RESEARCH ARTICLE

Probing the Viability of Scopus-Indexed Journal Quantity as Alternative Metric for Knowledge Capital: Evidence From Selected ASEAN+3 Economies

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Abstract: With Industry 4.0, the role of research cannot be undermined. As innovations drive the economy, we explicated the contribution of knowledge capital to the macroeconomy. Following the endogenous growth theory, we estimated a three-factor Cobb-Douglas aggregate production function for selected ASEAN+3 economies. Using the total number of Scopus-indexed journals as our proposed alternative metric for knowledge capital, we found that investing in the creation of more scientific researches and using it as productive inputs allow an economy to experience growth in the long run. Results showed that increasing knowledge capital, constituting higher levels of research, creates new technologies and innovations that stimulate economic growth.

Keywords: knowledge capital, production function, research and development, Scopus

As we enter the knowledge-based economy where intellectual capital (i.e., expertise and talent) creates wealth, research and innovation (R&I) has become a critical element to development (Olsson & Meek, n.d.). For O'Brien et al. (2011) and Tullao (2019), knowledge has become a valuable resource that can only be created through R&I. Recognizing that knowledge is also a resource suggests that "it can be acquired, transferred, combined and used, and it may be a potential source of sustainable competitive advantage" (O'Brien, et al., 2011, p. 237). According to Tullao (2018), knowledge capital formation via innovative activities, research and development, and technological development facilitate international competitiveness that contributes to productivity growth. In fact, as per the Organisation for Economic Co-operation and Development [OECD] (2013), economic growth in OECD-economies is being driven by rising investments not only in physical capital (e.g., property, plant, and equipment) but also in knowledge-based capital (i.e., intangibles) that generated long-term transformations. In fact, as discussed by Eliasson (2001), technologies based on invention and increased sophistication allowed for fundamental reorganization of economic production.

Clearly, this is reflective of the endogenous growth theory (Arrow, 1962; Uzawa, 1965; Sidrauski, 1967; Romer, 1987; Lucas, 1988; Grossman & Helpmann, 1989; Romer, 1990; Rebelo, 1991; Ortigueira & Santos, 1997) wherein infinite investment in human capital, innovation, and knowledge are significant contributors to economic growth thereby generating spillover effects and reducing diminishing returns to capital accumulation (Barro & Sala-i-Martin, 2004; Romer, 1994). That is, the theory underscores the positive externalities and spillover effects of a knowledge-based economy that drives economic development. In fact, Okokpujie et al. (2018) empirically exposed the contribution of research in economic development of developing economies. That is, research facilitated positive growth in Gross Domestic Product (GDP) and Net Domestic Product (NDP), creation of new inventions, and establishments of standards. Specifically, Khan (2015) underscored the studies of Blackburn et al. (2000) wherein research and development creates inventions and innovation that improve the quality of manufacturing and update existing technologies. Consistent with the models of earlier studies, it is recommended that to achieve economic growth, the accumulation of skills and knowledge in an economy is imperative. Human capital accumulation has an accelerator effect that provides incentives for research and innovations thereby boosting the economy as it improves the quality of manufacturing (Khan, 2015).

Research problem and objectives

We aim to provide an empirical approach to the endogenous growth model using country-specific time-series data on the stock of knowledge capital. That is, our contribution to the body of knowledge is the exploration of the contribution of knowledge capital, alongside human and physical capital on economic growth. We also aim to do time and space comparison between and among the impact of knowledge capital on aggregate output. In our study, we measure knowledge capital by the number of Scopus-indexed journal publications for each of the ASEAN5 (Indonesia, Malaysia, Singapore, Thailand, and the Philippines) and East Asian economies (China, Japan, and Korea). From here, we estimate a three-factor aggregate Cobb-Douglas production function supplementing the earlier findings such as that of Romer (1990) and Rebelo (1991). In doing so, we address our research question: *how does knowledge capital contribute to economic output?*

Contribution to literature

More importantly, in addressing our research questions, we are able to explore and test an alternative metric for knowledge capital despite availability of traditional measures (Samuelson & Nordhaus, 1998; Kim 2006; Jana 2016). Instead of using the traditional measures of knowledge (some studies aggregate physical and knowledge capital into accumulated capital), *we probe on the viability of using the total number of Scopus-indexed publications that economies generate*, following the discussion of Viale and Etzkowitz (2010) and Jana (2016).

