Information and Communication Technology (ICT) Impact on Labour Productivity in Malaysia

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ABSTRACT

Industry 4.0 aiming at the transformation of industrial digitalization has been highly focusing on doubling productivity and efficiency in the production process. However, the measurement of productivity has still been subjecting to the intense debate of measurement between labour productivity or total factor productivity. This study aims to assess the contribution of technological development of the different measures of productivity between 1961 and 2016. Result of these findings shows that labour productivity measure is appropriate to compare to total factor productivity. Moreover, labour productivity growth has a positive impact on physical capital growth and ICT growth, yet has a negative impact on employment growth. Job eviction due to rapid industrial transformation and slower productivity growth is a major challenge in realizing industry 4.0 without an appropriate institutional reform in Malaysia.

Keywords: Total Factor Productivity, Productivity Growth, Labour, Technology, Gross Fixed Capital Formation

INTRODUCTION

Productivity growth in Malaysia over the last decade has been viewed as an important factor in striving the nation towards an advance economy. Malaysia Productivity Corporation (MPC) has cited a positive trajectory of productivity growth within the country often highly depends on the capability of workforce to transform advanced knowledge and technology into production. The adoption of Fourth Industrial Revolution and the Industry 4.0 aiming at transformation of industrial digitalization known as "smart factory" has been highly focusing in doubling productivity and efficiency in the production process. However, the measurement of productivity has still been subject of intense debate within the scientific and policy-making society to find the 'best' measurement between labour productivity (output per labour) or total factor productivity (TFP) (Sargent and Rodriguez, 2001). Until recently there has been no conclusive evidence to support the single best measurement as the both measurement of productivity growth has something to contribute in its' own way. This study aiming to assess the contribution of technological development of the different measurement of productivity between 1961 and 2016. This study also provides an exciting opportunity to know to what extend does the differences in productivity measurement able to render a specific knowledge on the contribution of technological development and employment in Malaysia.

LITERATURE REVIEW

Labor productivity growth is generally regarded as the symbol of technological progress. It is believed that when directly considering the relationship between labor productivity growth and employment growth, there is an alternative relationship (Eriksson, 1997). It has also been found that the alternative relationship is strengthening over time before 1980, based on the data analyzed (Beaudry and Collard, 2002). But the theory was adjusted by Cavelaars, P., later in 2003 that the relationship had been improving since 1980s and ultimately almost vanished in 2000, after his analysis of the data in OECD countries. As in further research, Cavelaars supported his theory by applying the Cobb-Douglas Model, combining with the law of diminishing margining return, he concluded that not only are the labor productivity growth and employment growth be negatively correlated, but they are both affected by the rate of capital accumulation, productivity growth and the growth of average working hour. Furthermore, according to the researcher of Wang (2011), the alternative relationship is least correlated in the secondary industry, meaning that in technology intensive industry, the skilled workers in the secondary industry is less substitutive by the new technology applied.

According to the labor productivity growth study of Chansarn (2010), which contains statistics during 1981 – 2005 in 30 countries, categorized into four groups, including G7 countries, western developed countries, eastern developed countries and eastern developing countries. Chansarn utilized the Growth Accounting Equation which represents the relationship between the growth rate of output and the growth rate of inputs and productivity (Bernanke et al., 2008). According to the Growth Accounting Equation above, the growth rate of labor productivity is positively correlated to the growth of gross fixed capital formation.

The work by Travaglini (2012) provides an explanation for the puzzling trade-off between labor productivity and capital accumulation, occurred in Italian energy sector from the late 1980s onwards. By using a vector autoregressive model, we decompose labor productivity into technological and non-technological shocks. Wang (2011), found that: (1) labor productivity responds positively to technological shocks, leading to a transition from one equilibrium to another; (2) capital accumulation shows a persistent decline in response to a positive technological shock, revealing that, in energy sector, technology and capital stock are substitutes. Study by Luque (2000), obtained results point out the importance of a comprehensive strategy aimed at increasing technological progress through research, innovation and human capital investment in energy sector. Conversely, our findings state that institutional reforms and changes in regulation can only have a transitory effect on labor productivity in energy sector, without permanent gains in the future.

