LPEM-FEB UI Working Paper 013, October 2017
ISSN 2356-4008

ICT Capital Spending, ICT Sector, and Firm Productivity: Evidence from Indonesian Firm-Level Data

Chaikal Nuryakin[1]*, Faisal Rachman[1], Ashintya Damayati[1], Nia Kurnia[1], & Moslem Afrizal[1]

Abstract
This study examined the impact of ICT on firm productivity in Indonesia. Using unbalanced panel data of medium and large manufacturing firms, we performed two kinds of estimation. The first estimation is Cobb-Douglas production function with output as the dependent variable. Capital was grouped into non-ICT capital and ICT capital in order to determine the impact of ICT on firm's output creation. The second estimation used total factor productivity as the dependent variable, where TFP was estimated using Levinsohn-Petrin productivity estimator. As other internal and external factors were added to the regression as control variable, the study provides early evidence that while the impact of R&D and innovation still needs to be further elaborated, ICT capital may have a positive, but not always significant, impact on firm's production and productivity in Indonesia.

JEL Classification: E22; D24; O3

Keywords
ICT — Productivity — TFP — R&D — Innovation

[1] *Institute for Economic and Social Research, Faculty of Economics and Business, Universitas Indonesia (LPEM- FEB UI)*
***Corresponding author**: Campus UI Salemba, Salemba Raya St., No. 4, Jakarta, 10430, Indonesia. Email: chaikall@gmail.com

1. INTRODUCTION

In the last 30 years, the way individuals, societies, businesses, and industries interact and function have been transformed by the internet. The world has been living in an age of digital economy that brings both opportunities and challenges to global growth. According to the G20 Digital Economy Development and Cooperation Initiative (2016), digital economy refers to a broad range of economic activities that include using digitized information and knowledge as the key factor of production, modern information networks as an important activity space, and effective use of information and communication technology (ICT) as an important driver of productivity growth. The latter—ICT as productivity driver—has attracted much attention in recent studies, considering that digitized, networked, and intelligent ICTs enable modern economic activities to be more flexible, agile, and smart.

Related to productivity, recent pre-crisis growth accounting exercises indeed attribute strong productivity growth to increased investments in information and communication technologies (ICT), especially during the mid-1990s (Strobel, 2012). The ICT-based digital economic development is experiencing high growth, rapid innovation, and broad application to other economic sectors. It is an increasingly important driver of global economic growth and plays a significant role in accelerating economic development, enhancing productivity of existing industries, cultivating new markets and industries, and help achieving inclusive, sustainable growth. It is believed that the adoption of new technologies, particularly in ICT, and an increase in the number of skilled school leavers, will augment human capital and help boost productivity (Tabor, 2015). This has encouraged many countries, including Indonesia, to increase the use of ICT.

The position of a country in ICT use can be evaluated through an index called the ICT Development Index (IDI). ICT Development Index measures global and reflects changes taking place in countries at different levels of ICT development by measuring three categories of indicator: ICT access, ICT use, and ICT skills.[1] Unfortunately, based on 2015 data, Indonesia only ranks 108th in the World ICT Development Index among 175 countries. The rank only represents an increase of one point compared to the 2010 ranking before plummeting to 115th in the world ranking and 19th in Asia in 2016. The index has increased from 3.63 in 2015 to 3.86 in 2016, but is still below the world average score of 4.94 and the Asian average score of 4.58.

However, in 2011, Ministry of Communication and Information of Indonesia (*Kementerian Komunikasi dan Informatika - Kemenkominfo*) also conducted a survey on ICT usage. While the ICT Development Index examines general ICT access, ICT use, and ICT skills, this survey looks at ICT usage specifically in business sector and surveys 803 business entities in Indonesia. In contrast to the ICT Development Index, the survey found that although the percentage of workers using computers was only 19 percent of total workers and the percentage of workers using the internet

[1] The access sub-index captures ICT readiness and includes five infrastructure and access indicators: fixed telephone subscription, mobile cellular subscription, international internet bandwidth, percentage of households with computer, and percentage of households with internet access. The use sub-index captures ICT intensity and includes three indicators: percentage of individuals using the internet, fixed broadband subscription, and wireless broadband subscription. The skill sub-index captures ICT capability or skills as indispensable input indicators: adult literacy rate and gross enrollment ratio of secondary and tertiary levels.

was only 13 percent of total workers, 92 percent of respondents have used computers and 86 percent used the internet to support their business. In this case, most businesses used the internet to send and receive e-mails (97.69%), find information about products and services (80.69%), and sell products or services online (45.97%). The survey also indicates hospitality as business sector with the largest percentage of internet use. Approximately 71.06% of hotels have used the internet, while the percentages for manufacturing industry and restaurants are 68.9% and 57.77% respectively. From the above data, it is evident that despite generally poor usage of ICT in Indonesia based on the ICT Development Index, the survey from the Ministry of Communication and Information shows that most of the business respondents have employed ICT in their activities.

The development of ICT usage in Indonesia raises an interesting question related to its impact. Given the general perception of ICT's significant role in enhancing productivity of existing industries, does increasing ICT utilization really improve firms' productivity in Indonesia?

Few studies have discussed the impact of ICT capital on industrial productivity and/or firm productivity. Studies such as those by Lee & Khatri (2003) on the impact of ICT capital on productivity growth in Asia and Ahmed (2017) on ICT and human capital spillover in ASEAN use Indonesia as one of the countries assessed in the studies, but do not specifically elaborate the Indonesian case. Rachman et al. (2006) provide further study on the Indonesian case, particularly regarding the role of outsourced ICT service model (that includes fixed and mobile telephones, internet, cloud computing, and other managed services) in the productivity of small and medium enterprises (SME), but only use small and medium enterprises data in Jakarta and Bandung. Thus, no study has examined the general impact of ICT capital on firm productivity (especially in medium and large manufacturing industries) in Indonesia, which is the subject of detailed discussion in this study.

2. LITERATURE REVIEW

As ample literatures have shown, productivity is no longer determined merely by traditional inputs, namely capital (machinery, building, and land) and labor. Therefore, it has become necessary to delve into empirical studies focusing on measuring the impact of Information and Communication Technology (ICT) capital on productivity. Many empirical studies on the impact of ICT capital on productivity have been performed at different entity level (industry and firm level) and using varying ICT types. Some studies also elaborate the impact of other internal and external factors, such as research and development (R&D), human resource development, innovation, openness to global market, and availability of source of funds, on productivity. Following studies mostly adopt the Cobb-Douglas function and panel data model in estimating the effect of those factors on productivity.

According to Polder (2015), a key factor determining industrial productivity growth is investment growth on intangible capital, which is described as spending growth of R&D and skills development and trainings for employees. The use of ICT capital, which is interpreted as total cost required for procuring computer hardware, software and telecommunication equipment, proved to have a very limited impact. Employing panel data consisting of 33 industries engaging in the commercial sector in the Netherlands and covering the period of 1995–2008, this study concluded that contribution of ICT capital growth was relatively small and the only variable that was insignificant. The study subsequently introduced one dummy variable into the model, which is a binary variable indicating whether the industry is ICT intensive or not by calculating the industry median of the user cost of ICT over labor cost and comparing it to the overall median. If it is above the overall median, the industry is considered having high intensity of ICT usage. Interaction variable between this dummy and intangible capital was also constructed so as to measure whether there was a meaningful difference in utilization of intangible capital between ICT-intensive and non-ICT-intensive industries. The result shows that both dummy and interaction variables were insignificant. Coefficient of ICT capital growth in this estimation was again found to be small and insignificant while coefficient of intangible capital, despite having the same sign and size as before, turned out to be insignificant.

