US$512 billion. China's FDI inflows increased by 4 per cent, reaching a high record of US$139 billion, 10 per cent more than the world's total. Despite the trade war between China and the United States, it does not reflect that more than 60,000 new companies in China became foreign investors in 2018. Meanwhile, for Malaysia, FDI flows have been oscillating between US$9 billion and US$12 billion, making Malaysia one of the highest recipients of FDI among neighbouring countries.

This contributes to the existing literature by introducing a new macroeconomic indicator, ICT development proxy by mobile cellular subscription per 100 people. Moreover, the existing literature has looked into the impacts of ICT on economic growth in the scope of the BRIC (Latif et al., 2018), Nigeria (Sulaiman et al., 2015) and the Sub-Saharan African Region (Albiman and Sulong, 2016). This present study contributes to the existing literature by focusing on economic growth and FDI inflows in ICT Development in China and Malaysia. To the best of the researcher’s knowledge, no empirical study has been carried out to examine how economic growth and FDI inflows influence the ICT development relationship. This study has proven that economic growth and FDI inflows significantly influence ICT development in China and Malaysia.

Literature Review

ICT development is one of the key determinants of our economy today. Some studies have researched how other economic indicators affect the development of ICT in different countries. Due to a lack of previous research, ICT was used as the dependent variable. In this part of the literature review, the researcher will provide some previous studies that use ICT as an indicator to influence economic growth.

Kumar et al (2015) studied the effects of ICT on out per worker in the Chinese economy. By implementing the ARDL model approach, this study used the sample period from 1980 to 2013. The result of the study showed that all indicators used to measure ICT significantly influenced China's economic growth over the period from 1977 to 2013.

In another study, Latif et al (2018) investigated the relationship between ICT, FDI, and economic growth for BRICS (Brazil, Russia, India, China, and South Africa) economies from 2000 to 2014. ICT includes multiple indicators, including landline phones, mobile phones, Internet users, Internet services, and fixed broadband. In order to combine all the ICT indicators, the authors used the Principal Component Analysis (PCA) technology to convert them into a single factor called the ICT index in their research. At the end of the study, it was found that ICT significantly impacted the economic growth of the BRICS.

This study was supported by Sulaiman et al. (2015). They investigated the impacts of ICT and human capital on economic growth in Nigeria. This study employed time series data for the period from 1975 to 2010. This study also applied a familiar econometric model, the ARDL approach. At the end of the study, it was found that both ICT and human capital were important determinants of economic growth in Nigeria when both showed a positive relationship towards economic growth. Nigeria needed to provide more funding in research and development to keep its economy sustained and improve its educational sector.

Albiman and Sulong (2016) studied the long-term impacts of ICT on the economic growth of the sub-Saharan region (SSA) from 1990 to 2014. This study differs from previous studies because they used the General Methods and Moments (GMM) method to analyse the collected data. The empirical analysis shows that mobile phones and the Internet were the main economic drivers for SSA.

Table 1
Summary of Literature Review

Studies of	**Sample Period**	**Time Series**	**Explanatory variables**
Kumar et al (2015)	China 1980-2013	ARDL	ICT, GDP
Latif et al (2018)	BRIC 2000-2014	OLS	ICT, FDI, GDP
Sulaiman et al (2015)	Nigeria 1975-2010	ARDL	ICT, GDP, HC
Albiman and Sulong (2016)	Sub Saharan African region 1990-2014	GMM	ICT, GDP, HC, FD, TO, DS

Methodology

The proposed econometric models are introduced in this section. All variables are transformed into log-linear from (LN); thus, the estimated results from these models represent elasticities. According to Shahbaz et al (2013), modelling the log-log model specification will provide efficient results by reducing the sharpness in time series data compared with the simple linear-linear specification.