Significance and limitations

On one hand, knowledge component-wise, we are also able to compare the direction and magnitude of knowledge capital between ASEAN5 and East Asian economies, using our alternative measure. On the other hand, policy component-wise, our findings can provide an insight toward the creation of policy measures that incentivizes education, research and development (R&D), and R&I. Likewise, following Eliasson (2001), our macro approach in scrutinizing the role of knowledge capital in economic growth is also designed to provide policy advice to both private and public sector, as well as the academe. However, given the differences in data availability per economy and the fact that the data on the number of Scopus-indexed publication started in 1996, we are compelled to use time series starting from this year until the most recent available for all economies. This would have implications in our chosen estimation procedure, which is discussed in the succeeding sections.

Our study is organized as follows: in the succeeding section, we model alternative specifications of the endogenous growth model with human capital. We then discuss the time-series data and technique used in the regression and estimates parameters of the alternative Cobb-Douglas production specifications for ASEAN5 and East Asian economies. We then discuss and validate the results vis-à-vis previous studies, in do time and space comparison. Finally, we present conclusions and recommendations for policymakers and future researchers.

Literature Review

On growth models

Over the years, the desire for national and industry growth has encouraged researchers to revisit and reanalyze the growth models. In its initial form, labor and capital were the key factors in achieving economic growth (Romer, 1986; Lucas, 1988; Rebelo, 1991). However, the simple growth model of labor and capital was further enhanced throughout the years. Just few years after the formulation of the initial growth model, a number of researchers realized that that sustainable growth is not possible without integrating technological advancement and innovation in the model (Romer, 1990; Grossman & Helpman, 1991). This created a more dynamic scheme for succeeding studies on growth by introducing growth effect that transcend one-to-one correspondence. Hence, our understanding of growth factors continued to expand and deepen.

Aghion and Howitt (1997) introduced a new concept to the growth factor wherein it was not mere capital that was to be factored in analyzing the growth of a nation or an institution but rather the accumulation of capital. Because the nature of capital of often being long term assets, the investments in the capital should also not be considered as a one-time factor in analyzing the growth. The long-term accumulation of capital was found to create a positive long-term growth in the economy. Following Aghion and Howitt (1997), van Marrewijk (1999) further focused on the nature of the growth factors wherein he created three main categories for these, namely: "(1) rival and non-accumulable inputs, (2) rival and accumulable inputs, (3) non-rival and accumulable inputs". An example of non-rival and accumulable inputs would be knowledge.

In addition, the dynamics of endogenous growth can also be defined by the experimentally organized economy (EOE) and competence bloc theory wherein technologies required to build a new industry include innovation, recognition, competition, market support, and receiver competence (Eliasson, 2001).

On human capital

Bucci (2009) used a balanced-growth model with physical and human capital accumulation to establish that the growth of the ratio of human to physical capital is driven by the economy's exogenous technological and preference parameters. It also positively depends on the share of skills invested in human capital formation. Moreover, Pegkas and Tsamadias (2014) used cointegration and error-correction model to establish that there exists a long-run cointegrating relationship between higher education, physical capital investments and economic growth. Likewise, they also found evidence of unidirectional long run and short-run Granger causality running from higher education and physical capital investments to economic growth. Alternatively, Tsen (2006) found that in China, economic growth Granger cause human capital accumulation, and not the other way around. Meanwhile, using a general equilibrium growth model, Lee (2004) provided interesting perspectives. Findings revealed that improving the quality of human capital by allocating more resources to education has positive effect on economic growth. However, this could be reversed by distortions in resource reallocation. Meanwhile, Kim (2003) used an extended growth model to contend that information technology and knowledge capital, arising from human capital (Rivera et al., 2019a, 2019b), are sources of productivity growth in Korea.

