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Technology and Automation as Sources of 21st-Century Firm Productivity: The Economics of Slow Internet Connectivity in the Philippines

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Abstract: Internet connectivity remains to be problematic in the Philippines. Although the government has increased the country's efforts to heighten connectivity, current Internet and smartphone penetration rates are well below the target numbers, which is theorized to be caused by institutional rigidities. The study aims to analyze technological progress and automation as a source of increasing productivity and to prove that Internet connectivity indicates aggregate growth. The technical note suggests that productivity is enhanced with an increase in technology level as seen in the behavior of the slopes. Other findings suggest that an increase in Internet level would also increase individual firm productivity by also showing growth, and thus improvements in Internet levels and an increase in the number of firms adopting Internet connectivity both heighten firm productivity. The study recommends some strategies such as demand creation for connectivity, telecommunication tax reliefs, competition in the telecommunication industry, and increased infrastructure to address such concerns.

Key Words: Productivity; technology; automation; connectivity; Philippines

1. INTRODUCTION

The Philippines formally connected to the Internet in 1994, but even today the Internet remains mostly problematic. Data suggests that the Philippines is among the lowest ranked countries in the world in terms of Internet speed, Internet accessibility, and information sharing (PIDS, 2016). Today, information and communications technologies (ICTs) have been a game changer in some countries in sharing information, accessing connection, and taking the next step from current Internet connectivity to the next big ICT revolution: The Internet of Things (IoT). This enables always-on connectivity of anything with an on and off switch and a chip to the Internet (PIDS, 2016). However, if basic connectivity is lacking, the fundamental requirement for IoT to operate is not met. The required Internet speed for IoT to maintain its reliability, quality, and pervasiveness is currently more than 55 times the current average Internet connection speed of the Philippines (Hammi et al., 2017). Without pervasive, reliable and quality enterprise Internet connectivity capacities of the country, there is no IoT. Thus, with the growing demand for more advanced technologies, there is an increasing need for firms to implement Internet connectivity solutions.

Recent data from the government suggest that the state of the Internet in the country has been improving. The Philippines has experienced steady improvements in Internet connection in past years through observing specific standard indicators of the state of Internet growth set forth by DICT such as average broadband speed from 4 Mbps during Q1 of 2016, to 5.5 Mbps during Q1 of 2017, Internet and smartphone penetration rate from 37% in 2013 to 43.5 in 2016. The DICT and the National Telecommunications Commission NTC have a vision of a connected Philippines by 2024 (2017). According to the DICT National Broadband Plan, while national plans champion ICTs for their socio-economic potential with an immediate national target of at least 80%, Internet penetration rate for the majority of the population remains low, with estimates for Internet usage at 43.5% of the population, mobile penetration is high at 101%, and yet just 30.0%, smartphone penetration in the Philippines is relatively low (DICT, 2017). The country's Internet connection problems that result to a gap in the Internet penetration rate could potentially be caused by institutional rigidities that could limit connection capacities of businesses, and thus serves as a barrier to growth for the country facing IoT demands.

The study claims that faster Internet in principle increases the productivity of individuals and firms. Research suggests that Internet connectivity increases firm productivity. According to the Organisation for Economic Co-operation and Development, or the OECD (2003), access to broadband Internet is widely considered to be a productivity-enhancing factor. Similarly, Internet connectivity adoption of firms boosts firm productivity by 7 to 10%, which are consistent across urban versus rural areas and high versus low knowledge-intensive sectors. A McKinsey study also suggests that the Internet drives not just productivity, but also economic growth as a whole. Across a range of large and developed economies, the Internet exerts a strong influence on growth rates, where the Internet accounts for, on average, 3.4% of GDP across large economies that make up 70.0% of global GDP, as shown in Exhibit 2. Among the studied economies, the Internet accounted for 10% of GDP growth over the past 15 years, and its influence is continuing to grow. Over the past five years, the Internet's contribution to GDP growth more than doubled to 21.0% (Manyika and Roxburgh, 2011).

Conversely, a slower Internet means sluggish overall productivity. Although studies have been conducted to analyze the role of Internet levels in driving growth and productivity, no publication to this date has proven which among all factor inputs of Internet connectivity contribute to an increase in output.

This theoretical note aims (1) to analyze technological progress and, as an extension, automation as a source of increasing productivity that contribute to an increase in output, and (2) to assess whether Internet connectivity indicates aggregate growth.

2. ANALYTICS

2.1 Production Theory

In macroeconomic theory, Romer (1986) describes technical change or technological progress as having many dimensions such as the situation of larger quantities of output for given quantities of capital and labor, production of new and better products, and the creation of a variety of goods and services. Thus, technological progress forms an expectation of enhanced productivity (Romer, 1986).