Adopting panel data for 24 industries in 16 OECD countries for the period of 1973–2004, Acharya (2010) deduced that ICT capital positively and significantly affected industrial productivity not only in industries producing ICT products. This explains the spillover effect from industries producing ICT products to industries that purchase them as production inputs. This study however found that contribution of ICT capital on industrial productivity was still relatively smaller than contributions of other factors, but bigger than the contribution of R&D. Similar to Polder's finding, this study concluded that when all variables were transformed into growth-form, contribution of ICT capital growth on industrial productivity growth became insignificant. R&D stock growth however had a positive and significant impact on industrial productivity growth. This study also found that ICT capital and R&D stock growths of all industries in one country had positive relationship with productivity growth of each other industry within that country. This again clarifies the within-country spillover effect of ICT products. Moreover, this study concluded that productivity growth of each industry in one OECD country was not influenced by ICT capital and R&D stock growths of each same industry or all industries in other OECD countries.

Unlike those two studies, Corrado et al. (2014), who estimated country-industry-time data of 10 EU members for the period of 1998–2007, reported that ICT capital growth had a positive and significant impact on industrial productivity growth. Its contribution however was considerably reduced when intangible capital growth, defined as investment growth in R&D and skill training for employees, was introduced. Interaction variable of overall average ICT capital and intangible capital growths also showed a positive and significant result, indicating that the return of intangible capital on productivity was higher in ICT-intensive industries. This study also included overall average ICT capital growth of the US and its interaction with intangible capital growth of 10 EU members in order to see spillover effect between countries. The result showed that ICT-intensive industries in the US had a positive and significant influence on industrial productivity growth in the EU.

Focusing on R&D impact, Guellec & van Pottelsberghe de la Potterie (2001) applied aggregate data for 16 OECD countries over the period of 1980–1998 and concluded that R&D had become an increasingly essential production factor in enhancing overall industry productivity growth. They also opined that there are three kinds of R&D based on its source, i.e., domestic business R&D, public R&D, and foreign business R&D. Among them, R&D developed by domestic business generated the highest overall industry productivity growth. It was because the domestic business was apt to have higher spillover effect and better ability to easily absorb R&D sourced from abroad, government, and university.

Findings from the above studies may shed some light on and help us in better understanding the relationship between ICT, R&D, human resource development, and industrial productivity. ICT capital may positively and significantly affect industrial productivity, but it cannot be claimed as always having a significant impact on industrial productivity growth. R&D and trainings for employees are empirically proven to have a meaningful influence on industrial productivity. Interestingly, those factors may reduce the contribution of ICT capital to industrial productivity when they are introduced into the model. This indicates that the use of ICT capital in production entails a specific set of R&D, skills, and abilities so that ICT can be utilized optimally. In other words, investments in R&D and human resources generate an indirect impact on ICT use in increasing productivity.

Following studies exercised smaller entity level, which is firm level, for their scope in investigating the impact of ICT, R&D, human resource development, and innovation on productivity. Some studies have further tried to categorize ICT capital into several types in order to capture the heterogeneity of ICT capital and find out which ICT capital has the most effect on firm productivity.

de Bondt & Polder (2015) found a causality between ICT and firm productivity. Their study classified ICT capital into four types, namely hardware (computer), network (communication equipment), purchased software, and own-account software. Number of personal computer (PC) users was used as a proxy for hardware type, while number of employees with ICT education background was chosen as a proxy for own-account software type. Data on software index and network index were introduced into the function as proxies for purchased software and network, respectively. The study utilized panel data consisting of 4,340 firms for year 2009 and 4,522 firms in the Netherlands for year 2010. The result showed that there was a positive and significant relationship between hardware and firm productivity. In general, of all ICT capital variables, own-account software was the only one having insignificant impact.

Similar finding emerged in a study performed by UNCTAD (2008) on the impact of ICT capital use on manufacturing firm productivity in Thailand. Dataset employed in this study is cross-section data covering 8,800 manufacturing firms in 2002. By selecting the number of computers, access to the internet and website as three independent variables representing ICT capital, it concluded that all three types of ICT capital positively and significantly increased firm productivity. Nevertheless, when the variable for the number of computers was replaced by number of PC users to better measure and explain usage intensity of ICT capital in production and business activities, coefficient for website variable became insignificant. Same result was obtained when number of computers was switched for computer to labor ratio. Moreover, this study grouped the firms based on size and age in estimating the impact. A firm was categorized as a small firm if it had around 11–50 employees, or medium-sized firm if it had 51–200 employees, or large firm if it had more than 200 employees. Number of computers was found to be positively and significantly influencing firm productivity for all firm sizes. PC users and computer to labor ratio also had the same impact. Access to the internet was significant only for small firms, whereas website was insignificant for all firm sizes. For age grouping, this study sorted the firms into three groups based on firm's year of establishment. Firms established in 1997–2002, 1991–2006, and before 1991 were categorized as young, middle-aged, and old firm, respectively. Number of computers was again found having a positive and significant relationship with firm productivity in all age groups. Same result applied in the case of PC users and computer to labor ratio. Access to the internet had a significant effect for young and middle-aged firms only if the model used number of PC users or computer to labor ratio, and did not have significant effect in the case of number of computers. All three variables representing ICT capital had a positive and significant impact only for old firms and only when the model included number of computers.

Charlo (2011) presented a parallel finding in her study on the impact of ICT on firm productivity. In contrast to the previous two firm-level studies, this study did not classify ICT capital into several types. Using panel data consisting of 738 manufacturing firms in Uruguay for the period of 2003–2007, this study concluded that all traditional production factors, ICT capital, and human resource capital but innovation had positive and significant impacts. Surprisingly, innovation had a significant and negative relationship with firm productivity. Compared to other determinants, contribution of ICT capital on firm productivity was the smallest whereas the contribution of human resource capital was the largest. Also interesting is the finding that while innovation coefficient had a negative sign, its interaction with ICT capital had a positive and significant effect on firm productivity. This means that innovation itself is costly for firms, but it may bring an additional effect on the use of ICT capital on firm productivity. When all variables were transformed into growth form, ICT capital growth still had a positive and significant impact and innovation-spending growth kept being insignificant. Additionally, their interaction turned out to be insignificant as well.

Similar result was found in a study performed by Hall et al. (2012). This study applied panel data of 9,850 manufacturing firms in Italy for the period of 1995–2006 and deduced that ICT capital was significantly able to increase firm productivity. Furthermore, this study introduced R&D variable into the estimation and concluded that it also had a positive and significant effect on firm productivity. The intensive use of R&D in production proved to have a larger impact on firm productivity than ICT capital. Most interestingly, the study found that innovation had a positive and significant effect only when ICT capital and R&D were excluded from the model. This study also attempted to explore the relationship between ICT capital, R&D, and innovation. It showed that ICT capital and R&D contributed to innovation development. Contribution of R&D on innovation was however more dominant. According to the study, the relationship between ICT capital and R&D—that is, whether they substitute or complement each other—still cannot be ascertained.

Castellani et al. (2016) stressed the importance of R&D utilization in increasing firm productivity. Using unbalanced panel data of 1,112 firms (504 European firms and 608 US firms) for the period of 2004–2012, they affirmed the positive and significant contribution of R&D stock to firm productivity in which US firms, especially the ones in the high-tech industries, possessed higher capacity to exert R&D to boost firm productivity than EU firms. They also added that firms with better capacity to translate R&D into productivity tended to be more resilient during the economic crisis period.