On knowledge capital

Most often, knowledge is interchanged with human capital wherein education (e.g., years of schooling) is used to represent the level of human capital in the study. For instance, the study of Laitner (1993) focused on the role of human capital and physical capital in the long-term growth of a closed economy. Similarly, the human capital was represented by years of education in the study. Similarly, Pyo (1995) explained the growth miracle of Korea by looking at the effects of accumulated human capital or human capital stock on economic output. Although the subject of the study differs, investment on human capital was used to represent human capital stock. The study of Klette and Johansen (1998) was able to somehow show the kind of infinitely accumulable growth factor mentioned by Rebelo (1991). In the study, the researchers looked into the spill over effect of the investment in previous R&D on the future growth of the company. Additionally, Diebolt and Hippe (2019) used larger and newer dataset on regional human capital and other factors spanning the 19th and 20th century. They found that past regional human capital is critical in explaining regional disparities in innovation and economic development.

Meanwhile, Mankiw (1995) pointed out that even lifetime is finite and thus, there is a limit to the extent of wealth accumulation. Moreover, Rebelo (1991) has already predicted that sustainable growth is possible only if there is a growth factor that can be accumulated indefinitely without diminishing returns. Given this, the use of flow capital such as investments in representing stock capital seems to be a flaw concept, which may lead to insignificant or misleading results.

On measuring knowledge capital

Several studies have alluded to knowledge capital as the product of education and innovation as key drivers of an economy's future. See Hunt (2003) for a discussion on the concept of knowledge and how to measure it. Hanushek and Woessmann (2008), "the magnitude of change needed makes clear that closing the economic gap with developed countries will require major structural changes in schooling institutions" (p. 607). That is, according to Berger and Fisher (2013), economies can create a solid foundation for economic success and shared prosperity by investing in human capital through expanded access to high quality education. Consequently, it will expand economic opportunity for the population and strengthen the overall state of economic health. Moreover, Hanushek and Woessmann (2020) reviewed the role of education in promoting economic growth, with emphasis on the role of knowledge capital (i.e., an economy's aggregate skills) and found strong evidence that the citizenry's cognitive skills (i.e., more than school attainment), are significantly related to long-run economic growth. That is, economic growth is the reward to investments in educational quality and R&D (Rivera et al., 2019a; 2019b). This is driven by complementarity of skills and quality of economic institutions.

As such, other than conventional measures of knowledge, we surmise that educational quality and R&D can be measured by research and publication. To emphasize quality, publications in at least Scopus-indexed journals are deemed acceptable (Erfanmanesh, 2017).

Research gap

With this, we will be using an actual stock knowledge capital represented by the number of Scopus-indexed journal publications for the Top 7 areas of research interest per country in analyzing its impact in an economy's real GDP (RGDP). We found no study that used such metric for knowledge capital. This is our contribution to literature – *probe the usefulness of our chosen measure for knowledge capital in estimating its impact on the economy*.

Aggregate Production Function with Knowledge Capital

Following Pyo (1995), in order to examine the role of knowledge capital in the context of time series data, consider the usual Cobb-Douglas production function (Equation 1).

$$Y_t = AK_t^a L_t^\beta ,\ 0 < \alpha\ 1,\ 0 < \beta < 1 \tag{1}$$

where Y_t, A_t, K_t, L_t are output, technology factor, capital, and labor, respectively. Note that the traditional neoclassical production function sets A as exogenously determined and the law of diminishing marginal returns holds.