As the researchers Pyo et al. (2006) showed that TFP growth has been positively affected by the growth of labor productivity. However, since its financial crisis in December 1997, the sources of growth seem to have switched to TFP-growth based and IT-intensive Service based. But lower productivity in service industries due to regulations and lack of competition seems to work against finding renewed sustainable growth path (Vicente, 2011). The research undertaken by Sargent and Rodriguez (2000) studied the labour and total factor productivity. The finding of the study was based on the data collected from different industries and sectors, and the finding showing that the total factor of productise varies based on the labour productivity. With higher labour productivity, this could lead to the lower capital used while labour contributes more to the output. Similarly, Vicente (2011) also examined the total factor productivity in the economic. The finding of the study concluded that the portion of labour and capital differs according to different industries, while manufacturing sector requires higher labour than capital than other industries. Nevertheless, the traditional view on the portion of capital and labours changes with the technology involvement and increases in labour experience curve (Chansam, 2010).

According to the labor productivity growth study of Chansarn (2010), which contains statistics during 1981 – 2005 in 30 countries, categorized into four groups, including G7 countries, western developed countries, eastern developed countries and eastern developing countries, the Labor productivity growth and growth of information and communications technology are positively correlated.The research conducted by Ceccobelli et al. (2011) investigated the ICT capital and labour productivity growth The results confirm the role of ICT as a general purpose technology that needs organisational and business process changes to fully exploit its growth opportunities. Chansarn (2010) also argued that, by applying a non-parametric test, that ICT technologies positively contribute to the generation of convergence clubs in the evolution of labour productivity. Besides, Khan and Santos (2002) indicated that the use of information and communication technology contributes to the increasing labour productivity, and there is positive relationship between growth of ICT and labour productivity. This was similar to the finding conducted by Vu, K. M. (2000) in UK in which ICT improves the output of labours.

METHODOLOGY

The methodology of this study adapted from Sargent and Rodriguez (2001) were the researchers argue that which measure appropriate for productivity growth for Canada. This study also wanted to investigate in Malaysia case.

The Cobb-Douglas production function specified as:

$Y_t = AK_t^{\gamma} L_t^{1-\gamma}$, 0 <γ <1,
(1)

Where *Y* is output, *K* is capital input and *A* if TFP, a parameter that has relationship between the input: capital, labour and output. The TFP generally identified with level of technology, yet it incorporates with variety of factor, *t* is time trend. Dividing equation (1) by labour input (L), written as:

$\dot{y}_t = \dot{A}_t + \gamma\ (\dot{k}_t)$
(2)

Where, $\dot{y}_t$is labour productivity, $\dot{k}_t$denoted as capital per labour. The equation (2) implies that growth rate of labour productivity is equal the growth rate of TFP and growth rate of capital intensity. According to neoclassical model, the capital stock categorized as an endogenous variables and it depend on TFP growth. TFP growth is calculated as a residual by subtracting the contribution of growth in capital –labour ratio from labour productivity growth. For that γ, the marginal productivity of capital is required. Under the perfect competition and constant return to scale , this parameter is equal to capital's share output $(\widehat{\gamma})$. TFP_t can be calculated according to the formula where $L\dot{P}_t$ is labour productivity.

$T\dot{F}P_t = L\dot{P}_t - \hat{\gamma}(\dot{k}_t)$
(3)

Equation (3) shows that in the short run, capital accumulation in practice has an independent role in the calculation of TFP growth. In order to analyse the information and technology (ICT) influence to production function, *A* with level of technology in TFP refer to the ICT conditions can express as:

$$A = ICT_t \quad (4)$$

Where ICT_t is the proportion of technology influence at *t* time period. By substituting (4) into (1), obtained:

$$Y = ICT_t\ (K_t^{\gamma} L_t^{1-\gamma}) \quad (5)$$

In order to derive the labour productivity function, both sides of (5) are divided by L_t expressed as:

$\frac{Y_t}{L_t} = \frac{ICT_t K_t^{\gamma}\ L_t^{1-\gamma}}{L_t}$
(6)

Labor productivity to capital-labor ratio and proportion of labour at certain period at *t* express as:

$$\frac{Y_t}{L_t} = ICT_t (\frac{K_t}{L_t})^{\gamma} L_t^{1-\gamma} \quad (7)$$

From (7) the OLS estimation model for this study is written as:

$LPG_t = \beta_{0t} + \beta_2 PCG_t + \beta_3 EG_t + \beta_4 GICT_{tt} + \varepsilon_t$
(8)

$TFPG_t = \beta_{0t} + \beta_2 PCG_t + \beta_3 EG_t + \beta_4 GICT_{tt} + \varepsilon_t$
(9)

Where LPG is Labour productivity per person employed, TFPG is growth of total factor productivity, PCG is Physical capital growth rate, GICT is growth of ICT and LEG is life expectancy growth rate. The subscript *t* represents the *t* refer to number of years. List of variable used and source of data as in Table 1. The data estimation period covers from 1991 to 2016 yearly, which has total 26 observations. Eviews software used to analysed the data.