These studies elucidate and confirm that ICT capital does give a positive and significant impact to firm productivity with number of computers used in production and business activities being the most superior determinant. R&D and human resource development have also been empirically proven to be playing important and significant roles in increasing firm productivity. Unexpectedly, the literature still doubts the significant causality between innovation and firm productivity. In addition, the studies have empirically proven the impact of ICT capital and R&D on innovation, but the relationship between the two variables remains to be ascertained.

The above literature mostly focus on the internal factors of production in determining productivity. Yet, some economists and researchers have suggested that external factors such as the degree of openness measured by exports and access to finance may be as crucial in increasing productivity. Following discussion reviews those studies that explore the impact of external factors on productivity.

Applying panel data for US manufacturing industries based on four-digit Standard Industrial Classification (SIC) for the period of 1958–1994, Bernard & Jensen (1999) found a significant causal relation from industrial productivity growth to export growth but not the reverse. They further argued that exports would only increase industrial productivity growth when an industry decided to switch from being non-exporter to exporter industry (Bernard & Jensen, 2004). There was a considerable rise in industrial productivity growth before and during the transition, and its trend was inclined to be flat afterwards. At firm level and utilizing panel data for 6,391 Slovenian manufacturing firms in 1994–2000, De Loecker (2007) supports Bernard and Jensen's finding. His study concluded that a firm would have a noteworthy jump in its productivity once it started exporting. There was little evidence for a firm that had been an exporter to have higher productivity than a firm that never exported. Moreover, he concluded that a firm with private ownership and exporting towards high-income regions was strongly associated with even higher productivity gains. Another study by Mukim (2011), using panel data containing 8,253 firms in India for the period of 1989–2008, also endorses the notion. She deduced that exporting caused a jump in firm productivities, but this effect diminished over time.

A study done by Ferrando & Ruggieri (2015) pointed out that financial constraint had a negative and significant impact on firm productivity. Employing unbalanced panel data of 1,022,638 firms in euro-area countries over the period of 1993–2011, they found a higher impact among firms operating in energy, gas, and water supply and R&D, communication, and information sectors, and firms categorized as micro and small firms. Dabla-Norris et al. (2010) using panel data for 16,392 manufacturing firms in 63 countries encompassing developed and developing countries between 2005 and 2007 in the estimation, drew a parallel conclusion. They reported that financial access indirectly affected firm productivity since it may enhance innovation activities, which in consequence would increase firm productivity. In other words, they argued that financial sector was one of the most important factors in encouraging the positive effect of innovation on firm productivity.

Based on the studies focusing on external factors as explained above, exports noticeably have a limited impact on productivity since the impact is only significant during the time a firm is deciding to be an exporter. Thus, it cannot be said that export always increases productivity. In terms of availability of source of funds, financial constraint has been empirically proven to reduce productivity. Access to finance indeed may boost productivity, but not in a direct way. It mostly channels financial needs of firms to innovation activities, which at the end of the day will enhance productivity. It suggests that inconclusive findings on the impact of innovation on productivity are perhaps strongly related to other external, influencing factors.

Many empirical studies on the impact of ICT capital on productivity as discussed above have obtained numerous findings and yet there is still no consensus regarding the impact. ICT capital may affect productivity, but it cannot be claimed to be having a certain and significant impact on productivity. The impact of innovation on productivity also seems quite vague since several empirical studies end up producing inconclusive findings. Other factors like R&D, human resource development, and access to finance have been reported as always having a positive and significant influence on productivity. Meanwhile, openness measured by export gives little evidence of enduring effect on productivity. These inconclusive findings provide the importance to further investigation on the impact of ICT capital and other internal and external factors on productivity, especially in the case of Indonesia.

2.1 Methodological and Empirical Approach

To examine the impact of ICT usage in businesses against its productivity in Indonesia, we began by utilizing a Cobb-Douglas production function at firm level in which labor (L), capital (K), and raw material (M) were used as the key input determinants for production measured by output (Y). In stochastic form, the function follows Equation (1):

$$Y_{it} = AK_{it}^{\beta_2} L_{it}^{\beta_4} M_{it}^{\beta_5} e^{u_{it}} \tag{1}$$

where sub-indexes i and t represent firm ($i = 1, 2, \ldots, N$) and year ($t = 1, 2, \ldots, T$), respectively; e is a base of natural logarithm; and u denotes a stochastic disturbance or error term. Linearizing Equation (1) by transforming it into natural logarithm form gives

$$\begin{aligned}\ln Y_{it} &= \ln A + \beta_2 \ln K_{it} + \beta_4 \ln L_{it} + \beta_5 \ln M_{it} + u_{it} \\ &= \beta_1 + \beta_2 \ln K_{it} + \beta_4 \ln L_{it} + \beta_5 \ln M_{it} + u_{it}\end{aligned} \tag{2}$$

where β_2, β_4, and β_5 are parameters for capital, labor, and raw material describing output elasticity of capital, labor, and raw material, respectively. Elasticity measures the percentage change in output due to 1% change in an input used in the production, holding another input constant. The sum of β_2, β_4, and β_5 informs the level of return to scale explaining how responsive the output is to a proportionate change in the inputs. It was assumed that $\beta_2 + \beta_4 + \beta_5 = 1$, meaning that the production function has a Constant Return to Scale (CRS). In other words, doubling the inputs doubles the output. If $\beta_2 + \beta_4 + \beta_5 < 1$, it implies that doubling the inputs will only increase output by less than double (Decreasing Return to Scale (DRS)), and $\beta_2 + \beta_4 + \beta_5 > 1$ indicates an Increasing Return to Scale (IRS), meaning that the output increases by more than double. Thereby, CRS does not hold.

This study furthermore grouped capital (K) into two types, namely non-ICT capital ($K^{non-ICT}$) and ICT capital (K^{ICT}) in order to determine the impact of ICT capital on firm productivity. Non-ICT capital includes machinery, building, and land whereas ICT capital refers to computer hardware, software, and computer and telecommunication equipment. The function thus becomes

$$\begin{aligned}\ln Y_{it} = \beta_1 &+ \beta_2 \ln K_{it}^{non-ICT} + \beta_3 \ln K_{it}^{ICT} \\ &+ \beta_4 \ln L_{it} + \beta_5 \ln M_{it} + u_{it}\end{aligned} \tag{3}$$

in which the return to scale is now obtained by summing β_2, β_3, β_4, and β_5.

Furthermore, we introduced variables capturing other internal and external factors into the model as the literature suggests. Intangible capital (IK), or total cost incurred for R&D and human resource development, was chosen as a proxy for the other internal factors. Innovation unfortunately had to be ignored as internal factor due to unavailability of data. Moreover, an export dummy for exporter firm (D^{EX}) and access to finance dummy (D^{AF}) were used as proxy for external factors. To avoid omitted variable bias problem causing the function parameters to be overestimated, this study also introduced some control variables believed to have direct effect to firm's output or value added, or to have correlations to at least one independent variable (indirect effect). The control variables include a dummy variable indicating whether a firm is located within industrial area (D^{IA}), dummy variable for firm producing any ICT product (D^{PICT}), dummy variable for firm's status based on investment type (D^{FS}), and dummy variable indicating formality of a firm (D^{FF}). This is denoted in the following equations:

$$\begin{aligned}\ln Y_{it} = \beta_1 &+ \beta_2 \ln K_{it}^{non-ICT} + \beta_3 \ln K_{it}^{ICT} \\ &+ \beta_4 \ln L_{it} + \beta_5 \ln M_{it} + \beta_6 \ln IK_{it} + u_{it}\end{aligned} \tag{4}$$

$$\begin{aligned}\ln Y_{it} = \beta_1 &+ \beta_2 \ln K_{it}^{non-ICT} + \beta_3 \ln K_{it}^{ICT} + \beta_4 \ln L_{it} \\ &+ \beta_5 \ln M_{it} + \beta_6 \ln IK_{it} + \beta_7 D_{it}^{EX} + \beta_8 D_{it}^{AF} + u_{it}\end{aligned} \tag{5}$$

$$\begin{aligned}\ln Y_{it} = \beta_1 &+ \beta_2 \ln K_{it}^{non-ICT} + \beta_3 \ln K_{it}^{ICT} + \beta_4 \ln L_{it} \\ &+ \beta_5 \ln M_{it} + \beta_6 \ln IK_{it} + \beta_7 D_{it}^{EX} + \beta_8 D_{it}^{AF} \\ &+ \beta_9 D_{it}^{IA} + \beta_{10} D_{it}^{PICT} + \beta_{11} D_{it}^{FS} + \beta_{12} D_{it}^{FF} + u_{it}\end{aligned} \tag{6}$$