2.3 Graph

Much of the work on productivity estimate the effects of production inputs on output. The economic theory of Brynjolfsson and Hitt (1994) states that the inputs of a firm can be related to output Q via a production function F, with another four variables such as capital K, labor L, differences in the industry j in which a firm operates, and differences in time t. Internet connectivity, in theory, represents factor-enhancing technical change. Thus, we treat the Internet captured by technical change A not as an input, but as a scalar to F. Formally,

$$Q = AF(K, L;\ j, t) \qquad (1)$$

The basic proposition is that a higher level of Internet connectivity translates to higher technical efficiency given inputs. With greater productivity, quantity increases when technical efficiency is higher. Thus, it must be so that the slope with the higher Q is less steep. Therefore, it must be that the effect of the technical change A would shift the supply curve to the right.

2.3 Model

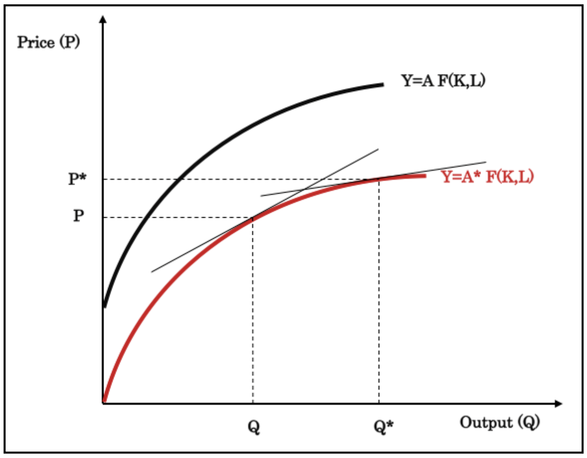

Figure 1: Production function with factor-enhancing technical change (Internet)

Connectivity is an increase in technology level (Dixon and Thompson, 2005). The Cobb-Douglas of the equation would need to incorporate the effect of technical change. Thus, there is a need to add another technology level parameter that represents Internet (percentage of effectiveness, i.e. quality) ϕ to be estimated together with the output elasticity ß of technical change. Equating the two parameters in the Cobb-Douglas function, we have the relationship

$$1 - \frac{1-\phi}{1-\beta} = \sigma \qquad (2)$$

where $\phi, \beta, \sigma \in \mathbb{R}_{+}$. The Cobb-Douglas function assumes that both ϕ and β output elasticities with respect to factors of production. Thus the output elasticities must be equal to one—a symmetric response $\phi + \beta = 1$ demonstrating constant returns to scale. The individual Cobb-Douglas function of the equation, where δ, γ, and σ are estimated parameters, in exponential form is as follows:

$$Q_{it} = A_{it} \exp\left(\Sigma_t \gamma_t T_t + \Sigma_{j-1} \delta_j J_j\right) K_{it}{}^{\sigma_1} L_{it}{}^{\sigma_2} \qquad (3)$$

Noticeably, technical change A as a scalar would directly affect Q; such that an increase in A_{it} would instantly increase Q_{it}. By taking logarithms and adding an error term, the individual linearized equation will be:

$$logQ_{it} = logA_{it}(\Sigma_{j-1} \delta_j J_j + \Sigma_t \gamma_t T_t + \sigma_1 logK_{it} + \sigma_2 logL_{it} + \epsilon_{it}) \qquad (4)$$

Working from (2), as technology level ϕ increases in each cycle in t, σ decreases and thus, from (4) the log of Q for the given cycle decreases. Therefore, given the technology level ϕ increase, the slope becomes less steep in each cycle in t. Similarly, as technology level ϕ decreases, σ increases and thus, the slope becomes steeper in each cycle in t, which decreases productivity.

This analysis illustrates that the level of productivity is increased with an increase in technology level, as seen in the marginal products of capital and labor subject to some technology level. The Internet level determines the magnitude of output given its scaling effect on the factors of production. Consequently, a negative Internet level decreases the level of productivity, as indicated by a lower output Q.

The fundamental proposition of this case with factor-enhancing technical change is that an increase in the level of Internet ϕ would translate to increases in productivity, ultimately resulting to output growth. From (1), we observe two variables: Internet level ϕ and output elasticity ß of Internet level, given $\phi, \beta, \sigma \in \mathbb{R}_{+}$ and $\phi + \beta = 1$ as long as $0 < \phi < 1$ and $0 < \beta < 1$. An increase in the level of Internet is represented by an increase in ϕ. Given the interaction of inputs in the Cobb-Douglas function, ceteris paribus, schematically,

$$1 - \frac{1-\uparrow\phi}{1-\beta} = \uparrow \sigma \qquad (5)$$

Where σ increases as a result of an increase in ϕ. Consequently, the effect of an increase in σ would also reflect in the Cobb-Douglas production function (3), schematically,

$$\uparrow Q_{it} = A_{it} \exp\left(\Sigma_t \gamma_t T_t + \Sigma_{j-1} \delta_j J_j\right) K_{it}{}^{\uparrow\sigma_1} L_{it}{}^{\uparrow\sigma_2} \qquad (6)$$

Where output Q_{it} also increases as an effect of an increase in σ. Although, the effects of $0 < \phi < 1$ and $0 < \beta < 1$ would mean that increasing either capital or labor increases output but at a diminishing rate, demonstrated by the diminishing marginal product of capital and labor. Simultaneously, a firm who is not connected to the Internet would have σ dropped to its production function, and will have no effect to the factor inputs of the firm.