Model of ICT Development

The second goal of this research is to determine the ICT development determination of China and Malaysia. Some previous studies have examined many variables chosen to explain ICT development. The regression equation of the ICT development model introduced in this study is as follows:

$$ICT = f(GDP, FDI, K, HC, L) ...(1.0)$$

Where *ICT* is Information and Communications Technology development ICT consists of three indicators: mobile cellular subscription per 100, fixed telephone subscription per 100 and individuals using the Internet based on the per cent of the population, *GDP* is real Gross

Domestic Product constant 2010 USD, *FDI* is Foreign Direct Investment as proxied by net inflows FDI as a percentage of GDP, *K* is capital proxied by gross capital formation (% of GDP), *HC* is human capital proxied by secondary school enrolment rate, and *L* is the total labour force.

All variables are transformed into the log form to measure elasticities. The log-linear form that represents *Ln* for the above equation is as follows:

$$\mathrm{LNICT}_t = \alpha_0 + \beta_1 LNGDP_{it} + \beta_2 LNFDI_{it} + \beta_3 LNK_{it} + \beta_4 LNHC_{it} + \beta_5 LNL_{it} + \varepsilon_t ...(2.0)$$

The term ε represents error term and the subscripts *I* and *t* denote country and time, respectively. The expected sign for and are positive. $\beta_1 \beta_2 \beta_3 \beta_4$ and β_5 are positive.

The ARDL model based on the Unrestricted Error Correction Model (UECM) is stated below:

$$\Delta LNICT_t = \beta_1 + \theta_0 LNICT_{t-1} + \theta_1 LNGDP_{t-1} + \theta_2 LNFDI_{t-1} + \theta_3 LNK_{t-1} + \theta_4 LNHC_{t-1} + \theta_5 LNL_{t-1} +$$
$$+ \sum_{i=1}^{a} \beta_i \Delta ICT_{t-i} + \sum_{i=0}^{b} \gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c} \delta_i \Delta LNFDI_{t-i} + \sum_{i=0}^{d} \lambda_i \Delta LNK_{t-i} + \sum_{i=0}^{e} \vartheta_i \Delta LNHC_{t-i} + \sum_{i=0}^{f} \psi_i \Delta LNL_{t-i} + \upsilon_t ...(3.0)$$

Where Δ is the first difference operator, and u_t is the white-noise disturbance term. Residuals for the UECM should be serially uncorrelated, and the model should be stable. This validation can be addressed with a series of diagnostic tests shown in the analysis section. The final version of the model represented in Equation 3.0 till 8.0 above can also be viewed as an ARDL of order (a b c d e f). The short-run effects are captured by the coefficients of the first differenced variables. The null of no co-integration in the long-run relationship is defined by:
H_0: $\theta_0=\theta_1=\theta_2=\theta_3=\theta_4=\theta_5=0$ (there is no long-run relationship),
is tested against the alternative of
H_1: $\theta_0\neq\theta_1\neq\theta_2\neq \theta_3\neq\theta_4\neq\theta_5\neq 0$ (there is a long-run relationship exists),
employing the familiar F-test. Suppose the computed F-statistic is less than the lower bound critical value. In that case, we do not reject the null hypothesis of no co-integration. However, suppose the computed F-statistics is greater than the upper bound critical value of at least the 10% significant level. In that case, we reject the null hypothesis of no co-integration.

Data

This study used annual data from 1980 to 2017, comprising 37 years, as a sample period. Data such as GDP, FDI, ICT, K, L, FD, INF and L were taken from World Development Indicator (WDI) 2016. HC data was taken from Barro and Lee database.

