Information-Communication Technology and Economic Growth in Malaysia

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Abstract: This paper examines the relationship between information and communication technology (*ICT*) and economic growth in Malaysia in two periods (1960–1982 and 1983–2004) to see how the contribution of *ICT* investment varied in the two periods. The results show that for the period 1960–1982, economic growth led to growth in *ICT* investment in Malaysia; in the second period 1983–2004, it was the other way around: *ICT* investment led to economic growth in Malaysia. This could be explained by the major economic structural change that took place during the second period, which is largely attributable to the various industrialization strategies and technology policies implemented in the country. In this period, *ICT* investment had a positive and significant impact on Malaysia's economic growth; indeed, it was the major source for the Malaysian economy experiencing increasing returns to scale in the second period.

I. Introduction

Over the last four decades, developments in information and communication technology (*ICT*) have transformed the global economic landscape. The benefits of *ICT* include cheaper and higher quality of communication; easier access to information and wider market reach; reduction of red-tape and corruption; and closer collaboration among all economic agents in the economy.

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Several empirical studies have shown that the benefits of *ICT* have powered the productivity and economic performance of developed nations over the last four decades. Lau and Tokutsu (1992) examined the relationship between *ICT* and economic growth in the US over the period 1960 to 1990 using the production function approach. They found that *ICT* had contributed to nearly half of the national output during the study period. Other key empirical studies showing similar results for the US include Oliner and Sichel (2000), Jorgenson and Stiroh (2000) and Stiroh (2002).

Kraemer and Dedrick (1993) examined the impact of *ICT* on economic growth in 11 Asia Pacific countries for the period 1983 to 1990. They found that there was a significant and positive relationship between *ICT* and economic growth. Niininen (1998) estimated the contribution of *ICT* to Finland's economic growth over the period 1983 to 1996 using the growth accounting framework. In this study, the author decomposed economic growth into capital, labour and multifactor productivity. The study also examined the impact of *ICT* (that is, computer hardware, software and computer labour) on economic growth. The empirical results showed that *ICT* had contributed significantly to the economic growth of Finland.

Daveri (2000) examined the contribution of *ICT* to economic growth in eleven OECD countries. Using the growth accounting framework, Daveri found that *ICT* contributed significantly to economic growth of most OECD countries, especially during the mid 1990s. Oulton (2001), using the same methodology, examined the contribution of *ICT* to economic growth in the UK over the years 1989–1998. The *ICT* capital in this study included computers, software, telecommunications equipments and semiconductors. The empirical results showed that *ICT* had significantly contributed to economic growth in the UK, especially from 1994 to 1998.

Colecchia and Schreyer (2002) estimated the contribution of *ICT* to output growth in nine OECD countries over the period of 1980 to 2000. The empirical results showed that *ICT* contributed between 20% and 50% of the national output growth over the study period in most countries. This increased to 30% – 90% per annum in the mid 1990s. Piatkowski (2003) investigated the impact of *ICT* on economic growth in Poland over the period 1995 to 2000 using the growth accounting framework. This study found that *ICT* investment had contributed nearly 9% of Poland's economic growth during the sample period. The study also found that the increase in *ICT* investment from 1993 to 2001 was due to declining prices in *ICT* products and services. A similar study by Mas and Quesada (2005) showed that *ICT* investment enhanced the economic performance of Spain from 1985 to 2002.

While there have been several studies of the relationship between *ICT* and economic performance for developed countries, the number of similar studies for Islamic economies has been limited. The primary objective of this paper is to examine empirically the relationship between *ICT* investment and economic output in an Islamic country, namely Malaysia.

From 1982 onwards, under the leadership of the then Prime Minister, Tun Dr. Mahathir Mohammad, major macroeconomic policies were put in place to transform Malaysia from an agrarian economy to a more technology-intensive economy. In this study we will assess whether these policy measures were able to transform the architecture of the Malaysian economy and to what extent statistically. To study the structural changes in the Malaysian economy, the Auto-Regressive Distributed Lagged (*ARDL*) model (Pesaran *et al*., 2001) was used to assess the relationship between *ICT* and real gross domestic product (*RGDP*) for the periods 1960–1982 and 1983–2004.