After using output as dependent variable, towards the end of the paper Total Factor Productivity (TFP) is used as dependent variable. Polder (2015), Acharya (2010), and Corrado et al. (2014) imposed CRS to the Cobb-Douglas function to estimate TFP using OLS, Fixed Effect/first differences, and Generalized Method of Moments (GMM) as robustness check. However, literature discussing TFP on panel data considers more complex model that allows for the part of the error term that is transmitted to inputs to vary over time. In this circumstance, Olley-Pakes (1996) and Levinsohn & Petrin (2003) created method to estimate TFP in panel data to allow input endogeneity with respect to a time varying unobservable error term[2], not just pure fixed-effect approaches. Olley-Pakes (1996) developed a semiparametric approach in which they used capital and investment as a proxy for unobserved productivity, while Levinsohn & Petrin (2003) suggested a modification of the Olley-Pakes approach by using intermediate input (raw materials, electricity, or fuels) instead of investment. However, taking into account the availability of data, this study chose to use the Levinsohn-Petrin intermediate inputs proxy estimator to estimate TFP.

In a panel data, the equation for Cobb-Douglas production function where labor, capital, and material are taken to be input is as follows:

$$\begin{aligned}\ln VA_{it} = \beta_0 + \beta_l \ln L_{it} + \beta_k \ln K_{it} + \beta_m \ln M_{it} \\ + \omega_{it} + \varepsilon_{it}\end{aligned} \tag{7a}$$

where VA_{it} represents value added and L_{it}, K_{it}, and M_{it} stand for labor, capital, and material, respectively. However, the estimation in the Levinsohn-Petrin procedure takes place in two stages. First, the following equation was estimated:

$$\ln VA_{it} = \beta_l \ln L_{it} + f(\ln K_{it}, \ln M_{it}) + \varepsilon_{it} \tag{8}$$

where

$$f(\ln K_{it}, \ln M_{it}) = \beta_0 + \beta_k \ln K_{it} + \beta_m \ln M_{it} + \omega_{it} \tag{9}$$

This completes the first stage of estimation from which β_l and f_{it} were estimated. The second stage identified the coefficient of β_k. Using levpet command in STATA, the output only reported the coefficient of β_l and β_k (not the coefficient of β_m).

[2] Moreno-Badia & Slootmaekers (2003) wrote: (in panel data) the firm specific error term consists of two parts: from productivity, ω_{it}, which is observed by the firm but not by econometrician, and ε_{it} which is unpredictable zero-mean shocks to productivity after inputs are chosen. This asymmetric information about ω_{it} causes two biases in the OLS estimates: a simultaneity bias and a selection bias. The endogeneity bias stems from the correlation between unobserved productivity and a plant's input decisions. If more productive plants tend to hire more workers due to higher current and anticipated future profitability, OLS will tend to provide upwardly biased estimates on the input coefficients. The selection bias arises because firms with larger capital stocks can expect larger future returns for any given level of current productivity and will therefore continue in operation for lower productivity levels, thereby leading to a negative bias in the OLS capital coefficient.

In this stage, ω_{it} was estimated by:

$$\omega_{it} = f_{it} - \beta_k \ln K_{it}$$

Using these values, TFP was estimated by regression

$$\omega_{it} = \alpha_0 + \alpha_1 \omega_{it-1} + \alpha_2 \omega_{t-1}^2 + \alpha_3 \omega_{t-1}^3 + e_{it} \quad (10)$$

In this study, we generally used raw material as the proxy variable. However, this study also examined other proxy and used electricity as the second proxy variable to estimate Equation (7a) and the total factor productivity.

$$\ln VA_{it} = \beta_0 + \beta_l \ln L_{it} + \beta_k \ln K_{it} + \beta_m \ln M_{it}^{ELEC} + \omega_{it} + \varepsilon_{it} \quad (7b)$$

TFP was subsequently used as dependent variable for estimating the following equation to estimate the impact of ICT on firm productivity:

$$\ln TFP_{it}^{RAW} = \beta_1 + \beta_2 D_{it}^{ICT} + \beta_3 L_{it} + \beta_4 D_{it}^{EX} + \beta_5 D_{it}^{AF} + \beta_6 D_{it}^{IA} + \beta_7 D_{it}^{PICT} + \beta_8 D_{it}^{FS} + u_{it} \quad (11a)$$

$$\ln TFP_{it}^{ELEC} = \beta_1 + \beta_2 D_{it}^{ICT} + \beta_3 L_{it} + \beta_4 D_{it}^{EX} + \beta_5 D_{it}^{AF} + \beta_6 D_{it}^{IA} + \beta_7 D_{it}^{PICT} + \beta_8 D_{it}^{FS} + u_{it} \quad (11b)$$

According to Polder (2015), Equation (11a) and (11b) introduced ICT dummy variable into the model, which is a binary variable indicating whether the industry is ICT intensive or not. If the ICT capital is more than 50 percent of the total capital, the industry is said to have intensity in ICT usage.

The annual survey of Indonesian medium and large manufacturing industries (Statistik Industri) conducted by Statistics Indonesia (Badan Pusat Statistik (BPS)) was used as the main data source for this study. We also utilized the average of each industry's wholesale price index (WPI) and average WPI of capital and raw material good as deflators for monetary values of output, value added, capital, and raw material, respectively. It should be noted that the use of Statistik Industri data is the main drawback of this study. Due to the data availability, we did not distinguish ICT capital into several types. Also, although ICT capital in this study was interpreted as total cost required for procuring computer hardware, software, and telecommunication equipment, the data of ICT capital were proxied by firm's total value of other capitals (besides land, building, machinery, equipment, and vehicles), which is a very strong and rough assumption. However, this assumption remains plausible because in the description column of the survey, some companies state that one component of other capitals is hardware, software, and telecommunication equipment, although it is not the only component. The detailed explanation of the dataset for each variable for estimating equation (3), (4), (5), (6), (7a), (7b), (11a), and (11b) can be seen in Table 1.

From the original dataset, we conducted two adjustments. First, only firms that existed during the observation period (routinely filled out surveys during the observation period) were used as sample in this study. After this adjustment, the samples covered a balanced panel of 33,151 firms operating between 2008–2014 (232,127 observations). The second adjustment included trimming the negative and zero values off the observations. Therefore, the function was estimated using unbalanced panel data of 69,768 observations for Equation (3); 38,200 observations for Equation (4), (5), and (6); and 95,181 for equation (7a), (7b), (11a), and (11b). Appendix A and B present the descriptive statistics of all samples used in the regression.