Table 2
Sources of Data

Model	Description	Sources
Model of ICT Development		
ICT	Mobile cellular subscription per 100 people	WDI
GDP	Real GDP constant (2010) USD	WDI
FDI	FDI inflows as % of GDP	WDI
K	Gross capital formation as % of GDP	WDI
HC	Secondary school enrolment rate	WDI
L	Total labor force	WDI

Empirical Fingdings

The analysis began with some descriptive statistics of the model. Table 3 summarises ICT (Information and Communication), GDP (economic growth), FDI, K, HC and L. The highest ICT is Malaysia (mean = 2.480) and followed by China (mean = 1.311). While, the trend of GDP has been led by China (mean = 28.304) and followed by Malaysia (mean = 25.643). From the descriptive statistics of the data, it is apparent that the differences between minimum and maximum values of ICT, GDP and FDI were big enough for a robust analysis. It implies the increasing trend of the variables. The mean and median variables' values in China and Malaysia were close to each other. This concludes that the variables are normally distributed.

Table 3
Descriptive Statistic for Model of ICT Development

	LNICT	LNGDP	LNFDI	LNK	LNHC	LNL
China						
Mean	1.311	28.304	0.581	3.682	0.737	20.309
Median	2.037	28.318	1.072	3.685	0.762	20.398
Maximum	3.320	29.950	1.822	3.865	0.943	20.481
Minimum	-1.535	26.556	-3.507	3.487	0.519	19.853
Standard Deviation	1.846	1.049	1.185	0.114	0.129	0.201
Skewness	-0.414	-0.0407	-1.556	0.063	-0.172	-1.044
Kurtosis	1.481	1.779	5.263	1.890	1.700	2.620
Malaysia						
Mean	2.480	25.643	1.185	3.315	0.899	16.015
Median	2.749	25.738	1.367	3.245	0.937	16.025
Maximum	3.035	26.622	2.170	3.776	1.120	16.531
Minimum	1.053	24.547	-2.870	2.881	0.577	15.498

Standard Deviation	0.553	0.638	0.840	0.227	0.161	0.317
Skewness	-1.095	-0.217	-3.208	0.613	-0.505	0.002
Kurtosis	3.013	1.764	15.729	2.427	2.027	1.777

Next, each variable's order of integration was conducted using unit root tests. As mentioned in the previous analysis, this step confirms the stationary of the data; as the bound test requires the variables to be either only stationary at the first difference, I (I) or a mixture of stationary at the level, I (0) and at the first difference, I (I). Besides, it is also important to ensure that the variables are not integrated of order two, I (2) or beyond as rules set by the Bound test. The two types of unit root tests used in this analysis are ADF and PP unit root tests. In these two-unit root tests, the null hypothesis of the series with a unit root was tested against the alternative of stationary. Table 4 summarises the outcome of ADF and PP on the natural logarithms of the levels and the first difference of the variables. In summary, the results indicated a mixture of stationary at I (0) and I (1) for the variables proposed in this model, thus validating the use of bound testing for cointegration.

Table 4
ADF and PP unit Root Tests for Model of ICT Development

Model	Variables		ADF test		PP test	
			Intercept	Trend and Intercept	Intercept	Trend and Intercept
China	Level	LNICT	-2.44(3)	-1.18(2)	-1.47(5)	0.24(4)
		LNGDP	-1.36(2)***	-3.39(3)*	-1.23(0)	-0.94(0)
		LNFDI	-2.30(1)*	-1.19(1)*	-5.10(1)***	-3.18(1)*
		LNK	-2.30(1)	-3.35(1)*	-1.51(4)	-2.47(3)
		LNHC	-0.26(1)	-2.59(1)	-0.67(4)	-1.45(4)
		LNL	-27.93(9)***	-27.66(9)***	-4.24(1)***	-1.05(3)
	First difference	LNICT	-1.49(1)	-2.22(1)	-0.92(1)	-1.82(2)
		LNGDP	-4.63(1)***	-4.29(1)***	-3.37(2)**	-3.52(3)**
		LNFDI	-5.69(0)***	-4.83(1)***	-5.69(2)***	-9.62(11)***
		LNK	-4.95(1)***	-4.30(0)***	-4.19(9)***	-4.12(9)***
		LNHC	-1.191(0)	-8.08(9)***	-2.04(2)	-1.99(2)
		LNL	-22.23(9)***	-2.10(5)	-4.88(3)***	-6.68(3)***
Malaysia	Level	LNICT	-0.30(1)	-1.84(1)	-3.56(3)***	-2.21(3)
		LNGDP	-1.12(0)	-1.25(0)	-1.08(2)	-1.41(2)
		LNFDI	-5.16(0)***	-5.18(0)***	-5.16(0)***	-5.18(1)***
		LNK	-1.793(0)	-2.076(0)	-1.92(1)	-2.31(2)
		LNHC	-2.67(1)***	-1.70(1)*	-7.80(4)***	-0.93(4)*
		LNL	-1.38(3)	-3.00(3)*	-0.089(1)	-2.46(1)
	First difference	LNICT	-1.40(2)	1.20(0)	-1.36(1)	0.73(1)
		LNGDP	-4.94(0)***	-4.96(0)***	-4.95(1)***	-4.97(1)***
		LNFDI	-6.81(1)***	-6.72(1)***	-25.08(23)***	-24.68(23)***
		LNK	-5.39(0)***	-5.31(0)***	-5.39(1)***	-5.31(1)***
		LNHC	-0.89(0)*	-2.25(0)**	-0.89(0)	-2.30(2)
		LNL	-4.60(2)***	-4.17(2)***	-4.69(2)***	-4.61(2)***

