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The Kuznets Curve, Information and Communication Technology, and Income Inequality in Malaysia

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ABSTRACT

This study re-investigates the presence of the Kuznets curve in the context of Malaysia, by employing an autoregressive distributed lag (ARDL) approach. We seek to examine the non-linear impacts of economic growth on income inequality by investigating the existence of a second turning point to the relationship. Furthermore, we also assess the impacts of information and communication technology (ICT) (through internet, mobile, and broadband usage) on income inequality, besides the determinants of income inequality which have been extensively studied within the framework. This endeavour leveraged a time series analysis whereby the data was employed from the time period of 1970–2018. Our estimation results support the S-curve hypothesis that relates economic growth to inequality starting from the back portion of the inverted U-shaped curve. Our results confirm that ICT can actually be part of an active economic policy aiming to reduce existing income inequalities.

JEL Classification: O33, O40

Keywords: Broadband usage; Income inequality; Kuznets curve; Mobile usage; Information and communication technology

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INTRODUCTION

Malaysia's economic development has contributed significantly to the decline in poverty throughout the past few years. Across the period of 1987–1996, Malaysia's economy has shown a steady growth of approximately 6-7% annually. The country has been categorised as an upper middle-income nation, with an annual real gross national income (GNI) per capita exceeding RM15,802 (equivalent to $4,046) since 1991. Since the 1997 Asian financial crisis, the country's economic growth began to rise gradually, and reached a GNI per capita of RM40,684 in 2020. Although statistics have pointed out that Malaysia is going through heightened economic growth, rising income inequality has always been a heated discussion, as it is an economic and social concern in the country. As surveyed by the Department of Statistics (2019), the average monthly household income for the low-income group (B40) in 2019 was RM3,152, an increase of only 3.4% as compared to RM2,848 in 2016. On the other hand, the middle- (M40) and high-income (T20) groups' average incomes were RM7,348 and RM18,506 in 2019, increasing by 4.1% and 4.7% since 2016, respectively.

Income inequality is defined by the Institute for Policy Studies as the degree to which income is unequally distributed among the population. The Gini coefficient (or Gini index) – ranging from 0 to 1 – is the most applied measure of income inequality. A coefficient that is closer to zero is preferable over the opposite that indicates maximal inequality, and vice versa. A coefficient of 0.4 and above indicates that the unequal income distribution is considered alarming. Although Malaysia's household income inequality has been slightly improving from 0.461 since 2004 to 0.410 in 2015, the Gini coefficient has not reached a figure lower than the 0.4 benchmark since 1970. In fact, the Gini coefficient started to increase again and recorded a value of 0.428 in 2018, against a background of long-standing policy issues faced by Malaysia that include, amongst others, financial shocks such as inflation and the mismatch of skillsets in the human capital department attributed to the rural–urban gap between the states.

The widened disparity was further exacerbated in 2020 when the world was plagued by the novel coronavirus, or now commonly known as Covid-19 ("the virus"). The Covid-19 pandemic brought most parts of the world to a standstill, from both the health and economic standpoints, and neither Malaysia nor its citizens were spared. The virus caused detriment and casualties to many lives, and brought about an equally grim impact on the Malaysian economy, which effects were particularly pronounced amongst the vulnerable households known as the B40 income group. According to the revised World Bank data in July 2020, it was estimated that approximately 6% of Malaysian households are currently living in absolute poverty.

Social implications of inequality have been warned by economists and philosophers, who remarked that social harmony could not be achieved without equal distribution of wealth (Khalid, 2011). Thus, it becomes clear that income equality is one of the most critical indicators of an excellent socio-economic environment (Lee and Khalid, 2020). Lee and Khalid (2020) observed that Malaysia's income inequality increases in both earnings and wealth ownership, which is believed to result from structural changes in the economy. Thus, there was a transparent debate surrounding the controversies on inequality from both the statistics and public standpoints.

A substantial number of studies on economic growth–income inequalities focus on the well-known Kuznets (1955) inverted U-shaped curve. Although Tribble (1999) supports the Kuznets hypothesis and the inverted U-shaped curve, the author's study mentioned that the Kuznets inverted U-shaped curve is actually an S-shaped curve with two turning points. The first turning point shows the relationship between economic growth and income inequality, changing from the agriculture sector to the manufacturing sector (ATM). On the other hand, the second turning point depicts the manufacturing sector to the services sector (MTS) shift in the economy. In sum, it implies that inequality will fall during the early stages of development and increase as the economy approaches the latter stages of economic growth.

The country selected for the present study, Malaysia, also experienced similar structural transitions mentioned in the previous literature. This is evident by the country's transformation from the ATM, and subsequently the, MTS with time. According to the Department of Statistics, sector contribution as a percentage of gross domestic product (GDP) shows that the service sector has significantly improved, and is currently leading the way. Currently, the year 2020 statistics show that the service sector stood at 54.78% with respect to GDP contribution, accounting for the largest share of income in proportion to GDP. On the other hand, the manufacturing sector only managed to achieve 35.91% of the overall percentage of GDP in 2020. Henceforth, there is a possibility that the nation is also going through a second turning point of the Kuznets curve, which implies an increase in growth and inequality. The first objective of this study is therefore aimed to examine if there is an existence of the Kuznets Hypothesis and an extension beyond that in the relationship between economic growth and income inequality in the case of Malaysia.

Reducing income inequality has been a worldwide goal, as stated by the Sustainable Development Goal 10. The increasing level of income inequality has led researchers to examine the determinants that may explain this scenario. To reduce income inequality, Khazanah Research Institute (2018) noted that policymakers should strive to reduce the income gap rather than focusing on the Gini coefficient alone. Therefore, identifying the determinants affecting income inequality would assist policymakers in deciding on the best measure to close the rising inequality gap. Studies on income inequalities have highlighted several important determinants including income growth, trade openness, education, human capital, and others (for details, see Njangang et al. (2021)). Despite ongoing efforts to understand the determinants that may influence income inequality, the role of information and communication technology (ICT) has often been overlooked.