The *ARDL* model used here has two major advantages over traditional error correction models such as the Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1990). First, the Pesaran *et al.* framework allows for the explanatory variables to be either stationary and/or non-stationary (that is, series with order of integration zero or one). Second, the cointegration test called the bounds test proposed by Pesaran *et al.* (2001) is super-consistent, that is, it is robust for small sample studies such as the present one.

The next section gives a brief review of the Malaysian economy. Section 3 of the paper discusses the econometric methodology used. Section 4 presents the empirical results, and Section 5 presents a summary and brief, concluding observations.

II. *ICT* Development in Malaysia: An Overview

Malaysia attained independence in 1957 and in the 1960s the agriculture sector was the main contributor to the economy. Many of the socioeconomic development polices in the 1960s and 1970s were catered towards developing basic infrastructure and rural development. After the racial riots in 1969, the New Economic Policy was formulated to eradicate poverty and eliminate racial segregation based on socioeconomic function and geography.

In June 1981, Dr. Mahathir Mohammad became the country's fourth Prime Minister. Under his leadership 'Vision 2020' was formulated to help transform Malaysia into a knowledge-driven society. Various macroeconomic policies were put in place to realize Vision 2020. Incentives were provided to foreign enterprises to set up manufacturing plants and industries in Malaysia. By the early 1990s, Malaysia had become the leading producer of electrical and electronics components outside the US and Japan.

Under Dr. Mahathir's leadership there was a major push to transform Malaysia into an industrial power-house. The Second Industrial Master Plan was launched with *ICT* playing a major role in the transformation of the economy. Informatization of the economy was seen as a key step to becoming an industry-based economy. The National Information Technology Agenda (*NICTA*) was formulated in 1996 with the following strategic objectives: development of people, infostructure and applications. *NICTA* was seen as an important driver for the diffusion, adoption and integration of *ICT* in all sectors of the economy.

The Multimedia Super Corridor (*MSC*) was one of the major initiatives under *NICTA*. The *MSC* was expected to catapult the nation into an informatized society. The *MSC* initiative was the country's largest infrastructure project to date, costing close to US$19 billion. The geographical area of the *MSC* is 800 square kilometers, which includes two new cities called Putrajaya and Cyberjaya. Putrajaya is the new administrative capital of Malaysia ('a paperless' government city) and Cyberjaya was the test-bed for new-generation multimedia and *ICT* technologies. The *MSC* roll-out was planned in three phases. In the first phase (1995–2003) various fiscal and non-fiscal incentives were provided to attract leading foreign *ICT* enterprises to the country to develop new-generation *ICT* products and services. Collaboration between these foreign *ICT* companies and local *ICT* firms was expected to enhance technology transfer between foreign and local enterprises. In the second phase (2003–2010), the *MSC* initiative was to expand to other major cities. In the third phase (2010–2020), the *MSC* environment is expected to spread across the whole nation.

To increase the quality of the *ICT* services in the country, the state-owned telecommunication provider, Telekom Malaysia was privatized. The government also liberalized the mobile phone market and the Internet industry. There were five new entrants in the mid 1990s. This increased competition in the *ICT* sector, reducing prices and increasing service quality. In the late 1990s and early 2000, *ICT* connectivity in rural communities was intensified. In 2000, 33 pilot community-based Internet centres were developed nationwide and of these twelve *ICT* community centers were in rural areas (EPU, 2001). Rural schools were connected to the Internet using Very Small Aperture Terminal (*VSAT*) and wireless loop technology.

Besides the *ICT* infrastructure investment, the Malaysian government also increased investment in education and training, especially in the *ICT* area. This was to ensure that future Malaysians would be *ICT*-savvy. To increase manpower and innovation in the *ICT* area, in 1996, a university focused in *ICT* and multimedia called the Multimedia University was established in the *MSC* area (Cyberjaya).

In sum, the Malaysia economy over the last 42 years has undergone major structural changes – transforming from an agriculture-based economy (1960–1982) to an industrial and manufacturing power-house (1983–2004). Much of the transformation was a result of government-driven policy initiatives. Large investments in *ICT* infrastructure, human capital and innovation were seen as vital for the nation to raise its competitiveness and catch-up with more developed countries.