Note:1,(*)(**)(***) indicate significant at 10%, 5% and 1% significant level respectively. 2. The optimal lag length is selected automatically using the Schwarz information criteria for ADF test, and the bandwidth has been the selected by using the Newey-West, method for the PP test.

Table 5 explains the long-run elasticates of each variable for China and Malaysia. F-test was obtained from the optimum lag based on AIC. AIC based ARDL as in Table 5 suggest that the optimum lag was (3, 0, 0, 0, 0, 0) for China and (1, 4, 0, 4, 3, 4) for Malaysia. The result of F-statistic is greater than its upper bound critical value for China and Malaysia and significant at 1% and 5% level, thus confirming the existence of cointegration in the model.

Table 5
ARDL Test for cointegration for Model of ICT Development

Model	AIC (Lag order)	F Statistic
China	(3, 0, 0, 0, 0, 0)	6.064***
Malaysia	(1, 4, 0, 4, 3, 4)	4.851***
Critical Values for F-statistic#	Lower Bound, I(0)	Upper Bound, I(I)
1%	3.41	4.68
k = 5 5%	2.62	3.79
10%	2.26	3.35

Note: # The critical value are obtained automatically under Eviews 9, k is several variables (IV), critical values for the bounds test: case III: unrestricted intercept and no trend *,**, and *** represent 10%, 5% and 1% level of significant , respectively.

Table 6 shows the results of some major diagnostic statistics, such as the LM statistic, which tested the serial correlation, the misspecification by RESET test, heteroscedasticity and normality tests. The null hypothesis of normality of residuals, the null hypothesis of no first-order serial correlation, the null hypothesis of no heteroscedasticity and the null hypothesis of no misspecification of functional form were accepted in all the selected countries because the probability value (p-value) is larger than 1%, 5%, and 10% significance levels.

Table 6
Diagnostic Test for Model of ICT Development

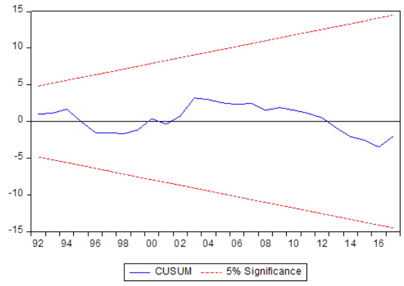
Model	Serial Correlation χ^2 (I) [p-value]	Functional Form χ^2 (I) [p-value]	Normality χ^2 (I) [p-value]	Heteroscedasticity χ^2 (I) [p-value]
China	2.264 [0.126]	1.454 [0.239]	2.368 [0.306]	0.550 [0.808]
Malaysia	3.175 [0.100]	2.372 [0.152]	0.130 [0.937]	1.566 [0.213]