TABLE 1: List of Variables

Variables	Actual data measure	Convert data measure	Data source
Dependent variable Labour productivity per person employed[a]	United State dollar (converted to 2017 price level with updated 2011 PPPs)	Labour productivity growth rate (percentage)	The Conference Board Total Economy Database
Growth of total factor productivity	Percentage	-	The Conference Board Total Economy Database
Independent variables Employed person[a]	Thousands of persons	Employment growth rate (percentage)	The Conference Board Total Economy Database
Gross fixed capital formation[a]	Ringgit Malaysia (Million)	Physical capital growth rate (percentage)	Department of statistic Malaysia
Growth of capital services provided by ICT Assets	Percentage	-	The Conference Board Total Economy Database

[a]convert to growth rate using formula $= \frac{\text{present}-\text{past}}{\text{past}}$ x100

EMPIRICAL RESULT

The descriptive statistics of the variable employed in this study shown in Table 2. The mean growth rate for labour productivity for the study period at 2.72%. Year 1998 recorded the lowest labour productivity growth at -7.69% and highest level recorded in 1991 at 8.92%. The mean growth rate for employment for the study period at 2.96%. Year 1998 recorded the lowest labour productivity growth at 0.36% and highest level recorded in 1996 at 9.87%. The mean growth rate for physical capital at 6.18%. Year 1998 recorded the lowest physical capital growth at -37.68% and highest level recorded in 2000 at 30.54%. The mean growth rate for total factor productivity at -0.25%. Year 1998 recorded the lowest total factor productivity growth at -9.79% and highest level recorded in 1999 at 3.93%. The mean growth rate for ICT at 12.13%. Year 2015 recorded the lowest ICT growth at 5.36% and highest level recorded in 1996 at 20.37%. the decline in growth rate for all variables observed in year 1998 could be due to global financial crisis.

TABLE 2. Descriptive Statistics of main variables

Variables	Mean	Standard Deviation	Minimum	Maximum
Labour productivity growth rate (LPG)	2.719	3.552	-7.686	8.920
Employment growth rate (EG)	2.955	2.435	0.355	9.865
Physical capital growth rate (PCG)	6.178	13.158	-37.678	30.537
Growth of total factor productivity (TFPG)	-0.250	2.807	-9.785	3.931
Growth of ICT(GICT)	12.129	4.352	5.358	20.365

The correlation among variables shown Table 3. Labor productivity growth has positive relationship with physical capital growth rate and ICT growth rate. However, for total factor productivity, physical capital growth rate has positive and ICT growth rate negative relationship.

TABLE 3 Correlation matrix among variables

Variables	LPG	TFPG	PCG	EG	GICT
LPG	1.000	0.674	0.706	-0.255	0.102
TFPG	0.674	1.000	0.532	0.097	-0.162
PCG	0.706	0.532	1.000	0.128	-0.101
EG	-0.255	0.097	0.128	1.000	0.134
GICT	0.102	-0.162	-0.101	0.134	1.000

Table 4 compare the estimate result for two dependent variables namely total factor productivity growth and labour productivity growth with same independent variables. Model 1 is basic model with capital and employment as independent variables for total factor productivity growth. The extended Model 2 with ICT growth rate. Similar for Model 3 as basic model and Model 4 as extended model for labour productivity growth. Mode1 and Model 2 has residual diagnosis problem such as the data not normally distributed and has heteroscedasticity problem. In Malaysia perspective, using TFP as dependent variable to measure Malaysia productivity in observed period of this study has residual problem. However, theoretical supported finding observed for employment growth yet, for growth of ICT shown contradict outcome, were negative relationship.

The heteroscedasticity problem raised in Model 1 due to violating Assumption 9 of Classical Linear Regression Model (CLRM) caused omitted variable bias or more generally, specification bias lead for very low R-square value in Model 1. Thus, to measure total factor productivity growth, if we not include the growth of ICT (the omitted variable bias), the residuals obtained from regression may give the distinct impression that the error variance may not constant. But if the omitted variable (growth of ICT) included in model as Model 2, the impression disappears. However, unexpected sign for ICT growth in Model 2, solved with including labour productivity growth as proxy for total factor productivity growth. With that, R^2 in Model 3 and 4 improved.