The convergence hypothesis implied by the model can be revisited by deriving the rate of return (r) (Equation 2) as the difference between the marginal product of capital and the depreciation rate (d):

$$\frac{\partial Y_t}{\partial K_t} = r = \alpha AK_t^{a-1} L_t^\beta - d \tag{2}$$

If the growth rate of labor is exogenously given as n, the following condition must be satisfied to keep r at a constant level (Equation 3),

$$\frac{\left(\dfrac{dK_t}{d_t}\right)}{K} = \left(\frac{\beta n}{1-\alpha}\right) \tag{3}$$

which implies the steady state growth rate of capital stocks. According to Pyo (1995), "if capital stocks are low relative to the population and, therefore, a higher rate of return prevails, then the growth rate of capital will be higher. As capital is accumulated, the rate of return will fall to the steady state level" (p. 231). From here, it can be construed that a developing economy like Indonesia and the Philippines, with lower per capita capital stocks is expected to grow faster to converge to the steady state achieved by developed economies like Singapore and Japan.

On the other hand, appealing to the new growth theory emphasizing on the role of knowledge capital (instead of human capital), we endogenize the technology factor (Equation 4),

$$A_t = BW_t^{\gamma},\ 0 < \gamma < 1 \tag{4}$$

where W_t is the level of knowledge capital stocks. Therefore, if W_t increases by one percent, A_t will increase by γ percent. Hence, Equation 1 can be rewritten as Equation 5.

$$Y_t = BK_t^{\alpha} W_t^{\gamma} L_t^{\beta} \tag{5}$$

With the assumption that there are constant returns to factors that can be accumulated, Romer (1990) and Rebelo (1991) argued that sustained growth can be made attuned with technologies that demonstrate constant returns to scale. Suppose physical and knowledge capital exhibit constant returns (i.e., $\alpha + \gamma = 1$), then non-converging growth is possible.

As such, consider an alternative endogenous growth model deviating from the exogenous technology factor assumption. Appealing to Kendrick (1976), we use total capital (i.e., sum of physical and knowledge capital). Hence, we restate Equation 1 to Equation 6.

$$Y_t = A_t\left(K_t + W_t\right)^{\alpha} L_t^{\beta},\ 0 < \alpha < 1,\ 0 < \beta < 1 \tag{6}$$

Suppose that the accumulation of total capital stimulates technological accumulation, as specified in Equation 7,

$$A_t = B\left(K_t + W_t\right)^{\gamma},\ 0 < \gamma < 1 \tag{7}$$

which assumes that one percent growth of total capital increases technology by γ percent. Plugging Equation 7 to Equation 6 generates Equation 8, with rate of return specified by Equation 9.

$$Y_t = B\left(K_t + W_t\right)^{\alpha+\gamma} L_t^{\beta} \tag{8}$$

$$\frac{\partial Y_t}{\partial\left(K_t + W_t\right)} = r = \left(\alpha+\gamma\right)B\left(K_t + W_t\right)^{\alpha+\gamma-1} L_t^{\beta} - d \tag{9}$$

Therefore, from Equation 9, if there is increasing returns to capital (i.e., $\alpha + \gamma > 1$), r will grow as the capital stocks increase (Romer, 1987), which explains why the convergence of growth rates among different economies is not universally observed, but it rules out the possibility of steady state equilibrium. Hence, in Romer (1990) and Rebelo (1991), a constant return to capital was assumed (i.e., $\alpha + \gamma = 1$). Thus, r will be given as constant regardless of the level of total capital stocks. As such, r will also be constant and equal to the growth rate of per capita income, and the economy will always be at the steady state.