3. ESTIMATION RESULT

Fixed Effect (FE)/Least Squares Dummy Variables (LSDV) with time fixed effect was used in estimating all equations except the Levinsohn-Petrin productivity estimator (Equation (7a) and (7b)). As described previously, we began the regression analysis in this study by utilizing a Cobb-Douglas production function at firm level in which labor (L), capital (K), and raw material (M) were used as the key input determinants for production measured by output (Y) which we then modified into four different specifications shown through Equation (3) to Equation (7). The regression results are presented in Table 2.

In Equation (3), the regression result shows that all independent variables had positive and significant impact on output. The estimated coefficient for the raw material equaled 0.700, higher than the estimated coefficient for labor that equaled 0.238. The sum of the estimated coefficients (non-ICT capital, ICT capital, labor, and raw material) was equal to 0.966, indicating that industries in Indonesia have been experiencing decreasing return to scale. Although positive and significant, the coefficient of ICT capital was relatively small compared to other input coefficients. However, this coefficient value can be considered reasonable since most industries in Indonesia are still labor intensive with only few industries being capital intensive, including those that are ICT-capital intensive.

Firm sample data show that in 2008–2013 the average share of ICT capital stock only reached 6% of total capital stock of the firm (Figure 1). For large manufacturing firms with more than 400 workers, 80% of the firms were already ICT-capital intensive, i.e. the value of their ICT capital stock accounted for more than 50% of their total capital stock. However, among smaller firms, only 40% were ICT-capital intensive (Figure 2). Although in 2014 there was a big spike that led to share of ICT capital stock to total capital stock touching 44% and 96% of the firm becoming ICT-capital intensive, the regression result shows that this surge had not been able to provide a meaningful impact on the creation of firm output. Thus, in 2008–2014, labor and raw materials still had a bigger role in the creation of firm output than non-ICT capital, while non-ICT capital had a bigger role in the creation of output compared to ICT capital. Nevertheless, ICT capital had a positive and significant impact on firm output—that is, an increase in firm's ICT capital stock would increase its production significantly.

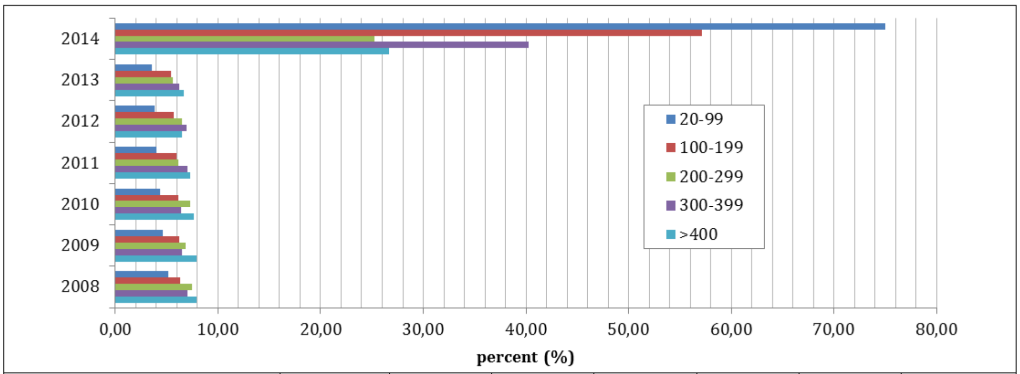
One thing to note here is that although the regression result of Equation (3) shows that ICT capital had a positive and significant impact on firm output, when the intangible capital was introduced in Equation (4), the contribution of

Table 1. Variable, Proxy, Definition, and Source

Variable	Proxy and Definition	Source
Output (Y)	Value of firm's output (in thousand rupiahs)	Statistik Industri
Value added (VA)	Value of firm's value added (in thousand rupiahs)	Statistik Industri
Total Factor Productivity – Raw Material Proxy (TFP^{RAW})	Total factor productivity estimated with Levinsohn-Petrin estimator using data of raw material as intermediate input	Estimated using Equation (7a)
Total Factor Productivity – Electricity Proxy (TFP^{ELEC})	Total factor productivity estimated with Levinsohn-Petrin estimator using data of electricity as intermediate input	Estimated using Equation (7b)
Total Capital (K)	Value of all fixed capital (land, building, machinery, equipment, vehicles, and other capital) (in thousand rupiahs)	Statistik Industri
Non-ICT Capital ($K^{Non-ICT}$)	Value of land, building, machinery, equipment, and vehicles (in thousand rupiahs)	Statistik Industri
ICT Capital (K^{ICT})	Value of computer hardware, software, and computer and telecommunication equipment. Proxied by firm's total value of capitals besides land, building, machinery, equipment, and vehicles (in thousand rupiahs).	Statistik Industri
Dummy for whether firm is ICT Capital Intensive (D^{ICT})	Capital intensive if value of ICT capital is more than 50% of the total fixed capital 1 if yes, 0 if no	Statistik Industri
Labor (L)	Number of labors (total paid and unpaid workers). Used as proxy for firm size in equation (11a) and (11b)	Statistik Industri
Raw Material (M)	Value of total material imported and non-imported used in a year (in thousand rupiahs)	Statistik Industri
Electricity (M^{ELEC})	Quantity of electricity purchased from state electricity company (Perusahaan Listrik Negara (PLN)) (kWh)	Statistik Industri
Intangible Capital (IK)	Total cost incurred for R&D and human resource development. Proxied by firm's spending for management fee, promotion/advertising, water, post, telephone, facsimile, travel-expenses, prevention of environment pollution, R&D and human resource development (in thousand rupiahs).	Statistik Industri
Export dummy for exporter firm (D^{EX})	Firm is an exporter 1 if yes, 0 if no	Statistik Industri
Access to finance dummy (D^{AF})	Firm makes loans to financial/banking sector. Proxied by interest paid on loan. 1 if yes, 0 if no	Statistik Industri
Dummy for whether firm location is within industrial area (D^{IA})	Firm's location: 1 if within industrial area, 0 if outside industrial area	Statistik Industri
Dummy for firm producing any ICT product (D^{PICT})	Firm's output type: 1 if ICT product (television and communication equipment), 0 if non-ICT product	Statistik Industri
Dummy for firm's status based on investment type (D^{FS})	Firm's investment type is Foreign Direct Investment (FDI): 1 if yes, 0 if no	Statistik Industri
Dummy variable indicating formality of a firm (D^{FF})	Formality indicated from firm's tax spending: 1 if a firm is in formal sector, 0 if a firm is in informal sector	Statistik Industri