There are two schools of thought on why and how ICT is a crucial determinant in the study of income inequality. On the one hand, ICT is a key determinant in making rich people richer. As reported by Forster et al. (2011), changes in technology are likely to be more beneficial for high-skilled individuals. According to Mehic (2018), some reasonably well-paid manufacturing jobs in advanced countries are being shifted to low-income countries or are being lost permanently due to the introduction of labour-saving technologies. Xu et al. (2019), Law et al. (2020), and Aghion et al. (2019) argued that although the use of ICT increases innovation that promotes economic growth, in a similar vein, its use also increases income inequality. More specifically, Aghion et al. (2019) observed that innovation will result in income inequality among top income earners across different occupations that are heavily linked to technological development, for example, entrepreneurs, engineers, and scientists.

Contrary to the above, technological globalisation creates a knowledge spill-over effect from skilled to unskilled workers in the labour market, which in turn increases overall productivity levels (Bukhari and Munir, 2016). The boom in mobile phone and internet use is observed to generate a lot of economic opportunities for low-skilled workers (Suvankulov et al., 2012), improve farming methods (Gerster and Zimmerman, 2003), access better information to make businesses more competitive (Muto and Yamano, 2009; Labonne and Chase, 2009; Overa, 2006), and offer new opportunities for entrepreneurship (Feldman and Klaas, 2002). In this regard, the use of mobile phones and internet helps in reducing income inequalities (Canh et al., 2020).

Malaysia had shown various initiatives throughout the years to engage in innovation activities as evidenced by the increasing expenditure on R&D from 0.8% in 2008 to 1.3% in 2018 (as a % of GDP). However, there is insufficient evidence that demonstrates if ICT can actually lead to a win-win economic growth-smaller income inequality situation. This beckons the question as to what extent does ICT contribute to narrowing income disparity. The second objective of this study is thus aimed to investigate the role of ICT in narrowing income inequality.

The contributions of this study are two-fold. Firstly, our study adds to the limited existing literature by investigating the relationship between economic growth and income inequality by considering the existence of an S-shaped curve in what is likely to be the few attempts doing so for a country such as Malaysia, where economic restructuring has been evident for the past 50 years. Secondly, we assess the influence of technologies on income inequality by adding ICT (measured by the use of the internet, mobile, and broadband) as one determinant in studying the growth-inequality relationship. Methodologically, the study focuses on analysing the short and long-run relationship between economic growth and income inequality, where ICT is included to address its influence on income inequalities in Malaysia.

This is a unique contribution as Malaysia looks toward upscaling its technology industry by first equipping its citizens with fundamental ICT needs. This is backed up by tax reliefs provided for purchase of ICT equipment such as handphones, laptops and tablets. These measures are complemented by budget spending on tech-related initiatives such as digital payment, merchant solutions, and digital alternative financing businesses, aimed at reviving the small and medium enterprises (SMEs) by giving them easier access to cost efficient platforms to grow their businesses.

Section 2 reviews the related literature on economic growth and income inequality. Subsequently, Section 3 discusses the methodology and data used. Section 4 concludes.

REVIEW OF LITERATURE

Economic growth and income inequality have been the subject of heated debate for decades. Kuznets (1955) is credited with proposing an inverted U-shaped relationship between income level and income inequality. Kuznets hypothesises that inequality arises due to the presence of development in a nation's economy. Before the development stages set in, countries usually record the same levels of income distribution as when the economy grows. Kuznets (1955) takes the US, Germany, and England as sample nations and deduces that these same levels are only evident in countries considered developed as opposed to those catching up. The study implies that high developments would only induce wealth in those who have control over capital due to its importance in the development process. Gradually, the increased inequality in the short run would decline when growth gains are redistributed back to the economy through welfare activities. Hence, the income disparity will be widened in the initial period but will subsequently normalise with increasing GDP per capita as in the case of the US during the high school movement. Germany also echoed the same sentiment.

Henceforward, the Kuznets hypothesis generates important deliberations with inconclusive outcomes. For instance, Rubin and Segal (2015) stated that in the US, the growth process has been accompanied by increases in income inequality over the periods of 1953–2008, where the high-income group received more wealth income and compensation as the economy expanded. Huang et al. (2015) continued to support the Kuznets paradigm in groups of 65 countries. Similarly, Younsi and Bechtini's (2020) findings supported an inverted U-shaped curve in six countries across different regions over the period of 25 years. The inverted U-shaped is further supported by studies focusing on China (Wu and Yao, 2015), Thailand (Paweenawat and McNown, 2014), and Africa (Meniago and Asongu, 2018).

A number of studies have provided evidence that contradicts the Kuznets hypothesis. Kim et al. (2011), and Frazer (2006), to name a few, discovered that the relationship between economic growth and income inequality was U-shaped rather than inverted. Perera and Lee (2013), on the other hand, found no support for Kuznets hypothesis in Asian countries over the 1985–2009 period.

These mixed findings call for further investigation, especially in two different spectrums. First, Tribble (1999) regarded economic growth–income inequality to capture two distinct structural transitions. These two specific transitions are graphically combined and form an S-shaped curve – an extension of the Kuznets curve. Sassen (1990) found that an increasing trend in income inequality over the past few decades in the US was attributed to an economic restructuring that emphasised on the shift away from manufacturing to service sector, which supports the findings by Tribble (1999) of the existence of an S-shaped curve. This transition involves middle-pay-range manufacturing jobs being replaced by a more diverse range of professions in the service industry. However, it was observed in previous studies (Bhattacharya, 2011; Dobson and Ramlogan-Dobson, 2012) that a disparity existed between the quality of jobs within the service sector, with bulk of the workers concentrated in less-skilled and low paying jobs as compared to highly-skilled and paid professions, ultimately leading to an increase in income inequality.