In the next section, we will empirically examine whether the *ICT* policies and strategies implemented from 1983 to 2004 have resulted in a structural shift in the Malaysian economy.

III. Methodology

To ascertain the relationship between *ICT* investment and economic development, we first have to determine the direction of causality between *ICT* investment and economic growth in Malaysia. In this paper, the direction of causality between *ICT* investment and economic output or real gross domestic product (*RGDP*) will be conducted using the Granger causality test. If *ICT* investment is a function of *RGDP*, then the model will be specified as:

$$ICT_t = f(RGDP_t, NICT_t, L_t) + u_t \qquad (1)$$

where at period t, ICT_t is *ICT* investment; $RGDP_t$ is the real gross domestic product; $NICT_t$ is non-*ICT* investment, and L_t is labour employed in Malaysia. In model (1), the *RGDP* 'Granger-Cause' *ICT* ($RGDP \overset{GC}{\rightarrow} ICT$). In this case, the economic output of a country plays a key role in enhancing *ICT* development in the country.

On the other hand, suppose *RGDP* is a function of *ICT* investment, then the model is specified as follows:

$$RGDP_t = g\left(ICT_t,\ NICT_t,\ L_t\right) + v_t \tag{2}$$

In model (2), *ICT* 'Granger-Cause' *RGDP* $(ICT \overset{GC}{\to} RGDP)$. In this case, *ICT* investment plays a key role in economic output of the country. The causality test for $(RGDP \overset{GC}{\to} ICT)$ involves estimating the following *VAR* (Vector Autoregression) model:

$$ICT_t = \sum_{i=1}^{p} \xi_i ICT_{t-i} + \sum_{i=1}^{q} \zeta_i RGDP_{t-i} + \sum_{i=1}^{r} \lambda_i NICT_{t-i} + \sum_{i=1}^{s} \delta_i L_{t-i} + u_t \tag{3}$$

and testing the following null hypothesis $H_O : \zeta_1 = \ldots = \zeta_q = 0$.

If we wish to test, $(ICT \overset{GC}{\to} RGDP)$ then we estimate the following VAR model:

$$RGDP_t = \sum_{i=1}^{p} \gamma_i RGDP_{t-i} + \sum_{i=1}^{q} \theta_i ICT_{t-i} + \sum_{i=1}^{r} \tau_i NICT_{t-i} + \sum_{i=1}^{s} \eta_i L_{t-i} + v_t \tag{4}$$

and test the following null hypothesis $H_O : \theta_1 = \ldots = \theta_q = 0$.

Engle and Granger (1987) have argued that estimation of (1) and (2) using ordinary least square (*OLS*) may lead to spurious result if the variables in the models are non-stationary. The stationarity properties (unit roots) of the time series were investigated using the Phillip-Perron test (*PP*-test). If the variables are non-stationary, then the Auto-Regressive Distributed Lag (*ARDL*) framework (Pesaran *et al.* 2001) will be used to examine the relationship between *ICT* investment and economic growth. The *ARDL* (*p*, **q**) version of (1) is as follows:

$$\Delta ICT_t = \alpha_0 + \alpha_1 t + \varphi ICT_{t-1} + \psi \mathbf{x}_{t-1} + \sum_{j=1}^{p-1} \beta_{y,j} \Delta ICT_{t-j} + \sum_{j=1}^{q-1} \beta_{\mathbf{x},j} \Delta \mathbf{x}_{t-j} + \omega \Delta \mathbf{x}_t + u_t \tag{5}$$

where, Δ is the first-difference operator, the matrix $\mathbf{x}_{t-j} = [RGDP_{t-j},\ NICT_{t-j},\ L_{t-j}]'$. The long-run coefficient is $-\frac{\psi}{\varphi}$. The short-run information is given in the βs. On the other hand, the *ARDL* (*p*, **q**) version of (2) is as follows:

$$\Delta RGDP_t = \alpha_0^* + \alpha_1^* t + \varphi^* RGDP_{t-1} + \psi^* \mathbf{x}_{t-1}^* + \sum_{j=1}^{p-1} \beta_{y,j}^* \Delta RGDP_{t-j} + \sum_{j=1}^{q-1} \beta_{\mathbf{x},j}^* \Delta \mathbf{x}_{t-j}^* + \omega^* \Delta \mathbf{x}_t^* + v_t \tag{6}$$

where $\mathbf{x}_{t-j}^* = [ICT_{t-j},\ NICT_{t-j},\ L_{t-j}]'$. The long-run coefficient is $-\frac{\psi^*}{\varphi^*}$.