Estimation of Alternative Endogenous Growth Models with Knowledge Capital

Model and data specification

In revisiting the endogenous growth models with knowledge capital, we have derived log-linear equations from the alternative Cobb-Douglas production function for estimation. From Equations 1, 5, and 8, we can specify it as follows (see Equations 10, 11,12, and 13, respectively). Equations 10 to 13 are expressed in log-linear form for estimation, incorporating the stochastic disturbance term (u_t), which as per standard time series model is assumed to be a white noise process.

$$\ln Y_t = \Psi_0 + \alpha \ln K_t + \beta \ln L_t + \mu_t \tag{10}$$

$$\ln Y_t = \Psi_0 + \alpha \ln W_t + \beta \ln L_t + \mu_t \tag{11}$$

$$\ln Y_t = \Psi_1 + \alpha \ln K_t + \gamma \ln W_t + \beta \ln L_t + \mu_t \tag{12}$$

$$\ln Y_t = \Psi_1 + \left(\alpha+\gamma\right)\ln\left(K_t + W_t\right) + \beta \ln L_t + \mu_t \tag{13}$$

We also specify Equations 10 to 12 into its Harrod-Neutral formulation as seen in Equation 13 to 15. Here, we divide both sides of the equation with L_t so that the left-hand side becomes output per effective worker (Y_t/L_t) and the right-hand side becomes capital per effective worker (K_t/L_t) (Blanchard, 2003).

$$\ln\left(Y_t/L_t\right) = \Psi_0 + \alpha \ln\left(K_t/L_t\right) + \mu_t \tag{14}$$

$$\ln\left(Y_t/L_t\right) = \Psi_1 + \alpha \ln\left(K_t/L_t\right) + \gamma \ln\left(W_t/L_t\right) + \mu_t \tag{15}$$

$$\ln\left(Y_t/L_t\right) = \Psi_1 + \left(\alpha+\gamma\right)\ln\left[\left(K_t+W_t\right)/L_t\right] + \mu_t \quad (16)$$

In estimating the above equations, we can test the convergence hypothesis implied by the neoclassical growth model (i.e., whether α + β = 1 from Equation 10). Also, we can also test the statistical significance of the coefficient of knowledge capital stocks, as well as the hypothesis of constant returns to capital (i.e., α + γ = 1) in Equations 11, 12 and 15. Likewise, the same hypothesis (i.e., α + γ = 1) is tested from the estimation results of Equation 13 and 16. However, if the hypothesis of constant returns to capital is accepted from the estimation results of Equations 12 and 13, it may be necessary to re-estimate Equations 12, 13, 15, and 16 by imposing the constraint α + γ = 1. Table 1 summarizes the data requirements, measurements, and sources to estimate Equations 10 to 16. Note that for Y_t, K_t, and L_t, we have used traditional metrics prescribed by literature.

Table 1

Data requirements and measurements

#	Variable	Description	Measurement	Label	Source
1	Y_t	Aggregate Output	Real GDP at constant national prices (in millions of 2011 USD) from 1996 to 2018	$RGDP_t$	Federal Reserve Economic Data (Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/)
2	K_t	Physical Capital	Capital Stock at constant national prices (in millions of 2011 USD) from 1996 to 2018	CSK_t	Federal Reserve Economic Data (Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/)
3	L_t	Labor	Labor Force (number of active population aged 15 to 64) from 1996 to 2018	LAF_t	For Korea: Korea Statistical Yearbook; for the Philippines: Euromonitor; for Singapore: Ministry of Manpower; for the other economies, data was sourced from the Federal Reserve Economic Data (Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/)
4	W_t	Knowledge Capital	Number of Scopus-indexed journal publications for the Top 7 areas of research interest per country, as per Tullao (2019) from 1996 to 2018	$TKC7_t$	Scimago Journal & Country Rank (https://www.scimagojr.com/)
5	$K_t + W_t$	Total Capital	Sum of physical capital and knowledge capital	KW_t	Computed from existing data
6	Y_t/L_t	Aggregate Output per effective worker	Ratio between aggregate output and labor	$RGEW_t$	Computed from existing data
7	K_t/L_t	Physical Capital per effective worker	Ratio between physical capital and labor	$CSEW_t$	Computed from existing data
8	W_t/L_t	Knowledge Capital per effective worker	Ratio between knowledge capital and labor	$KCEW_t$	Computed from existing data
9	$(K_t + W_t)/L_t$	Total Capital per effective worker	Ratio between total capital and labor	$TKEW_t$	Computed from existing data