Afandi et al. (2017) further supported the positive relationship between economic growth and income inequality premised on growth contributed from the service sector that is capital intensive and requires specific skillsets (i.e., transport and communication). Based on the findings, the authors offered a few solutions to address technology disruption in the service sector aimed to reduce income inequality. Implementing a broad-based sharing system, for example, might be possible to employ substantially more individuals than previously. As a result, the distribution of income is expected to improve. This S-shaped curve hypothesis relating economic growth to inequality is also evidenced in a study by Yang and Greaney (2017) in South Korea, Japan, China, and the US for the 1960–2014 period. However, the starting points of the S-shaped curve for these four economies are not similar.

On the other hand, the second spectrum of literature examines the determinants that influence the economic growth–income inequalities. These determinants include a variety of economic drivers that are synchronised with the growth process and contribute to income inequalities indirectly (for details, see Njangang et al. (2021)). Many studies have addressed income inequality with respect to trade openness, foreign direct investment (FDI), education, and urbanisation. Despite continued efforts to study the determinants that may influence income disparity, the importance of ICT has been largely neglected.

The increasing importance of technology extends the economic growth–income inequality literature by including ICT as a potential determinant to bridge the gap of the omitted variables. To a certain extent, the influence of ICT on income inequality is more remarkable than other determinants, such as trade openness (Jaumotte et al., 2013). Furthermore, Liu and Lawell (2015) point out the importance of technological globalisation in shifting the paradigm of income inequality, particularly in developing countries.

Fundamentally, there are two schools of thought on the above statement. Aghion et al. (2019) explained that the upper-class income category/large companies – commonly referred to as the "rich" – are thought to reap the benefits first-hand (or get a larger share of the pie) from a technological development standpoint as they possess capital to leverage on advanced tools and machines to increase their production capacity and earn huge returns as a result. This is achieved at the expense of the lower income bracket groups, further widening the income disparity.

Van Reenen (2011) highlighted that technological development might increase income inequality, especially the wage gap. Xu et al. (2019) in their study – which examines the relationship between internet access and the number of patents filed in the US – noted that while ICT (measured by innovation) boosts economic growth, it widens income inequality in some regions of the world. Law et al. (2020) showed that ICT – measured through the number of patents granted – plays a significant role in worsening income inequality using panel data from 23 industrialised nations. According to Aghion et al. (2019), ICT promotes the percentage of income earned by entrepreneurs, resulting in increasing inequality. In summary, while the development of ICT creates many business opportunities, it is also a key factor making rich people richer.

Contrary to the above, Bukhari and Munir (2016) suggested that technological globalisation creates a knowledge spill-over effect from skilled to unskilled workers in the labour market, which in turn increases overall productivity levels. As a result, this caused a reduction in income inequality as ICT bridges the gap of mismatched skillsets. De Palo et al. (2018) also showed that implementing policies that encourage innovation will inevitably lead to a contraction of the income gap, with the focus being patenting innovation particularly among small companies.

Gerster and Zimmerman (2003) in their farming research found that improved farming methods, increased agricultural yields, and grass preservation were all aided by ICT via increased access to community radio programmes in Uganda. Muto and Yamano (2009) found that increased mobile phone usage among farmers enhances access to information and reduces marketing expenses in Uganda. The influence of mobile phone usage on Filipino farmers is examined by Labonne and Chase (2009). They discovered that possessing a mobile phone increased per capita consumption growth by 11-17%. The use of a mobile phone enabled farmers to obtain more and better information. As a result, they are able to price their products more competitively. According to Overa (2006), the use of mobile phones in Ghana lowers transportation and transaction expenses for businesses and contributes to trust building.

Recently, Canh et al. (2020) and Njangang et al. (2021) included ICT as a determinant of income inequality for a global sample of 87 economies and 45 developed and developing countries over the 2002-2014 and 2000-2017 period, respectively. Both studies conclude that technology diffusion is evidenced to be one of the paths to narrow income disparity.

Conversely, Ishida (2014) found that ICT investment shows no significant impact on economic growth in Japan. However, this should not be conclusive as there is a possibility of growth with input of labour and capital stock without a corresponding increase in energy consumption, hence the term "more output with the same energy".

In Malaysia, the evidence on economic growth and income inequality nexus is limited. Shari (2000) observed a negative relationship between economic growth and income inequality, whereas Sulaiman et al. (2017) found no support for the inverted U-shaped relationship. In addition, Sulaiman et al. (2017) tested and confirmed that education and FDI are shown to improve income inequality whereas trade openness widens the income disparity in Malaysia.

To the best of our knowledge, the existing studies include either inverted Kuznets curve or ICT usage, and none of them investigated both the cubic term and ICT in the economic growth–income inequality nexus.

METHODOLOGY AND DATA

Theoretical Model

This study investigates the existence of a second turning point (S-shaped curve) to the economic growth-income inequality relationship and the influence of ICT on income inequality through a well-known theoretical framework, namely the Kuznets curve.

The study first starts with the Kuznets curve theoretical model (Kuznets, 1955). The basic form of the Kuznets hypothesis suggests a quadratic relationship between income inequality and economic growth. A common specification along these lines is:

$$IE = f\ (Income,\ Income^2) \quad (1)$$

where IE is a measure of income inequality and Income represents economic growth. The coefficients of income level (Income) and its squared form ($Income^2$) are expected to have positive and negative signs, respectively, provided that the entire 'inverted U-shaped' is captured (Adam et al., 2015; Zhang and Ben Naceur, 2019).