The short-run information is given in β^*s. To determine the optimal lag length for model (5) and model (6), the Akaike Information Criterion (*AIC*) was used.

In order to test the existence of a long-run relationship between the dependent and independent variables, the bounds test proposed by Pesaran *et al.* (2001) is used. The test is similar to the Wald-type test for coefficient test. In the case of the *ARDL* model in (5), the test will show no cointegration relationship under the null hypothesis $H_0 : \varphi = \psi = 0$. In the case of the *ARDL* model in (6), there is no cointegration relationship under the null hypothesis $H_0 : \varphi^* = \psi^* = 0$.

The *F-test* has a non-standard distribution and the critical bounds (Upper and Lower bound values) for the test were taken from the tables given in Pesaran *et al.* (2001). If the computed *F* statistics are above the Upper Critical Bound, there is cointegration relationship between the variables in the model. If the computed *F* statistics are below the Lower Critical Bound, then there is no cointegration relationship. Alternatively, if the computed *F* statistics are between the Lower and Upper Critical Bound, then a conclusive inference cannot be made without examining the order of integration of each of the variables.

Once the optimal *ARDL* model is chosen, various diagnostic tests are conducted to ensure that the residuals of the models satisfy the standard regularity conditions. This involves the Lagrange Multiplier test for serial correlation, White's test for heteroskedastic, the Auto-regressive conditional heteroskedastic (*ARCH-LM*) test and the Jarque-Bera test for normality of the residuals. Finally, we test the model specification using the Ramsey *RESET* test.

To compute the *ICT* investment for the sample period, 13 *ICT* based products were summed. The components of *ICT* were identified based on the classification of the Malaysian Standard Industrial Classification (MSIC) 2000 (see Table 1). The non-*ICT* investment data comprised investment made in land and buildings, administration, health, economic services, education and transportation services. Data on labour employed and real GDP were obtained from the *DXEcon Database* (available at Monash University, Malaysia). Also, data on *ICT* investment and non-*ICT* investment were compiled from various published government reports available from the Malaysian Department of Statistics. Except for the labour-employed variable (denoted in millions of workers), the other variables are denoted in Malaysian Ringgit (in millions) at current price.

Table 1: ICT Investment Products Classification MSIC 2000

Commodity Division (MSIC 2000 Classification)	Industry/Product Description
75	Office machinery and automatic data processing equipment.
76	Telecommunication, sound recording, reproducing equipment
751	Office machines
752	Automatic data processing machines
759	Parts and accessories for other automatic machines
761	Television receivers
762	Radio broadcast receivers
763	Gramophones, dictating machines, sound recorders
764	Telecommunication equipments and parts
771	Electrical power machinery and parts
772	Electrical apparatus, resistors and switchboards
773	Equipment for distributing electricity
774	Electro medical and radiological apparatus

Source: ICT Survey Report (2003)

In this study, we test if the data generation process is significantly different in the following periods 1960–1982 and 1983–2004. As mentioned earlier, in the period 1960–1982, the Malaysian economy was dependent on the agriculture sector. From 1983 onwards, under the leadership of Prime Minister Dr. Mahathir, there were major policy initiatives to increase the diffusion of new technology, especially *ICT*, in the Malaysian economy. Investment patterns in the two sample periods are significantly different (refer to Figure 1). In this study, we are interested in assessing whether the *ICT* investment patterns in the latter period have changed the underlying structure of the Malaysian economy (output).

IV. Empirical Results

In this section, we report the empirical results for the two sample periods (1960–1982 and 1983–2004).

4.1 Unit Root Test

Table 2 provides the results of the unit root test using the *PP* test. The result shows that *RGDP*, *ICT* and *NICT* are non-stationary, that is, integrated of order one *I*(1), while, *L* is a stationary series.