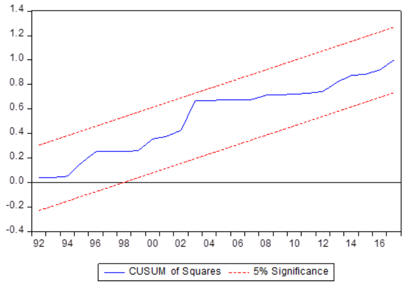
Note: The probability values of the battery of Diagnostic tests are presented in squared brackets. A Lagrange multiplier test for residual serial correlation; B. Ramsey's RESET test using the square of the fitted value; C. Based on the test of skewness and kurtosis of residuals; D. Based on the regression of square fitted values.

The stability test using CUSUM and CUSUMQ were as in Figure 2. The stability of the model was supported, in all the cases, because the plot of both CUSUM and CUSUMQ fell inside the critical bounds of five % significance.

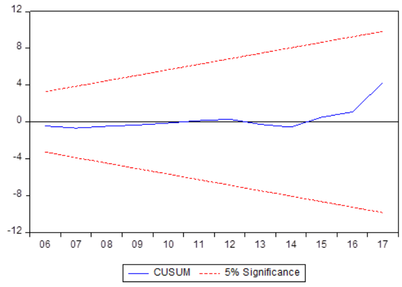
CUSUM	CUSUMQ

China





Malaysia



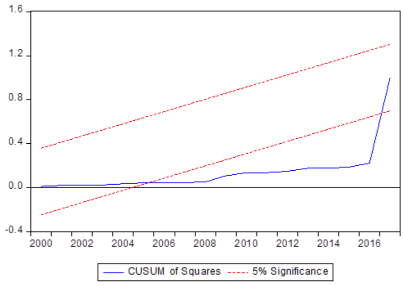


Figure 2: CUSUM and CUSUMQ Stability Test for Model of ICT Development

Table 7 shows the long-run elasticities of each variable for China and Malaysia. Based on LNGDP, there is a positive and significant relationship at a 10% significance level influence on the ICT development of China, where a 1% increase in economic growth will increase 0.34% ICT development in China. Kumar et al. (2015) also supported the positive impact of economic growth on China's ICT development. Meanwhile, a negative and significant sign was found between LNGDP and LNICT for Malaysia. For LNFDI, both countries showed the same result as the previous indicator: a positive and significant relationship for China and a negative and significant relationship for Malaysia. The outcome of LNFDI in this model for China was supported by Latif et al. (2017). They found that FDI inflows positively correlated with the BRICS countries.

Next, for capital LNK, a significant and positive relationship sign showed in China and Malaysia. Both countries have significance at 10% and 1 % significance levels. In other words, a 1% increase in the capital increased 0.71% and 0.91% LNICT for China and Malaysia. Besides, for human capital LNHC towards LNICT, Malaysia showed a positive and significant sign. At the same time, China did not have a significant negative relationship. For Malaysia, 1% increase in human capital while increasing LNICT by 11.63%. The role of human capital is synonymous with knowledge accumulation that may be significant to ICT development, as Ramlan and Ahmed (2009) found. Lastly, for labour LNL, both countries have shown different results where China has positive and not significant. In contrast, Malaysia has a negative and significant sign.

Table 7
Long- Run Elasticities for Model of ICT Development

Country	China	Malaysia
DV	LNICT	LNICT
Lag order	(3, 0, 0, 0, 0, 0)	(1, 4, 0, 4, 3, 4)
IV	Coefficient	Coefficient
LNGDP	0.342*	-2.016***
LNFDI	0.107*	-0.041***
LNK	0.705*	0.908***
LNHC	-0.319	11.683***
LNL	0.378	-1.363**
C	4.111	63.948***

Note: (*), (**), (***) indicate significance at 10%, 5% and 1% significance level respectively.