Before we assess the existence of S-curve and the influence of ICT on income inequality as proposed in our objectives, we extend the basic model of Kuznets curve by including common control variables of income inequality suggested in the literature, namely trade openness (Trade) (Zhuang et al., 2014; Xiong, 2020) and foreign direct investment (FDI) (Reuveny and Li, 2003; Kaulihowa and Adjasib, 2018; Yang and Greaney, 2017). These two variables are considered as controls because of their importance as the stimulant for economic growth in Malaysia (Baharom et al., 2008; Idris et al., 2018). The equation (1) can then be extended into:

$$IE = f\ (Income,\ Income^2,\ Trade,\ FDI) \quad (2)$$

Trade openness (Trade) is a key determinant of income redistribution. In the standard trade theory, greater openness should boost relative demand and prices for unskilled labour, resulting in a better wage distribution in low-skilled labour-abundant countries. For industrialised countries with plenty of trained workers, on the other hand, this outcome should be reversed. However, the relationship between trade openness and income inequality remains a contentious issue in the literature. According to Zhuang et al. (2014), trade openness will boost the demand for skilled labour relative to the demand for unskilled labour in economies with abundant skilled workers, hence exacerbating income disparities. While Zhuang et al. (2014) find that trade openness has a positive influence on income inequality, Xiong (2020), Goh et al. (2021) conclude the opposite – trade openness has a negative effect on income inequality. As a result, we anticipate the sign to be either positive or negative.

Similar to trade openness, foreign direct investment (FDI) has also been recognised as one of the important determinants of income inequality. Reuveny and Li (2003) state that multinational companies (MNCs) via FDI promote unemployment among unskilled workers, distort income distribution, and hurt the poor. Various FDI theories have recently been formulated to explain the impact of FDI on income inequality. Kaulihowa and Adjasib (2018) and Yang and Greaney (2017) mention different processes, and the results of their predictions are mixed. The expected sign thus can be either positive or negative.

In line with the study by List and Gallet (1999) – which sees another rise in inequality due to the shift from manufacturing to the service sector (MTS) – we therefore include the cubic term of GDP per capita in the model to allow us to assess the second turning point to the economic growth-income inequality relationship as follows:

$$IE = f\ (Income,\ Income^2,\ Income^3,\ Trade,\ FDI) \quad (3)$$

where $Income^3$ is the cubic form of Income. The coefficients of Income, $Income^2$ and $Income^3$ are expected to be negative, positive, and negative, respectively, capturing the second turning point of the economic growth-income inequality relationship.

To investigate the influence of the ICT on income inequality, the equation (3) can be formulated as follows:

$$IE = f\ (Income,\ Income^2,\ Income^3,\ Trade,\ FDI,\ ICT) \quad (4)$$

Consistent with recent ICT literature (Canh et al., 2020; Njangang et al., 2021), this study uses three indicators to proxy ICT, namely, internet usage (Internet), mobile phone usage (Mobile), and fixed broadband usage (Broadband). These ICT variables are added one by one into equation (4) to avoid multicollinearity in our estimations.

Data

The sample data collected span from 1970 to 2018, a total of 49 years of observation. The dependent variable is income inequality (IE) and is measured by the Gini index. The indicator of economic growth (Income) is computed using the natural logarithm of real gross domestic product (GDP) per capita. Trade openness (Trade), which represents total exports and imports, is measured as a percentage of GDP. FDI is measured using FDI inflows ($ million) over GDP (World Bank, 2020). The percentage of individuals using the Internet to total population (Internet), the mobile cellular subscriptions (Mobile), and the fixed broadband subscriptions (Broadband) are collected to proxy the ICT.

Data on Gini index, GDP per capita, trade openness, foreign direct investment, and ICT (Internet, Mobile, Broadband) are collected from the World Bank's World Development Indicators (WDI).

Estimation Techniques

This study leveraged the Autoregressive Distributed Lag (ARDL) approach proposed by Pesaran et al. (2001) to estimate the relationship between economic growth and income inequality. The ARDL approach is selected with the premise of it being able to account for the extensive application of variables and depict ramifications from the estimates of the long-run model. This approach is a unique feat that has not been achieved under other cointegration procedures. Furthermore, the technique is reliable when the regressors are mutually cointegrated or portray $I(0)$, $I(1)$ order. In addition, the method proposed by Pesaran et al. (2001) is said to yield more significant results, mainly when small samples of the dataset are employed in the study. The ARDL approach's small sample properties are significantly superior to the Johansen and Juselius' cointegration technique (Pesaran and Shin, 1999). Another significant advantage of the ARDL approach is that it allows for estimate even when the explanatory variables are endogenous (Pesaran et al., 2001). Furthermore, in ARDL, short-run adjustments can be integrated with the long-run equilibrium by deriving the error correction mechanism (ECM) via a simple linear transformation without trailing long-run information.

Econometrically, the function in (4) can be detailed as:

$$\begin{aligned} IE_t = \alpha + \sum_{i=1}^{p} \beta_i IE_t & \\ + \sum_{i=0}^{q} \theta_i Income_t + \sum_{i=0}^{r} \delta_i Income_t^2 + \sum_{i=0}^{s} \gamma_i Income_t^3 & \\ + \sum_{i=0}^{t} \tau_i Trade_t + \sum_{i=0}^{u} \lambda_i FDI_t + \sum_{i=0}^{v} \vartheta_i ICT_t + \mu_t & \end{aligned} \tag{5}$$

The ARDL approach to cointegration is utilised to investigate the long-run relationship between these variables.