However, the estimation for Mode1 3 and 4 shows that physical capital growth and employment growth influence labour productivity growth with 1% significant level. Moreover, this two model free from residual diagnosis problem. Model 4 chosen as best model since higher R^2, lower Akaike and Schwartz information criterion value and all the independent variables are significant. The estimation of Model 4 shows that one percent increase in physical capital growth rate lead 21% increase in labour productivity. One percent increase in employment growth caused 56.3 percent decrease in labour productivity. Moreover, this percentage seen lesser in Model 3 without growth of ICT, only 51.3 percent decreases. Furthermore, one percent increase in growth of ICT, 19 percent increase in labour productivity growth. Finally, labour productivity growth has positive impact on physical capital growth and ICT growth, yet has negative impact on employment growth. This indicate that labour productivity in Malaysia increase however, employment growth had decreased.

TABLE 4: Estimated Result

	Growth of Total Factor Productivity		Labour Productivity Growth	
	(Model 1)	(Model 2)	(Model 3)	(Model 4)
Constant	-1.046	-0.180	2.981***	0.782
	(0.788)	(1.575)	(0.727)	(1.361)
PCG	0.113***	0.120***	0.203***	0.210***
	(0.038)	(0.039)	(0.035)	(0.033)
EG	0.034	0.054	-0.513**	-0.563***
	(0.205)	(0.210)	(0.189)	(0.182)
GICT		-0.075		0.190*
		(0.117)		(0.101)
Breusch-Godfrey Serial Correlation LM Test:	0.056 Prob. F(2,21):0.946	0.146 Prob. (2,20): 0.865	0.122 Prob. F(2,21):0.886	0.969 Prob. F (2,20):0.400
Normality test (Jarque-Bera)	JB statistics: 2.525 Prob. value: 0.283	**JB statistics: 6.718 Prob. value: 0.035**	JB statistics: 0.326 Prob. value: 0.849	JB statistics: 2.178 Prob. value: 0.337
Heteroskedasticity Test (White)	**Prob. Chi-Square (2): 4.807 Prob. F(5,20): 0.005**	Prob. Chi-Square(2): 2.004 Prob. F(9,16) : 0.108	Prob. Chi Square(2): 1.287 Prob. F(5,20):0.309	Prob. Chi Square(2): 1.809 Prob. F (9,16):0.144
Multicollinearity test (Variance Inflation Factor)	1.397	1.422	2.320	3.049
Akaike information criterion	4.759	4.818	4.597	4.526
Schwartz information criterion	4.904	5.011	4.742	4.719
R^2	0.284	0.297	0.620	0.672

*** 1% significant; ** 5% significant ; *10% significant

Although it has been widely reckoned on the positive effect of productivity growth on employment, the positive effect on employment occasionally subjected to the net effect of productivity on GDP growth (Isaksson et al., 2005; 2007; Anders et.al. 2006). The effect of positive productivity growth often passes through the process of destructive creation before impacting the overall economic growth. During the process, the structural transformation and the incessantly revolving technology from within, potentially implicate stronger job destruction than job creation. The criterion for positive employment growth depends on the minimum output growth threshold of one percentage point above productivity growth

(Isaksson et al.2005; Duygun et.al. 2017). In some instances, rapid productivity growth can be followed by falling employment due to prevalence of deficient growth in the sectors with already declining employment (Isaksson et. al., 2005; Bigsten et al., 2000). Besides the slower growth of productivity, negative growth in employment shall be caused by other factors due to inefficient reallocation of labour, poor technological absorption and the price elasticity of demand. This study argues that employment in Malaysia could have been suffer from 'destructive creation', a stronger job destruction than the slower job creation. As we could see Malaysia has been adopting Industry 4.0 with overarching industrial digitalization of "smart factory", technological influence on employment highly seem to influence the productivity growth.

CONCLUSION

This study aimed at assessing the impact of technological development on different measurement of productivity growth in Malaysia between 1991 and 2016. So far there has been little discussion on the comparison of different measurement between TFP and labour productivity growth in relation to technological contribution in Malaysian perspective. Furthermore, heteroscedasticity problem observed due to omitted variable and violation of assumption 9 in CLRM. Remedy for this issue found with choosing labor productivity growth as proxy for total factor productivity growth and include ICT growth in the Model 4. This study also had rendered an important insight on to what extend does the differences in productivity measurement reflecting the variance in technological contribution. The findings of this study are consistent with most of the former studies which showed positive association between technological improvement and productivity growth regardless of variance in measurement. However, the findings of the current study do not support several other previous studies on positive association between employment and labour productivity in Malaysia. Job eviction due to rapid industrial transformation and slower productivity growth shall be a major challenge in realizing industry 4.0 without an appropriate institutional reform in Malaysia.