Table 2: Phillip-Perron Unit Root Test

Factor	Level	1st Difference	Order of Integration
RGDP	1.380	-5.912 *	*I* (1)
ICT	3.476	-4.047 *	*I* (1)
NICT	1.202	-3.328 **	*I* (1)
L	-2.105 *		*I* (0)

Notes: (1) '*', '**', '***' refer to statistical significance at 1 %, 5% and 10% level, respectively. (2) All tests were conducted with trends and intercept.

4.2 Granger causality test

The Granger Causality test was used to assess the direction of causality between *ICT* and economic growth in the two sample periods. Table 3, with the results for Granger causality for these periods, shows that in the sample period 1960 – 1982, RGDP Granger causes *ICT* at 10 % significance level ($RGDP \overset{GC}{\rightarrow} ICT$). More precisely, growth in the Malaysian economy led to higher *ICT* investment over the period 1960–1982. This result is not surprising because during this period the *ICT* infrastructures were basic and a large segment of the population did not have access to the new technology. As such the *ICT* infrastructure was financed by the government.

In the sample period 1983–2004, *ICT* Granger causes *RGDP* at 10% significance level ($ICT \overset{GC}{\rightarrow} RGDP$). During this period, Malaysia's economic growth was significantly influenced by the growth in *ICT* investment. This is because there was greater diffusion of the new technology to a wider segment of the population and to the industrial sector of economy. Increased *ICT* infrastructure investment coupled with greater investment in human capital led to greater efficiency gains in the economy, resulting in higher economic growth.

Table 3: Granger Causality Test

	Period 1960 – 1982		Period 1983 – 2004	
Ho	*F-Statistic*	*P-value*	*F-Statistic*	*P-value*
ICT does not *GC* GDP	1.02	0.44	4.33	0.06 ***
GDP does not *GC* ICT	3.21	0.06 ***	0.69	0.65

Note: ' ***' denotes statistical significance at 10% level.

4.3 The *ARDL* Estimation

The results from the Granger causality test showed *ICT* and *RGDP* as the dependent variables in the sample periods 1960–1982 and 1983–2004, respectively. In order to select the appropriate model, the *ARDL*[*p, q*] in (5) and (6) were estimated using the following lag lengths (*p*, *q*) = {1,2, and 3}. Lag length more than 3 was not used due to loss in the degree of freedom. The optimal lag structure for the model (5) and (6) were chosen based on *AIC*. The optimal model for (5) and (6) are ARDL [1,2,2,2] and *ARDL* [2,1,2,1], respectively. The estimated models for (5) and (6) are reported in Table 4. The diagnostic analysis for (5) and (6) shows that the residuals satisfied the standard regularity conditions. The Ramsey *RESET* test showed that the models in (5) and (6) were correctly specified.

Table 4: The ARDL Estimation and Diagnostic Analysis Results in Both Sample Periods

Sample period 1960 – 1982: Dependent Variable: ICT			Sample period 1983 – 2004: Dependent Variable: RGDP		
Variables	**Coefficients**	**t-stats**	**Variables**	**Coefficients**	**t-stats**
Constant	402.995	1.714	Constant	283.483	1.234
Δ *ICT* (-1)	0.957	2.903 **	Δ *RGDP* (-1)	-0.572	-1.428
Δ *RGDP* (-1)	0.229	0.937	Δ *RGDP* (-2)	-0.756	-2.518 **
Δ *RGDP* (-2)	0.294	1.426	Δ *ICT* (-1)	0.002	0.006
Δ *NICT* (-1)	-1.803	-1.681	Δ *NICT* (-1)	0.73	3.032 **
Δ *NICT* (-2)	0.766	-1.288	Δ *NICT* (-2)	1.125	4.368 *
Δ *L* (-1)	33.051	1.854	Δ *L* (-1)	5.025	0.593
Δ *L* (-2)	24.005	1.583			
Diagnostic Analysis			**Diagnostic Analysis**		
R-Squared	0.859		R-Squared	0.901	
Residual sum of squares	0.029		Residual sum of squares	0.011	
Akaike Info. Criterion	21.066		Akaike Info. Criterion	24.924	
Durbin-Watson	2.607		Durbin-Watson	2.401	
F-statistic	3.070 [0.089]		F-statistic	5.016 [0.03]	
Jarque Bera	0.038 [0.981]		Jarque Bera	0.687 [0.709]	
LM test	5.282 [0.122]		LM test	1.522 [0.217]	
White's Heteroskedasticity	14.824 [0.537]		White's Heteroskedasticity	18.965 [0.27]	
ARCH	5.615 [0.690]		ARCH	5.525 [0.70]	
Ramsey RESET	2.367 [0.124]		Ramsey RESET	5.360 [0.121]	

Notes: '*' and '**' stands for statistical significance at the 1% and 5% significance level respectively. The *p*-value is given in the parentheses.