Equation (5) can be specified in an unrestricted error correction model as follows:

$$\begin{aligned} \Delta IE_t = \alpha_0 + \beta_1 IE_{t-1} + \theta_0 Income_{t-1} + \delta_0 Income_{t-1}^2 + \gamma_0 Income_{t-1}^3 + \tau_0 Trade_{t-1} + \lambda_0 FDI_{t-1} & \\ + \vartheta_0 ICT_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta IE_{t-i} & \\ + \sum_{i=0}^{q-1} \theta_i^* \Delta Income_{t-i} + \sum_{i=0}^{r-1} \delta_i^* \Delta Income_{t-i}^2 + \sum_{i=0}^{s-1} \gamma_i^* \Delta Income_{t-i}^3 & \\ + \sum_{i=0}^{t-1} \tau_i^* \Delta Trade_{i,t-i} + \sum_{i=0}^{u-1} \lambda_i^* \Delta FDI_{i,t-i} + \sum_{i=0}^{v-1} \vartheta_i^* \Delta ICT_{t-i} + \varepsilon_t & \end{aligned} \tag{6}$$

in which:

Δ	=	First difference operator;
t	=	year 1970 to 2018;
α_0	=	constant term;
$\theta_k, \delta_k, \gamma_k, \tau_k, \lambda_k, \vartheta_k$	=	slope coefficient; and
ε	=	residual term

The optimum lags selection was based on the Schwarz Bayesian Criterion (SBC). The hypothesis for the assessment of cointegration existence is shown as: H_0: $\theta_0 = \delta_0 = \gamma_0 = \tau_0 = \lambda_0 = \vartheta_0 = 0$ (there is no existence of cointegration between the variables). The F-statistics values obtained will be subject to the critical values provided by Narayan (2005), as the sample size was less than 100 observations. The upper represents the highest critical values amongst the given set and vice versa. If the calculated F-statistic is larger than the upper-tier critical value, H_0 is rejected.

After confirming the presence of cointegration among the variables, the short-run coefficients of Income, $Income^2$, $Income^3$, Trade, FDI, and ICT are given as $\sum \theta_i^*$, $\sum \delta_i^*$,$\sum \gamma_i^*$, $\sum \tau_i^*$,$\sum \lambda_i^*$ and $\sum \vartheta_i^*$respectively. The diagnostic tests on autocorrelation, heteroscedasticity, and normality of the residuals are performed to ensure the model's goodness of fit. Ramsey's RESET test is performed to ensure the functional form is specified correctly.

RESULTS AND DISCUSSIONS

Table 1 presents variables, definitions, descriptive statistics, and correlation matrix. In brief, we observe that the average income inequality (proxied by Gini index) is 46.6 with the highest value at 55.7 (1979) and lowest at 40.1 (2015), while the average income (GDP per capita) is USD6018.14 with the highest value of USD12,131.49 (2018) and lowest of USD1915.87 (1970). There are, on average, 22.94% individuals using the internet over the period 1970-2018. There are 11.9 million and 0.66 million mobile cellular and broadband subscriptions on average over the studied period. The ICT variables have a high degree of correlation. As a result, if all the variables are utilised simultaneously in the model, there is a high possibility of multicollinearity, which could lead to inaccurate inferences. To address this issue, each of these ICT variables is estimated separately in different model specifications.

Table 1 Definitions, descriptive statistics and correlation matrix

A: Definitions and Description

Variable	Definition	Mean	Std. Dev.	Min	Max
IE	Gini index of inequality which takes the value from 0 (perfect equality) to 100 (perfect inequality)	0.466	0.037	0.401	0.557
Income	GDP per capita (constant 2010 USD)	6,018.137	2927.641	1915.872	12131.493
Trade	Trade (% of GDP)	143.009	42.968	73.376	220.407
FDI	Foreign direct investment, net inflows (% of GDP)	3.718	1.716	0.057	8.760
Internet	Individuals using internet (% of population)	22.941	29.754	0.000	84.213
Mobile	mobile cellular subscription (million)	11.907	16.841	0.000	44.929
Broadband	fixed broadband subscription (million)	0.664	1.119	0.000	3.064

B: Correlation Matrix

	IE	Income	FDI	Trade	Internet	Mobile
IE	1.0000^{***}					
Income	-0.5527^{***}	1.0000				
Trade	-0.4876^{***}	0.4304^{***}	1.0000			
FDI	-0.0336^{*}	0.0385^{*}	0.2100^{**}	1.0000		
Internet	-0.7793^{***}	0.6240^{***}	0.2739^{**}	-0.1953^{**}	1.0000	
Mobile	-0.7865^{***}	0.5444^{***}	0.1334^{*}	-0.1607^{**}	0.9676^{***}	1.0000
Broadband	-0.7632^{***}	0.4845^{***}	0.0615^{*}	-0.1213^{**}	0.9146^{***}	0.9811^{***}

Note: *** and ** denote significant at 1% and 5% respectively.

Source: World Development Indicators (WDIs), World Bank.

As shown in Table 2, the unit root tests deduced that all variables are not stationary at levels. However, after first differencing, all variables became stationary at 1% significance level. Our results imply that all variables present are integrated at first order *I*(1), confirming its eligibility to leverage the ARDL bounds testing approach, which also runs its course at *I*(0).

Table 2 Unit Root Tests Results

Variable	ADF (Intercept and Trend)		PP (Intercept and Trend)	
	Level	First Difference	Level	First Difference
IE	-2.4426	-4.7312***	-1.9955	-4.5082***
Income	-2.5859	-6.0959***	-2.6802	-6.0978***
Trade	0.0758	-5.3371***	-0.1054	-5.3030***
FDI	-3.5316	-7.8197***	-3.5316	-8.4078***
Internet	-1.9785	-4.1364**	-2.1115	-4.0895**
Mobile	-2.0468	-3.7782**	-1.9902	-3.8254**
Broadband	-1.4692	-5.4519***	-1.6338	-5.6251***

Note: *** and ** denote significant at 1% and 5% respectively.