3. FINDINGS AND DISCUSSION

The analytics prove that productivity is increased with rises in technology level as seen in the character of the marginal products of capital and labor. We have established that the Internet is factor-enhancing, which contributes to a higher level of output. More importantly, we have found that there is a need for quality estimators for Internet level beyond basic connectivity.

Although Internet connectivity (i.e., connected to the internet regardless of quality or speed) is a necessary condition for inducing productivity, it might not be sufficient enough. Theoretically, output would increase as more firms connect to the Internet than without. On the other hand, the effect of the Internet in enhancing production is also determined by speed and quality. These are characteristics of internet productivity introduced in this theoretical note.

The effective strategy then is, first, to increase the number of firms connected to the Internet, and second, to increase the Internet speed and quality for the connected firms. Otherwise, there would be, unsurprisingly, a sluggish pace of growth.

4. EXTENSION

4.1 A Model with Automation

The arbitrary effect of technical change is automation, and therefore the substitution of labor L. Acemoglu (2009) introduced a theoretical model where labor L and computer automation are perfect substitutes; thus L diminishes over time, and no new jobs for labor are created:

$$Q = AF(K, 0;\ j, t) \tag{7}$$

In the short run, labor will have no use in a fully automated world. Thus, rebuilding equation (4), where $L = 0$:

$$logQ_{it} = \ logA_{it}(\textstyle\sum_{j-1}\delta_j J_j + \sum_t \gamma_t T_t + \sigma_1 logK_{it} + \epsilon_{it}) \tag{8}$$

In the long-run, however, Acemoglu argues that labor will have a strict comparative advantage over the tasks previously held, creating a disincentive to automate production further. New jobs are created once the cost of automation is less than the cost of labor. Technical change σ represented in the Cobb-Douglas function becomes ineffective. Thus, with a constant technology level A, labor L increases as capital K goes down. This cycle will continue until labor L is equal to technology level A. Formally,

$$Q = \bar{A}\,F(K, L;\ j, t) \tag{1'}$$

In equilibrium, we re-express the production function as:

$$\tilde{Q}_\iota = \ \textstyle\sum_{j-1}\delta_j J_j + \tilde{A}_i + \tilde{K}_i + \tilde{L}_i \tag{1''}$$

At this point, lower-skill level jobs will be automated, where the Cobb-Douglas function σ is ineffective, while higher-skill level jobs carried out by labor. At this point, Internet level through σ has no further effect on steady-state output. Although observing the long-run impacts of automation, the effects of technology on productivity weaken over time.

5 CONCLUSIONS AND RECOMMENDATIONS

This theoretical note shows that productivity is indeed increased with an increase in technology level, i.e. connectivity as seen in the behavior of the marginal products of the factors of production. A technology level decrease, on the other hand, decreases the level of productivity. Improvements in Internet levels and growing the number of firms connected to the Internet, in the first place, would enhance overall productivity.

Practical policy solutions to further improve Internet connectivity in the Philippines must, therefore, be designed to increase the number of firms connected to the Internet, increasing Internet speeds, and enhancing its quality.

5.1 Tax Relief

A plan to encourage more firms to avail of enterprise-grade Internet subscription would increase the demand for productivity-enhancing connectivity. An increase in the demand for high-quality internet would address cost barriers. Both the telecommunications sector and the government can stimulate demand for high-quality Internet through

(1) special product packages and (2) conditional tax reliefs for small and medium-scale enterprises (SMEs), respectively.

Conditional tax reliefs, in practice, would accord internet connectivity an infant industry treatment that would allow early-stage enterprises to access enterprise-grade internet that can facilitate the implementation of cost-reducing innovations using IoT and the development of linkages to digitally facilitated supply chain trade. The application of limited, conditional tax reliefs would stimulate demand without creating a disincentive for the telecommunications sector from upgrading its facilities that price control measures (e.g., price ceilings) would inevitably create.

5.2 Competition in the Telecommunication Industry

Ramping up the third telecommunication player in the category can lower prices of higher-quality Internet through heightened competition through innovative pricing. The third player is entering the market with firms offering parity pricing and service bundles. It is likely that the third player would temporarily undercut incumbent firms by pricing while simultaneously driving product innovations targeted to SMEs to create an advantage in the market. Firms ultimately benefit from this heightened competition and consumers likewise benefit from an increase in efficiencies from the companies they patronize.

5.3 Infrastructure

Freeing up bandwidth for high-quality internet must be a top priority for the Philippine government. As this study shows, quality is a sufficient condition for factor productivity, investments in the Internet infrastructure to support growth is mandatory.

The Philippine government must also consider to proactively pursue discussions with other Association of Southeast Asian Nation (ASEAN) Member States on broadband infrastructure sharing within the region via the ASEAN Broadband Corridor, the creation of an ASEAN Single Telecommunications Market and participation in other relevant work programmes as specified in the ASEAN Master Plan on Connectivity 2025 (ASEAN, 2016).

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