Lastly, the results of short-run elasticates are seen in Table 8. The estimated results showed that much information was revealed in the short-run analysis. Regarding economic growth, LNGDP, Malaysia and China showed a positive relationship and significant sign. Next, foreign direct investment inflows LNFDI, and both countries achieve significance. However, China showed a positive relationship while Malaysia showed a negative relationship sign. The positive relationship sign between LNK and LNICT is detected in China and Malaysia, where China is positive and significant, and Malaysia is positive and not significant. For LNHC, both countries showed a negative relationship, whereas, in LNHC, both countries showed negative and insignificant levels. Lastly, for the relationship between LNL and LNICT, a positive relationship and no significant signs were detected in China. In contrast, a negative relationship and significant signs were detected in Malaysia.

Table 8
Short Run Elasticates and Error Correlation Term for Model of ICT Development

Variables	China Coefficient	Malaysia Coefficient
ΔLNICT(-1)	0.163	-
ΔLNICT(-2)	0.032	-
ΔLNGDP	0.155*	1.959***
Δ (LNGDP(-1))	-	0.977*
Δ (LNGDP(-2))	-	-0.079
Δ (LNGDP(-3))	-	0.880*
ΔLNFDI	0.048*	-0.055***
ΔLNK	0.320*	0.163
ΔLNK(-1)	-	-0.037
ΔLNK(-2)	-	-0.137
Δ (LNK(-3))	-	-0.292***
ΔLNHC	-0.145	-8.798
Δ (LNHC(-1))	-	14.288
Δ (LNHC(-2))	-	-50.099***
ΔLNL	0.171	-5.936**
ΔLNL(-1)	-	7.698***
Δ (LNL(-2))	-	-0.503
Δ(LNL(-3))	-	-9.318***
CointEq(-1)	-0.453***	-1.356***
R square	0.97	0.87
Adj. R square	0.96	0.64

Note: Δ is refer to first difference. Dependent variables is LNICT. (*), (**), and (***) indicate significance at 10%, 5% and 1% significance level.

Conclusion

In conclusion, this study investigates the impact of selected macroeconomic variables on information and communication technology (LNICT) in China and Malaysia. The selected variables consist of economic growth (LNGDP), foreign direct investment (LNFDI), capital (LNK), human capital (LNHC) and labour (LNL). This study uses the augmented neoclassical growth framework and the ARDL model to examine the long-run and short-run relationship between ICT development and selected macroeconomic variables by considering annual data from 1980 to 2017. The findings show that economic growth, FDI inflows and capital significantly influence China's ICT development in the long run. While human capital and labour were found insignificantly influence China’s ICT development. For Malaysia, only capital and human capital significantly influence ICT development in the long run. While other variables, economic growth, FDI inflows and labour, negatively influence ICT development in Malaysia.

Overall, economic growth and FDI inflows significantly influence ICT development in China. The policymakers in China need to ensure that the economic growth should not only be centred in urban areas but also encompass rural areas. Hence, growth is evenly widespread and improves inequality in China. Besides, policymakers should liberalisation of FDI rules to required diversify and expand the prospect of new investment opportunities for foreign investors especially. Next, China and Malaysia capital found a significant relationship toward ICT development. Lastly, human capital positively influences ICT development in Malaysia. Those policy implications refer to the government's role in continuously upgrading human capital development, in line with the industrial need in the IR4.0 era. Therefore, the funds allocated to developing human capital should continuously increase regardless of any situation. The priority should be given to vocational training like Technical and Vocational Education and Training (TVET), which is one of the initiatives by Malaysia's government to produce high-skill workers that can meet industry requirements.

This study only uses mobile cellular subscriptions per 100 people as a proxy for ICT development. It is not strong enough to show real data for ICT development. For future research, we suggest forthcoming studies include more proxies for ICT development indicators like fixed cellular subscription per 100 and individuals using the internet-based per cent of the population.

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