The ARDL models were derived through the OLS estimation and the error correction model techniques. Model (1) is the baseline specification, while models (2) to (4) focus on investigating the impact of ICT on income inequality. The maximum lag length used in this study is four due to sampling size restrictions if an increase in lag length is considered.

The F-statistics were computed and compared to the Upper *I*(1) and Lower *I*(0) critical values to assess and make a hypothetical decision. Given that the total observation of this study is well below 100, the underlying variables in equation (6) will be cointegrated if the calculated F-statistics are more significant than the upper bound critical value *I*(1) provided by Narayan (2005). Based on the bounds test shown in Table 3, it may be said with certainty that there is cointegration between variables of this endeavour at 1% significance level where the F-statistic for each model specification exceeds the upper bound critical values *I*(1). Henceforth, it can also be summarised that there exists a long-run correlation between the variables.

Table 3 Bound tests for cointegration

Model	F-statistics	Significance level	Bounds test critical values	
			I(0)	*I*(1)
			k=5	
1: Baseline (IE |Income, $Income^2$, $Income^3$, Trade, FDI)	6.3984	1%	3.674	5.019
		5%	2.694	3.829
		10%	2.276	3.297
			k = 6	
2: Internet (IE |Income, $Income^2$, $Income^3$, Trade, FDI, Internet)	8.9825	1%	3.540	4.931
		5%	2.591	3.766
		10%	2.188	3.254
			k = 6	
3: Mobile (IE |Income, $Income^2$, $Income^3$, Trade, FDI, Mobile)	9.4407	1%	3.540	4.931
		5%	2.591	3.766
		10%	2.188	3.254
			k = 6	
4: Broadband (IE |Income, $Income^2$, $Income^3$, Trade, FDI, Broadband)	7.7753	1%	3.540	4.931
		5%	2.591	3.766
		10%	2.188	3.254

Note: The test statistics of the cointegration tests were compared against the critical values reported n Narayan et al. (2005) for samples of less than 100 observations.

The long- and short-run estimations of the ARDL model are presented in Table 4 with several diagnostic test statistics. For the convenience of comparison, the estimated results for all model specifications are as summarised in Table 4. In the long run, among the key determinants that we are interested in investigating, it may be deduced that the cubic relationship between economic growth (Income) and income inequality (IE) speaks volumes statistically. More specifically, the coefficients of Income, $Income^2$, and $Income^3$ are shown to be statistically significant at a 5% significance level for all four model specifications. In other words, due to the significant coefficient depicted in $Income^3$, it may be further implied that there is an extension (second turning point) of the U-shaped curve.

Our results from these model specifications indicate a negative correlation between economic growth and income inequality, where the initial stages of economic development and low-income levels will decrease income inequality. As the Malaysian economy continues to enjoy persisting growth attributed to a boom in the manufacturing sector, the opposite occurred where the nation experiences a hike in income inequality. This echoed the first turning point, signifying a U-shaped curve as observed in both Income and Income^2 coefficients. Contradictory to that, the second turning point depicts a negative correlation between economic growth and inequality. In other words, the income gap began to contract when the transition from manufacturing to services sector occurred. In summary, the findings are proven to be unique in Malaysia where the differences in expected outcome could be further explained by the historical significance and current issues of the nation supported by the literature.

In addition to investigating the nonlinear impacts of economic growth on income inequality, our study also investigates the influence of ICT (proxy of internet, mobile, and broadband) on income inequality (IE). The results presented in Models 2-4 of Table 4 reveal the findings when internet, mobile, and broadband usage are being included as one of the determinants of income inequality, respectively. Our analysis shows that the use of the internet, mobile, and broadband has a significant negative impact on income inequality in the long run. This finding is shown to be consistent with a recent study by Canh et al. (2020) and Njangang et al. (2021) – in which the technology diffusion is evidenced to be a path of narrowing income disparity for a global sample of 87 economies and 45 developed and developing countries over the 2002-2014 and the 2000-2017 periods, respectively. The contribution of technology in reducing inequality, as explained earlier, is that the internet allows skilled workers to be more productive than before (Akerman et al., 2015). Therefore, if users are given the right training to improve their technological skills, productivity will increase (Economist, 2019). From the socioeconomic perspective, the use of the internet and mobile phone provides new economic opportunities not only for skilled but also for non- or low-skilled workers. Income inequality might be reduced as the use of the internet and mobile phone offers new opportunities for economic activities based on innovation (Feldman, 2002) and entrepreneurship (Madon, 2000). The Government of Malaysia has recently undertaken several initiatives to alleviate income inequality in their recent budget. More specifically, the government's allocation of RM30 million to provide internet access to 40 low-cost housing schemes and RM700 million towards ensuring digital connectivity in 47 industrial areas and 630 schools in rural area is a true testament of their efforts to reduce the existing rural-urban income disparity.