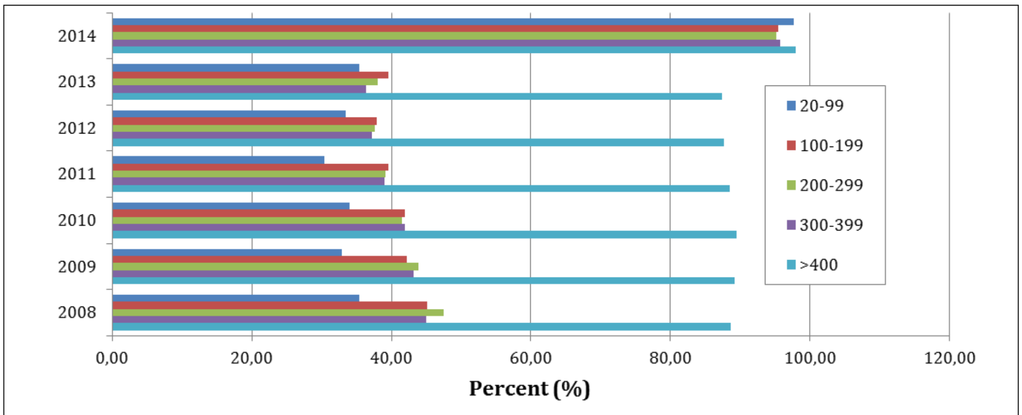
ICT capital to the output creation was considerably reduced and became insignificant. The coefficient magnitude and significance were also consistent when other control variables were added to Equation (5) and (6). In Equation (5), when external variables such as export dummy for exporter firm and access to finance dummy were added to the model, ICT capital remained insignificant while intangible capital was significant. In Equation (6), when dummy for firms producing any ICT product was introduced into the model as a control variable, although the dummy itself returned significant and negative coefficients—possibly because the post-crisis observation period affected the performance of technology-based firms—the estimated coefficients and significance of ICT capital and intangible capital remained consistent. This is in line with the results of studies by Polder (2015), Acharya (2010), and Corrado et al. (2014) arguing that ICT capital may positively and significantly affect production activity but cannot be claimed as always having a significant impact. Meanwhile, it has been empirically proven that R&D and trainings for employees invariably have meaningful influence on firm production not only in industries producing ICT products but also in those that do not. In other words, in all kinds of industries, investments in R&D and human resources generate an indirect impact on ICT use in increasing production.

This result indicates that the use of ICT capital in production entails a specific set of R&D, skills, and abilities in order to optimally utilize ICT. It thus becomes important to further explore the specific set of R&D needed by the firm as Guellec & van Pottelsberghe de la Potterie (2001) found that R&D, especially R&D conducted by domestic firm, is one of the essential factors in output creation. Unfortunately, since there are many limitations in Indonesian firm-level data in Statistik Industri, we were unable to break down



Firm Size (Number of Labor)	2008	2009	2010	2011	2012	2013	2014
20-99	5.16	4.65	4.34	4.00	3.82	3.54	75.00
100-199	6.32	6.21	6.15	5.97	5.73	5.42	57.11
200-299	7.48	6.87	7.29	6.16	6.45	5.57	25.26
300-399	7.05	6.52	6.44	7.00	6.91	6.18	40.31
>400	7.91	7.92	7.60	7.26	6.51	6.67	26.67
Average	6.17						44.87

Figure 1. Share of ICT Capital Based on Firm Size (Number of Labor) 2008–2014



Firm Size (Number of Labor)	2008	2009	2010	2011	2012	2013	2014
20-99	35.47	32.84	33.98	30.42	33.45	35.36	97.62
100-199	45.19	42.23	41.94	39.55	37.90	39.55	95.43
200-299	47.48	43.84	41.53	39.19	37.65	38.04	95.14
300-399	44.96	43.12	41.91	39.09	37.19	36.39	95.68
>400	88.60	89.26	89.55	88.52	87.68	87.36	98.01
Average	48.30						96.38

Figure 2. Percentage of ICT-Intensive Firm Based on Firm Size 2008–2014

and further elaborate the R&D data into domestic-business R&D and foreign-business R&D as practiced by Guellec & van Pottelsberghe de la Potterie (2001). The only thing we could do regarding domestic and foreign R&D was to add dummy variables to indicate whether the firm's investment type is foreign direct investment (FDI) or domestic investment (see Equation (6)). However, unlike Guellec & van Pottelsberghe de la Potterie (2001) who found that domestic R&D has a positive and significant impact on firm's production activities because it has higher spillover effect and better ability to easily absorb R&D sourced from other parties, regression result of Equation (6) shows that there was no significant difference between domestic and foreign companies in Indonesia in terms of output creation. This is reasonable considering most industries in Indonesia are labor intensive. Ferragina et al. (2009) and Görg & Strobl (2001, 2003) reported that in some cases where most industries are still technologically simple, the physical capital will not be much different between foreign and domestic firms, especially if the industry is labor intensive and requires local skills.

Other variables showing different results from the literature were export dummy for exporter firm and location dummy for whether firm is located in industrial area. Location dummy shows negative and significant results, in contrast to the general assumption that a location within industrial area will have a positive effect on firm's output creation due to agglomeration. It indicates that firms located in the industrial area produced lower output compared to firms not located in industrial area. However, according to Press (2006), firms located in industrial cluster may suffer from the negative effect of congestion that leads to increase in production cost, such as excessive pollution and higher infrastructure cost due to the emergence of new firms in industrial area. Using Indonesian firm-level data, Sukmaretiana (2016) also found similar result in some industries

Table 2. Cobb Douglas Regression with Output as Dependent Variable

	Eq. (3)	Eq. (4)	Eq. (5)	Eq. (6)
Non-ICT Capital	0.019***	0.017***	0.018***	0.018***
	(0.003)	(0.005)	(0.005)	(0.005)
ICT Capital	0.009***	0.005	0.005	0.005
	(0.002)	(0.003)	(0.003)	(0.003)
Labor	0.238***	0.219	0.222***	0.221***
	(0.008)	(0.011)	(0.011)	(0.011)
Raw Material	0.700***	0.701	0.698***	0.698***
	(0.004)	(0.006)	(0.006)	(0.006)
Intangible Capital	-	0.007**	0.007**	0.007**
		(0.003)	(0.003)	(0.003)
Export Dummy (1 = exporting)	-	-	-0.049***	-0.045***
			(0.007)	(0.007)
Access to Finance Dummy (1 = receiving loans)	-	-	0.005	-0.007
			(0.015)	(0.015)
Location dummy (1 = in industrial area)	-	-	-	-0.021***
				(0.007)
Producing ICT Product Dummy (1 = producing ICT product)	-	-	-	-0.196***
				(0.056)
Firm Status (1 = FDI)	-	-	-	-0.021
				(0.023)
Firm Type (1 = formal)	-	-	-	0.047
				(0.013)

Note: All regression is in natural log
Standard errors are in parentheses, all are robust standard errors
* significant at 10% level, ** significant at 5% level, *** significant at 10% level

in Indonesia. In terms of export, this study found that exports had significant, negative effect on firm output. It contrasts with the findings of Bernard & Jensen (1999) and De Loecker (2007), who maintained that export produces limited impact on productivity since the impact is only significant during the time a firm is deciding to be an exporter and it cannot be said that export always increases productivity. The negative results found in this study are related to the observation period, during which the economy was still affected by crisis. The volatility of foreign conditions hampered the performance of exporting firms and resulted in exporting firms making less outputs compared to non-exporting firms. Finally, for the other internal and external factors, regression results of Equation (5) and (6) indicates that the formality status of a firm and access to finance did not have a significant impact on firm output. However, from the regression results of Equations (3) to (6) with output as dependent variable (Table 2), it is apparent that ICT capital in general may positively affect firm output but its impact was not always significant. Again, the use of ICT capital in production entails a specific set of R&D, skills, and abilities in order to guarantee the optimal utilization of ICT.

This study further looked at the impact of ICT capital on productivity as estimated using the Levinsohn-Petrin productivity estimator. The regression result of Levinsohn-Petrin productivity estimator (Table 3) shows the estimated coefficient of labor and capital. These results indicate that there was a considerable difference in the coefficient of labor between Equation (7a) that used raw material data as proxy for the unobserved heterogeneity and Equation (7b) that used electrical data as proxy. By using raw material as proxy for unobserved heterogeneity (Equation (7a)), labor coefficient reached 0.981, indicating that the role of labor and raw material in value-added creation of the firm was larger compared to the role of capital. While the labor estimated coefficient was only 0.542 in Equation (7b), the relative impact of labor on output was still relatively larger than the impact of capital, thus agreeing with the previous regression result. Estimated total factor productivity (TFP) based on these two equations is presented in Table 4, which was used as the dependent variable for Equations (11a) and (11b) regression.