4.4 Cointegration Test

Once the optimal *ARDL* models were ascertained, we examined whether the dependent factor (*ICT* for period 1960–1982 and *RGDP* for period 1983–2004) is cointegrated with the explanatory variables. The results are reported in Table 5. In both the sample periods the computed *F* statistics are higher than the Upper Critical Bound at the 1% significance level. This implies that there exists long-run relationship between all the variables in the two periods.

Table 5: Bounds Test Cointegration Results

Sample period: 1960 – 1982	***Computed F-statistic:*** 7.04	
Sample period: 1983 – 2004	***Computed F-statistic:*** 10.33	
Critical Values	**Lower Bound**	**Upper Bound**
Critical Bound's value at 1%	5.17	6.36
Critical Bound's value at 5%	4.01	5.07
Critical Bound's value at 10%	3.47	4.45

4.5 Short-run and long-run elasticities

In this section, the short-term and long-term elasticities were computed (refer to Table 6) for the two sample periods. For sample period 1960–1982, the result showed that *RGDP* and *NICT* have positive impact on *ICT* in the short- and long-run. However, the impact of RGDP and NICT was not statistically significant in the short- and long-run. L was found to be positive and significant in the long-run. A 1% increase in labour force resulted in an increase of 1.47% increase in *ICT*. However, in the short-run, *L* was found to be positive but not statistically significant.

Table 6: Short and Long Term Elasticities

Sample period: 1960 – 1982	**Dependent: ICT**	
Factors	**Short term**	**Long term**
RGDP	0.08	0.08
NICT	0.174	0.174
L	7.88	1.472**
Sample period: 1983 – 2004	**Dependent: RGDP**	
Factors	**Short term**	**Long term**
ICT	0.5402 **	1.7367 ***
NICT	0.2727	-0.901
L	-0.6024 ***	-1.9365

Note:'**' and '***' denote statistical significance at 5% and 10%, respectively.

Over the period 1983–2004, the result showed that the impact of *ICT* on *RGDP* was positive and significant at the 5% significance level. A one percent increase in *ICT* investment contributed to 0.54% of *RGDP*. In the short-run *L* was found to have a negative impact on *RGDP* at the 10% significance level. This is not surprising because in this period Malaysia experienced a serious shortage of workers. Given that the economy was relatively small compared to other regional economies, Malaysia was not a cost-effective centre for labour intensive-sectors. *NICT* was found to have a positive impact on *ICT*. However, the impact was not statistically significant. Summing the coefficients that are statistically significant in the model, we observe that in the short-run, the Malaysian economy experienced decreasing returns to scale.

In the long-run, during the period 1983–2004, *ICT* was the only factor to have a positive and significant impact on *RGDP* (at the same 10 % significance level). A 1% increase in *ICT* investment contributed 1.74% in *RGDP*. Note that in the long run, *ICT* investment was the main factor enabling the economy to experience increasing returns to scale. This implies that the diffusion of *ICT* into the economy from 1983–2004 was the main source of economic efficiency, hence increased real output (*RGDP*).

V. Conclusion

The aim of this paper has been to examine the relationship between *ICT* development and economic growth in Malaysia, one of the fastest-growing Islamic countries in the world. The empirical analysis was conducted for two sample periods, in order to detect any structural change in the economy due to the *ICT*-driven policy implemented in the country.

The empirical analysis suggests that the Malaysian economy has undergone major structural change (increasing returns to scale) from 1983 to 2004 due to increased *ICT* investment. The policies and strategies under NICTA have contributed positively to the Malaysian economy. Lessons from the Malaysian case will be useful for other Islamic countries in formulating *ICT* policies that will increase their socioeconomic status.

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