Table 4 ARDL Results

Optimal Lag	Model 1 - baseline ARDL (2,1,1,0,1,0)	Model 2 - Internet ARDL (2,1,0,0,0,1,0)	Model 3 - Mobile ARDL (2,0,1,1,1,0,0)	Model 4 - Broadband ARDL (2,1,0,0,0,0,1)
Long-run coefficients				
Income	-0.5888^{**}	-0.5862^{***}	-0.5695^{**}	-0.6350^{***}
Income^2	0.1526^{**}	0.1536^{***}	0.1455^{**}	0.1634^{***}
Income^3	-0.0013^{*}	-0.0135^{***}	-0.0124^{***}	-0.0140^{***}
Trade	0.0317^{*}	0.0372^{***}	0.0089	-0.0160
FDI	0.0659^{*}	0.1829^{***}	0.0242	0.0615^{**}
Internet	-	-0.0011^{***}	-	-
Mobile	-	-	-0.0015^{*}	-
Broadband	-	-	-	-0.0259^{***}
Short-run coefficients				
ECT_{t-1}	-0.5123^{***}	-0.5439^{***}	-0.4823^{***}	-0.5982^{***}
Income	-0.2760^{*}	-0.3169^{***}	-0.2747^{**}	-0.3430^{**}
Income^2	0.0749^{*}	0.0835^{***}	0.0741^{**}	0.0929^{***}
Income^3	-0.0068^{*}	-0.0073^{***}	-0.0066^{**}	-0.0084^{***}
Trade	-0.0056	0.0202^{***}	-0.0159	-0.0096
FDI	0.0338^{*}	0.0093	0.0117	0.0368^{**}
Internet	-	-0.0006^{***}	-	-
Mobile	-	-	-0.0007^{**}	-
Broadband	-	-	-	-0.0014
Diagnostic test				
R^2	0.9760	0.9791	0.9789	0.9821
Adjusted R^2	0.9683	0.9726	0.9718	0.9761
Serial Correlation (χ^2)	0.3800 [0.8270]	0.7957 [0.6718]	0.1949 [0.9071]	1.7794 [0.4108]
Heteroscedasticity (χ^2)	11.2558 [0.3379]	15.4708 [0.1158]	11.8289 [0.3766]	12.6800 [0.3148]
Normality (χ^2)	3.0191 [0.2211]	0.5580 [0.7566]	3.3919 [0.1400]	1.3164 [0.5178]
Ramsey RESET (F)	1.3331[0.2574]	0.1608 [0.6912]	2.2472 [0.1428]	0.4807 [0.4931]

Note: ***, ** and * denote statistically significant at 1%, 5% and 10% level respectively. The optimum lags are selected based on Schwarz Information Criteria.

In all our estimated ARDL models, the diagnostic test statistics indicate no serial correlation, normality, and heteroskedasticity. The insignificance of the Ramsey RESET test statistics also implies no evidence of parameter instability on the model. Lastly, diagnostic test results obtained from the Breusch–Godfrey Serial Correlation LM test confirmed that the ECM models were free from serial correlation. According to the CUSUM and CUSUM square (Figures 1-4), the statistics were within the 5% confidence interval bands. As a result, there was no structural instability in the residuals of the estimations, ensuring the model's policy simulations are reliable.