References

Anders, I., & Hee, N. T. (2006). Determinants of Productivity: Cross-Country Analysis and Country Case Studies. Staff working paper 01/2006, Research and Statistics Branch, UNIDO.

Beaudry, P. and Collard, F., Why has the Employment - Productivity Tradeoff among Industrialized Countries been so Strong? NBER Working Paper 8754, 2002, National Bureau of Economic Research, Cambridge, Mass.

Bernanke, B.S., A.B. Abel and D. Croushore (2008). Macroeconomics. 6th Edition. Boston, MA: The Addison-Wesley.

Bigsten, A., Isaksson, A., Söderbom, M., Collier, P., Zeufack, A., Dercon, S.,& Gauthier, B. (2000). Rates of return on physical and human capital in Africa's manufacturing sector. Economic Development and Cultural Change, 48(4), 801-827

Cas, Alexandra, and Thomas K. Rymes, (1991) On Concepts and Measures of Multifactor Productivity in Canada, 1961–1980, Cambridge: Cambridge University Press.

Cavelaars, P., Has the Tradeoff between Productivity Gains and Job Growth Disappeared? MEB, (Dec., 2013).

Ceccobelli, Gitto, and Mancuso (2011). Ict and growth: A DEA Analysis of 14 OECD Countries. Econpapers Issue 3, 435-454.

Chansarn, S., Labor Productivity Growth, Education, Health and Technological Progress: A Cross-Country Analysis. Economic Analysis & Policy, Vol. 40 No. 2, September 2010, pp. 249 – 261.

Duygun, M., Hao, J., Isaksson, A., & Sickles, R. C. (2017). World productivity growth: a model averaging approach. Pacific Economic Review, 22(4), 587-619.

Eriksson, C., Is there a Trade-off between Employment and Growth? Oxford Economic Papers, New Series, Vol 49, No. 1 (Jan., 1997), pp. 77- 88.

Isaksson, A., Ng, T. H., & Robyn, G. (2005). Productivity in developing countries: trends and policies. Vienna, Austria: UNIDO.

Isaksson, A. (2007). Determinants of total factor productivity: a literature review. Research and Statistics Branch, UNIDO.

Isaksson, A. N. D. E. R. S. (2010). Structural change and productivity growth: a review with implications for developing countries. United Nations Industrial Development Organization.

Khan. H. and M. Santos (2002), Contribution of ICT Use to Output and Labour. Productivity Growth in Canada, Working Papers 2002-7, Bank of Canada, Ottawa, March.

Lam, P. L., & Shiu, A. (2010). Economic growth, telecommunications development and productivity growth of the telecommunications sector: Evidence around the world. Telecommunications Policy, 34(4), 185–199.

Luque, A. and J. Miranda (2000), Technology use and Worker Outcomes: Direct Evidence from Linked Employee-employer data, CES WP-00-13, Center for Economci Studies, Washington, DC.

Muysken, J., Yetkiner, I.H., and Ziesemer, T. (2004), "Health, Labor Productivityand Growth", in Growth Theory and Growth Policy (Eds. Harald Hagemann andStephan Seiter), Routledge, London.

Pyo, H.K., Rhee K.H. and Ha, B., Estimates of Labor and Total Factor Productivity by 72 industries in Korea (1970-2003). OECD Workshop on Productivity Analysis and Measurement, Bern, 16-18 October 2006

Sargent, T. C., & Rodriguez, E. R. (2001). *Labour or total factor productivity: Do we need to choose?* Department of Finance.

Sengupta, K., Health and Its Impact on Labour Productivity and Labour Market, IJHM Vol 2(1) Mar 2017, pp 13 - 16.

Travaglini, G., Trade-off between labor productivity and capital accumulation in Italian energy sector. Journal of Policy Modeling 34 (2012) pp. 35–48.

Vicente, M. R., & Lopez, A. J. (2011). Assessing the regional digital divide across the European Union-27. Telecommunications Policy, 35(3), 220–237.

Vu, K. M. (2011). ICT as a source of economic growth in the information age: Empirical evidence from the 1996–2005 period. Telecommunications Policy, 35(4), 357–372.

Wang, Z., Study on the Employment -productivity Trade-off. Journal of Graduated School of Chinese Academy of Social Sciences, No. 5 (Sep., 2011), China Academic Journal Electronic Publishing House.