Table 3. Levinsohn-Petrin Productivity Regression with Value Added as Dependent Variable

	Eq. (7a)	Eq. (7b)
Labor	0.981***	0.542***
	(0.009)	(0.007)
Capital	0.080***	0.031***
	(0.006)	(0.003)

Note: All regression is in natural log.
STATA only reported coefficient of β_l and β_k
Standard errors are in parentheses
* significant at 10% level,
** significant at 5% level,
*** significant at 10% level

Table 4. Levinsohn-Petrin TFP Estimation Result

Year	TFP – Proxy Raw Material	TFP – Proxy Electricity
2008	11.20	8.83
2009	11.10	8.73
2010	11.31	8.90
2011	11.37	8.95
2012	11.54	9.11
2013	11.65	9.21
2014	13.40	10.50

Note: Data are in natural log

Based on the regression results using TFP as dependent variable (Table 5), it appears that ICT intensive firms had higher productivity compared with other firms. The regression results also show that the productivity of a firm did not depend on whether it produced ICT goods, but instead on whether the firm was ICT intensive. This corresponds with the result of previous regression using output as the dependent variable. The coefficient of firm ownership status was not significant either on production or productivity, while the coefficients of export and location in industrial area are consistent and show that export and location in industrial area had negative effect on both firm output and firm productivity.

However, the regression results for access to finance dummy instead show different results from previous regression that used output as dependent variable. In the previous regression, access to finance did not have significant impact on output creation. As mentioned earlier, Ferrando & Ruggieri (2015) found that access to finance indeed did not have a direct impact on production and productivity. Access to finance may boost production activity only if the funds are used by the firm to innovate. If access to finance is not significantly affecting firm output, it is possible that companies are not using the access to innovate. However, regression employing productivity as dependent variable shows that access to finance was significant and positively affected productivity. Unfortunately, data on firm innovations were not available, barring the possibility to ascertain whether access to finance influenced innovation and subsequently affected productivity. As a result, the roles of access to finance as well as innovation towards production and productivity become inconclusive. Nevertheless, several studies on the impact of access to finance on productivity have argued that access to finance can indeed be counterproductive to the firm (Heil, 2017). Some firms can actually be burdened by interest payments, thus countering the positive impact of access to finance. It is possible that the explanation to why access to finance is not significantly affecting production but nevertheless significantly and positively affecting productivity lies in this counterproductive effect. When firms are burdened with interest and debt repayments, companies are forced to "innovate" because they have to reduce some production factors while continuing to maintain its production, thus giving the picture that this "innovation" improves productivity. This presumption remains to be further ascertained.

Lastly, this regression result shows that firm size had a negative relationship to productivity. According to Evans (1987) and Yasuda (2005), small firms have higher productivity growth in order to reach minimum efficient scale. The bigger the firm (the increase in the number of labor), the production of efforts reaches a certain point that decreases productivity. This is reasonable considering the samples used in this study are comprised of well-established companies. Thus, firm size had a negative coefficient and was significant to productivity.

4. CONCLUSION

We can conclude several things from the results. First, ICT capital might positively affect industry's output, but did not necessarily pose significant impact since ICT capital in production entails a specific set of R&D, skills, and abilities to ensure optimal utilization of ICT. Looking at the firm's investment status, the study found that there might be no different impact between domestic and foreign R&D on firm's output. Second, the regression results show that ICT-intensive firms were more productive compared with the other firms. They also show that the productivity of a firm did not depend on whether it produced ICT goods, but instead on whether the firm was ICT intensive. Thus, this study provides early evidence that ICT capital and ICT usage have a positive impact on firm productivity in Indonesia.

Table 5. Regression with Total Factor Productivity as Dependent Variable

	Eq. (11a)	Eq. (11b)
ICT Intensive Dummy (1 = firm is ICT intensive)	0.090***	0.132***
	(0.031)	(0.032)
Firm Size (proxied by labor)	0.0006	-0.0001***
	0	(0.000)
Export Dummy (1 = exporting)	-0.375***	-0.378***
	(0.011)	(0.010)
Access to Finance Dummy (1 = receiving loans)	0.072***	0.055***
	(0.011)	(0.011)
Location Dummy (1 = in industrial area)	-0.038***	-0.040***
	(0.009)	(0.009)
Producing ICT Product Dummy (1 = producing ICT product)	-0.049	-0.016
	(0.083)	(0.085)
Firm Status (1 = FDI)	0.012	-0.009
	(0.039)	(0.039)

Nevertheless, further analysis is required to find what kind of R&D sets is specifically required by Indonesian firm, as the limitation on Statistik Industri's R&D data made this information impossible to be elaborated in this study. Further studies are also needed to elaborate the innovation data in order to ensure the impact of access to finance on production and productivity that so far remains inconclusive. Finally, changes in firm's identity code (PSID) in Statistik Industri made it difficult to match or track firm data before 2008. In the observation period, the economy was still affected by the crisis—allegedly causing exporting firms and firms producing ICT product to have lower production and productivity. Thus, subsequent research will need to employ longer period of observation in order to see the actual impact of exports and dummy for firms producing any ICT product against the production and productivity of the firms.

References

Acharya, R. (2010). ICT and Total Factor Productivity Growth: Intangible Capital or Productive Externalities?. *Economic Research and Policy Analysis Branch Working Paper 2010-01*. Industry Canada. http://www.ic.gc.ca/eic/site/eas-aes.nsf/eng/h_ra02264.html.

Ahmed, E. M. (2017). ICT and human capital spillover effects in achieving sustainable East Asian knowledge-based economies. *Journal of the Knowledge Economy, 8*(3), 1086–1112. doi: https://doi.org/10.1007/s13132-017-0474-0.

Bernard, A. B., & Jensen, J. B. (1999). Exporting and productivity. *NBER Working Paper 7135*. National Bureau of Economic Research. doi: 10.3386/w7135. http://www.nber.org/papers/w7135.pdf.

Bernard, A. B., & Jensen, J. B. (2004). Exporting and Productivity in the USA. *Oxford Review of Economic Policy, 20*(3), 343–357. doi: https://doi.org/10.1093/oxrep/grh020.

Castellani, D., Piva, M., Schubert, T., & Vivarelli, M. (2016). R&D and Productivity in the US and the EU: Sectoral Specificities and Differences in the Crisis. *Henley Discussion Paper JHD-2016-03*. Henley Business School, University

Appendix A. Descriptive statistics of all sample data used in the Cobb-Douglas regression with output as dependent variable

Variable	Obs	Mean	StdDev	Min	Max
Output (in 10 million rupiahs)	38200	15.9	120	0.00129	8400
Non-ICT Capital (in 10 million rupiahs)	38200	3.15	249	1 x 10-7	419000
ICT Capital (in 10 million rupiahs)	38200	71.2	7400	1 x 10-7	14200000
Number of Labor	38200	273	939	20	41374
Raw Material (in 10 million rupiahs)	38200	9.31	80.6	5.6 x 10-4	81000
Intangible Capital (in 10 million rupiahs)	38200	0.32	7.59	1 x 10-7	812
Export Dummy (1 = exporting)	38200	0.45	0.49	0	1
Access to Finance Dummy (1 = receiving loans)	38200	0.77	0.41	0	1
Location Dummy (1 = in industrial area)	38200	0.12	0.33	0	1
Producing ICT Product Dummy (1 = producing ICT product)	38200	0.01	0.11	0	1
Firm Status (1 = FDI)	38200	0.12	0.33	0	1
Firm Type (1 = Formal)	38200	0.86	0.34	0	1