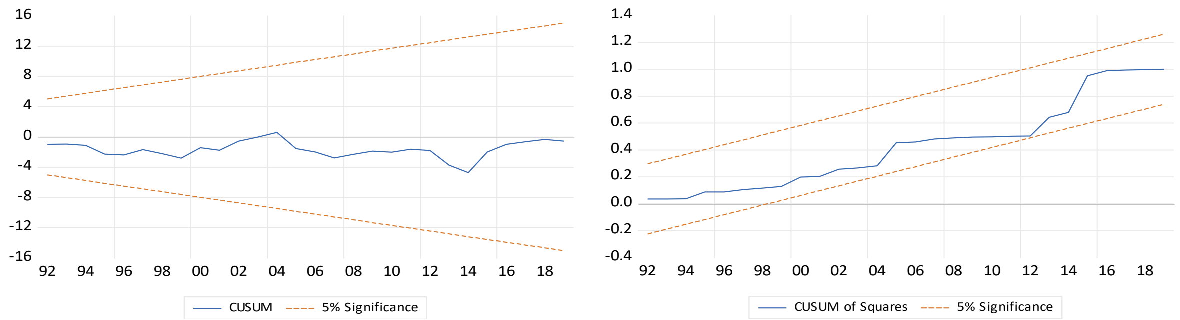

Figure 1 CUSUM and CUSUM^2 Test for Model 1 – Baseline

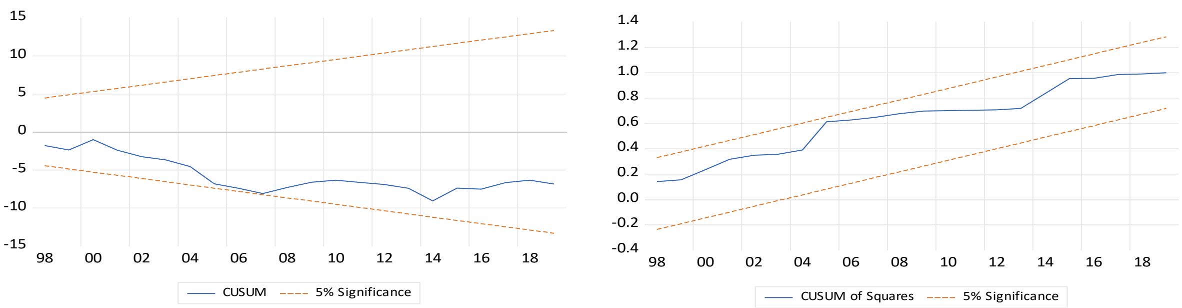

Figure 2 CUSUM and CUSUM^2 Test for Model 2 – Internet

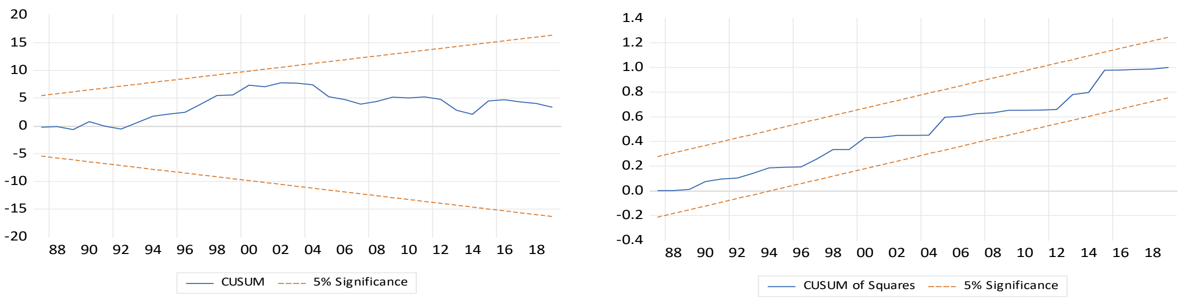

Figure 3 CUSUM and CUSUM^2 Test for Model 3 – Mobile

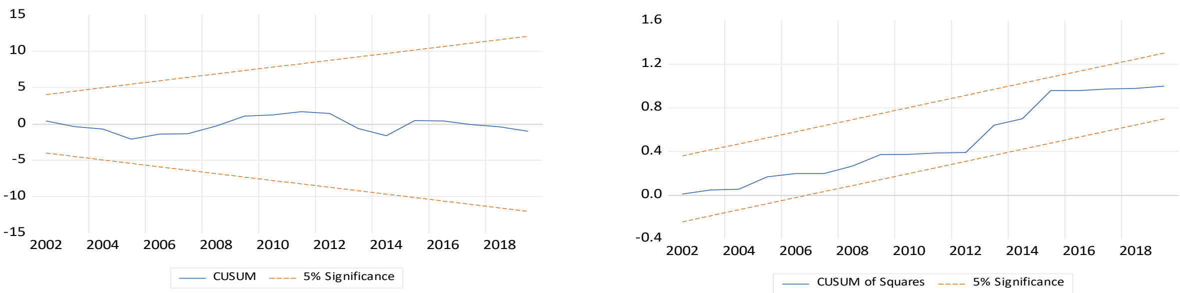

Figure 4 CUSUM and CUSUM^2 Test for Model 4 – Broadband

In addition to the long-run estimates, Table 4 also reports the short-run estimates. It is worth noting that although different model specifications are considered, the dynamic adjustment coefficients of ECM are shown to be negative and statistically significant for each model specification. As for the short-run effect estimated in the ECM regression, the changes of Income and Income^3 negatively impact income inequality, whereas the change of Income^2 positively impacts inequality, consistent with the long run estimation. The short-run coefficients of ICT, i.e., the internet, mobile, and broadband, are all negative. However, only the internet and mobile coefficients are statistically significant at 5% level.

The evidence we obtained – in which ICT is revealed to have a negative and significant impact on income inequality, be it in the short- or long-run – implies the crucial role of the internet, mobile, and broadband in closing our society's income inequalities gap. More importantly, the magnitudes of the long-run coefficients for the use of the internet, mobile, and broadband are much more prominent than their short-run effects. This shows the growing importance of ICT in the nation's policies directing at improving income inequalities. As Hargittai and Shaw (2015) stated, the use of the internet and mobile phone improves the ways of boosting business opportunities and narrows workers' skill gaps, contributing to narrowing income inequalities gap.

CONCLUSIONS

This study aims to re-examine the existence of a Kuznets curve by analysing the nonlinear impacts of economic growth on income inequality and by extending the analysis to parameters capturing the influence of ICT (e.g., internet, mobile, and broadband subscription). Our model specification is estimated based on the ARDL approach using annual data covering the sample period from 1970 to 2018.

Not many studies were performed along similar lines to the above in a country such as Malaysia, which has undergone tremendous transformation in an economic sense through sectoral shifts coupled with economic growth and income inequality. In addition, ICT was added as a determinant in the study to assess the influence and the role of technology in reducing income inequality.

Malaysia is shown to have experienced the S-shaped curve in its economic development process, as evidenced by our research. This clearly shows that throughout the development process, Malaysia has the potential to experience both positive and negative causal linkages between growth and inequality. In addition to that, our findings show that ICT (internet, mobile, and broadband use) should be part of a proactive economic policy aimed at eliminating income inequalities. This is reinforced by the government's Budget 2022 allocation to drive the ICT industry forward through collaborations with digital partners such as Malaysia Digital Economy Corporation, to empower the nation with digital skills, enabling digitally powered businesses, and driving digital sector investments that may attract FDI inflows and trade opportunities.

Malaysia will have to revisit its policy measures such as addressing the rural-urban gap by providing wider internet connectivity in rural areas, fostering champions of tech education for upscaling needs to efficiently integrate ICT to benefit the society as a whole, which leads to a more equal income distribution.

The Malaysian Government should not resort to short-term solutions like creating a dependence on cash handouts for a long-term problem such as income inequality. Instead, it is advisable for the Government to create a window for self-sustaining purposes through providing avenues for individuals/companies to flourish. With respect to ICT, a great example would be to revive the SMEs, which account for approximately 40% of the Malaysian GDP, by equipping them with the right ICT skillsets coupled with cost saving strategies to ease business processes and maximise returns.

Furthermore, the government should look to implement tax reliefs specifically on ICT-related products and activities. This initiative echoes the study conducted by Shahbaz (2010), which stated that tax cuts were well received and would encourage economic activity and gradually maintain high growth rates, a step that could see more businesses flourish and more households having the ability to satisfy their basic needs as compared to a mere quick fix.

Therefore, a holistic policy that combines economic (trade openness, FDI inflows), education, and technological factors may have the potential to reduce income inequalities in Malaysia.

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