Measuring knowledge capital

However, for W_t, we emphasize that our measure for knowledge capital is the total number of Scopus-indexed journal publications for the Top 7 areas of research interest per country, as enumerated by Tullao (2019). As opposed to using the regular measures of knowledge capital such as R&D capital, number of schooling, among others (see Kim, 2006; Jana, 2016), we used the total number of Scopus-indexed journal publications because according to Viale and Etzkowitz (2010), "the scientific knowledge contained in a publication generates technological applications represented by patents, and technological exploitations generates scientific questions and answers" (p. 4), which have the capacity to create wealth (Stewart & Ruckdeschel, 1998; Jana, 2016). Hence, following Bock et al. (2005) and Fong et al. (2011), the foundation of competitive advantage and the primary driver of value is knowledge. This is because knowledge comprises experiences, understanding, and comprehension of an environment and its problems that compel economic agents to design and develop an appropriate response (McQueen, 1999). Alternatively, it is a combination of framed experience, values, contextual information, and expert insights that provides a framework for evaluating and incorporating new experiences and information (Ipe, 2003). This is our major contribution to literature – introduce an alternative measure for knowledge capital.

Estimation technique

Since we are working on a time series data (1996 to 2018) on a 3-factor input Cobb-Douglas production function, it is mandatory that we establish stationarity and cointegration (Enders, 2014). By implementing the Phillips-Perron Stationarity Test (Rivera, 2015) and the Engle-Granger Cointegration Test (Enders, 2014), we have determined that: (1) we would be working on first differenced values; and (2) there exists cointegration and Granger causality between and among some of our variables of interest except for those expressed in effective worker (see Table 2 and Table 3 for summary of results, respectively). However, the physical capital of the Philippines and the knowledge capital of Indonesia remained to be non-stationary despite the differencing. This may be due to the extreme fluctuations of investment inflows in the Philippines and unsustainable knowledge creation in Indonesia. Thus, the results of the regressions for the Philippines and Indonesia specifically on physical capital and knowledge capital, respectively, may not reflect their actual effect. Equations 10 to 13 specify the long run relationship between aggregate output and the factors of production namely physical capital, knowledge capital, and labor. On the other hand, Equations 14 to 16 specify the long run relationship between aggregate output per effective worker and the factors of production namely physical capital per effective worker and knowledge capital per effective worker.

Table 2

Order of intergration of variables as per Phillips-Perron stationarity test

#	Variable	Philippines	Indonesia	Malaysia	Thailand	Japan	South Korea	Singapore
1	$\ln RGDP_t$	1	1	1	1	1	1	1
2	$\ln CSK_t$	2	1	1	1	0	0	1
3	$\ln LAF_t$	1	0	1	1	1	1	1
4	$\ln TKC7_t$	1	2	1	1	0	0	0
5	$\ln KW_t$	0	0	1	1	1	1	1
6	$\ln RGEW_t$	1	0	1	1	1	1	1
7	$\ln CSEW_t$	1	0	1	1	0	0	1
8	$\ln KCEW_t$	1	0	1	1	0	0	1
9	$\ln TKEW_t$	2	0	1	1	0	0	1

Note: Because at least one variable is $I(2)$, statistically, the order of integration should be 2. However, we would work with $I(1)$ to preserve the economic interpretability of the variables.

Table 3

Summary results of the Engle-Granger cointegration test

Economy	Results
Philippines	• D.ln$RGDP_t$, and D.ln$CPSK_t$ are cointegrated • D.ln$RGDP_t$ and D.ln$LBFR_t$ are cointegrated • D.ln$RGDP_t$ and D.ln$TKC7_t$ are cointegrated • D.ln$RGDP_t$ and D.ln$CSKC_t$ are cointegrated • D.ln$RGEW_t$ and D.ln$KCEW_t$ are cointegrated
Indonesia	• D.ln$RGDP_t$, and D.ln$CPSK_t$ are cointegrated • D.ln$RGDP_t$ and D.lnLAF_t are cointegrated • D.ln$RGEW_t$ and D.ln$KCEW_t$ are cointegrated
Malaysia	• None of the variables are cointegrated
Thailand	• None of the variables are cointegrated
Japan	• None of the variables are cointegrated
South Korea	• None of the variables are cointegrated
Singapore	• None of the variables are cointegrated.