Appendix B. Descriptive statistics of all sample data used in the TFP regression

Variable – raw material as proxy	Obs	Mean	StdDev	Min	Max
Value Added (in 10 million rupiahs)	95181	3.83	48.8	975 x 10-4	4840
Firm Size (number of labor)	95181	182	689	20	41374
Capital (in 10 million rupiahs)	95181	27.4	4990	1 x 10-7	1530000
Raw Material (in 10 million rupiahs)	95181	5.37	57.2	3 x 10-6	8100
Electricity (in kwh)	95181	1553	56400	0	16900000
ICT intensive dummy (1 = ICT intensive)	95181	0.22	0.14	0	1
Export Dummy (1 = exporting)	95181	0.46	0.49	0	1
Access to Finance Dummy (1 = receiving loans)	95181	0.39	0.48	0	1
Location Dummy (1 = in industrial area)	95181	0.13	0.33	0	1
Producing ICT Product Dummy (1 = producing ICT product)	95181	0.009	0.096	0	1
Firm Status (1 = FDI)	95181	0.08	0.27	0	1

of Reading. https://s3-eu-west-1.amazonaws.com/assets.henley.ac.uk/legacyUploads/pdf/research/papers-publications/JHD-2016-03_Castellani_et_al.pdf.

Charlo, G. (2011). Impact of ICT and innovation on industrial productivity in Uruguay. In M. Balboni et al. (Eds), *ICT in Latin America: microdata analysis*. pp. 185–202. Santiago: ECLAC.

Corrado, C., Haskel, J., & Jona-Lasinio, C. (2014). Knowledge spillovers, ICT, and productivity growth. *IZA Discussion Paper 8274*. Institute for the Study of Labor. http://ftp.iza.org/dp8274.pdf.

Dabla-Norris, E., Kersting, E., & Verdier, G. (2010). Firm productivity, innovation and financial development. *IMF Working Paper WP/10/49*. International Monetary Fund. https://www.imf.org/external/pubs/ft/wp/2010/wp1049.pdf.

de Bondt, H., & Polder, M. (2015). Types of ICT and Firm-Level Productivity. In Statistics Netherlands, *ICT and Economic Growth*, pp. 51–66. The Hague: Statistics Netherlands. https://www.cbs.nl/en-gb/publication/2015/24/ict-and-economic-growth.

De Loecker, J. (2007). Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics, 73*(1), 69–98. doi: https://doi.org/10.1016/j.jinteco.2007.03.003.

Evans, D. S. (1987). The relationship between firm growth, size, and age: Estimates for 100 manufacturing industries. *The Journal of Industrial Economics, 35*(4:The Empirical Renaissance in Industrial Economics), 567–581. DOI: 10.2307/2098588.

Ferragina, A., Pittiglio, R., & Reganati, F. (2009). The impact of FDI on firm survival in Italy. *FIW Working Paper, 35*. FIW - Kompetenzzentrum 'Forschungsschwerpunkt Internationale Wirtschaft'.

Ferrando, A., & Ruggieri, A. (2015). Financial Constraints and Productivity: Evidence from Euro area Companies. *ECB Working Paper, 1823*. European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1823%20en.pdf.

G20 Digital Economy Development and Cooperation Initiative. (2016). http://www.mofa.go.jp/files/000185874.pdf.

Görg, H., & Strobl, E. (2001). Multinational Companies and Productivity Spillovers: A Meta-analysis. *Economic Journal, 111*, F723–F739.

Görg, H., & Strobl, E. (2003). Multinational companies, technology spillovers and plant survival. *Scandinavian Journal of Economics, 105*(4), 581–595. doi: 10.1111/j.0347-0520.2003.00003.x.

Guellec, D., & van Pottelsberghe de la Potterie, B. (2001). R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries. *OECD Economic Studies 33, 2001/II*, pp. 103–126. https://www.oecd.org/eco/growth/1958639.pdf.

Hall, B. H., Lotti, F., & Mairesse, J. (2012). Evidence on the impact of R&D and ICT investments on innovation and productivity in Italian firms. *Economics of Innovation and New Technology*, 1–29, iFirst. doi: http://dx.doi.org/10.1080/10438599.2012.708134.

Heil, M. (2017). Finance and Productivity: A Literature Review. *Economics Department Working Papers 1374, ECO/WKP(2017)6*. doi: http://dx.doi.org/10.1787/41194fea-en. https://www.oecd.org/eco/Finance-and-productivity-A-literature-review.pdf.

Kemkominfo. (2011). *Hasil Survei Penggunaan Teknologi Informasi dan Komunikasi (TIK) di Sektor Bisnis Indonesia 2011*. Pusat Data dan Sarana Informatika Kementerian Komunikasi dan Informatika Indonesia.

Lee, I. H., & Khatri, Y. (2003). Information technology and productivity growth in Asia. Asia and Pacific Department, International Monetary Fund. *IMF Working Paper WP/03/15*. https://www.imf.org/external/pubs/ft/wp/2003/wp0315.pdf.

Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies, 70*(2), 317–341. doi: https://doi.org/10.1111/1467-937X.00246.

Moreno-Badia, M., & Slootmaekers, V. (2009). The Missing Link Between Financial Constraints and Productivity. *IMF Working Paper WP/09/72*. European Department, International Monetary Fund. https://www.imf.org/external/pubs/ft/wp/2009/wp0972.pdf.

Mukim, M. (2011). Does exporting increase productivity? Evidence from India. *Manuscript*. London School of Economics. http://personal.lse.ac.uk/mukim/mukim_jmp.pdf.

Polder, M. (2015). Determinants of economic growth and productivity. In Statistics Netherlands, *ICT and Economic Growth*, pp. 7–29. The Hague: Statistics Netherlands. https://www.cbs.nl/en-gb/publication/2015/24/ict-and-economic-growth.

Press, K. (2006). *A Life Cycle for Clusters?: The Dynamics of Agglomeration, Change, and Adaption*. New York: Physica-Verlag Heidelberg.

Rachman, S., Gregory, M. A., & Narayan, S. W. (2015). *The Role of ICT Services on Indonesian Small to Medium Enterprise Productivity*. In 2015 International Telecommunication Networks and Applications Conference (ITNAC), Sydney, 18–20 November 2015. IEEE. doi: 10.1109/ATNAC.2015.7366807.

Sukmaretiana, F. (2016). The Role of R&D and Location in a Cluster on Total Factor Productivity Growth of Indonesian Manufacturing. *Journal of Applied Economics and Business, 4*(4), 5–20.

Strobel, T. (2012). ICT Intermediates, Growth and Productivity Spillovers: Evidence from Comparison of Growth Effects in-German and US Manufacturing Sectors. *Ifo Working Paper, 123*. http://www.cesifo-group.de/DocDL/IfoWorkingPaper-123.pdf.

Tabor, S. R. (2015). Constraints to Indonesia's economic growth. *ADB Papers on Indonesia, 10*. Asian Development Bank. https://www.adb.org/sites/default/files/publication/178041/ino-paper-10-2015.pdf.

UNCTAD. (2008). *Measuring the Impact of ICT Use in Business: The Case of Manufacturing in Thailand*. United Nations Conference on Trade and Development. http://unctad.org/en/docs/sdteecb20073_en.pdf.

Yasuda, T. (2005). Firm growth, size, age and behavior in Japanese manufacturing. *Small Business Economics, 24*(1), 1–15.