Our empirical analysis complied with standard time series econometrics techniques (Enders, 2014), specifically the Autoregressive Distributed Lag (ARDL) Model. Each economy was regressed individually to quantify the effects of the key dependent variables namely, the physical capital, the knowledge capital, and the labor on the RGDP.

We chose separate ARDL regression for each economy rather than panel data because of: (1) we are more interested in the direction, magnitude, and significance of the technical coefficients for each economy than differential intercepts across year and/or economy (i.e., allowing slope coefficients to vary by year and/or economy is more informative for our purposes and objectives than additional intercepts; and (2) although a panel with year and/or economy fixed effects should be adequate as per literature (Gujarati & Porter, 2009; Enders, 2014), separate regressions is an alternative if the true data generating process is unknown and given the differences in assumptions imposed on disturbances (Balestra & Nerlove, 1966; Baltagi, 1986).

Results

The results of the regressions on log GDP using ARDL model are shown in Appendix 1 for the Philippines, Indonesia, Malaysia, Thailand, Japan, South Korea, and Singapore.

Starting with the estimation of the Philippines, both physical capital and knowledge capital are insignificant while labor is significant to log RGDP. The insignificance of physical capital may be due to the data discrepancy wherein physical capital data remained to be unpredictable or non-stationary despite differencing in both unrestricted and the Harrod-Neutral models. This discrepancy may have also led to labor being insignificant when regressed together with capital stock. This being said, labor is significant at 1 percent confidence level when regressed with knowledge capital (Equation 12). Although minimal in magnitude, the coefficients of labor in equation 11 and 12 have positive signs, as predicted. However, log knowledge capital per labor in the Harrod-Neutral model is significant at the 10 percent confidence level.

Getting the inverse of the coefficient, we can say that knowledge capital increases labor productivity by 9.92 percent.

For Indonesia, physical capital, total capital, and labor are consistently significant and knowledge capital is insignificant in both unrestricted and Harrod-Neutral models. Interestingly, in the unrestricted model, physical capital has a negative coefficient, but this becomes positive when combined with knowledge capital. The magnitude of the impact increases as well. This shows that, although knowledge capital is not large enough to influence the country's output, it enhances the impact brought by the physical capital. Looking at the Harrod-Neutral model, physical capital per labor and total capital per labor positively affect the country output as well. Similar to the unrestricted model, total capital per labor has a greater contribution that physical capital per labor. However, the inverse of the coefficient of physical capital per labor portrays that the effect of physical capital in labor is minimal (0.098%). Nonetheless, the results show that physical capital is deeply integrated in Indonesia's level of output compared to knowledge capital. Similar to the Philippines, knowledge capital present in the economy in the forms of research may not be enough yet to create significant economic impacts.

As for Thailand, significant results are only present in the unrestricted model. An explanation could be that physical capital and knowledge capital are not yet that involved in labor productivity of the country. In the unrestricted model, Equation 12 shows significant effects for physical capital and knowledge capital. However, opposed to our expectation, physical capital has a negative sign which implies a percent increase in physical capital leads to 2 percent decrease in the economy's output. As for the knowledge capital, although it has a positive coefficient, the effect is very minimal (0.1355%).

Looking at Malaysia, it is the only developing economy that shows positive and significant results for knowledge capital in both unrestricted and Harrod-Neutral models (Equation 11, 12, and 14). However, the signs of the coefficients of knowledge capital are negative which means an increase in knowledge capital will lead to a decrease in the country's output. Moreover, the magnitude of its impact remains to be minimal. The same behavior is seen for the physical capital per labor. The magnitude of decrease is greater for total capital per labor wherein a percent increase in total labor leads to 6 percent decrease in output. Nonetheless, the impact of knowledge capital can be seen in Malaysia wherein the significant coefficients of knowledge capital allow us to surmise that Malaysia is one of the most developed economy in Southeast Asia with respect to knowledge capital.

Moving on to Japan, physical capital, knowledge capital, and total capital significantly impacts output. Although the coefficients are small, the results still show a positive increase in the RGDP when physical capital and knowledge capital increase. However, when the two capitals are combined, it creates a negative impact to total output (Equation 13). The magnitude of decrease is far much greater than the increase brought by each of the capitals. Moreover, the Harrod-Neutral model, Table 22, shows that capital stock and the combination of knowledge capital and capital stock have positive impacts in labor productivity. Taking the reciprocal of the coefficients of the Harrod-Neutral model, we are able to compute for the effect of the variable on labor force productivity. Capital has a remarkable effect of 15.87 percent in labor productivity. The combination of the capitals also positively influences the output of Japan but by a very minimal percentage (0.644%).

South Korea is an economy that benefited much from the increase in knowledge capital. In the unrestricted model, physical, knowledge, and total capital significantly affect the country's RGDP. As predicted, the coefficients of physical capital and knowledge capital are positive and the magnitude of physical capital is greater. On the other hand, total capital creates negative impact to the economy by a big percentage. Surprisingly, labor force remains to be insignificant. As for the Harrod-Neutral model, only physical capital per labor is significant and the reciprocal of its coefficient indicates that a percentage increase in physical capital will increase labor productivity by 125 percent. Moreover, the magnitude of the impact of South Korea's physical and knowledge capital on the country's output is almost double that of Japan's.

In Singapore, knowledge capital is consistently significant in both unrestricted and the Harrod-Neutral models. The coefficients of knowledge capital are positive which is in-line with our hypothesis. Physical capital becomes significant in the unrestricted model only when regressed with the knowledge capital. Moreover, physical capital negatively affects the output of the country in both models. The reciprocal of the coefficient of knowledge capital per labor (Equation 14) shows a remarkable result wherein it increases labor productivity by 7.48 percent. This percentage is the highest among all the countries included in the study. Based on these results, it can be inferred that the physical capital is deeply immersed with the knowledge capital in Singapore wherein these are complementary goods

Discussion

From the results, in order to create a more general analysis, the countries are categorized into two, the developing and the developed economies. Under the developing economies, we consider the Philippines, Indonesia, Thailand, and Malaysia. As for the developed economics, Japan, South Korea, and Singapore are included. Although a consistent characteristic for each category may not be made, these countries under a category react in a similar matter. For the developing countries, the output of the country is mostly affected by the labor and the physical capital. The effect of knowledge capital is only significant in Malaysia, a country that is considered to be the most developed among the developing economies. On the other hand, the developed economies have shown to be significantly affected by knowledge capital, whether negatively or positively.

We can construe from the results that the marginal benefits from R&D and R&I on economic growth and development are more pronounced in developing economies. Following the argument of Taylor (1966) wherein university research at the post-graduate level, in particular, can respond to the immediate needs of developing economies because it can drive the various development schemes and help many economic concerns get going. Hence, it is vital that a good proportion of an economy's better graduates be trained in research methods so that as they become experts in their fields, they get involved in projects that will be helpful in furthering the economic growth and development prospects of their respective countries.

Moreover, the local ability to put new technologies, arising from research, to industrial use matters to achieve a faster growth track (Eliasson, 2001). However, to do this, there is a need for a country's education system to imbibe in its youth the qualities of inquisitiveness, systematic enquiry, and desire to understand the unknown (Taylor, 1966). Consequently, in the long run, good results in fundamental research brings world recognition, which is vital for developing economies aiming for financial investments. If an economy is capable of making fundamental discoveries, technologies, and innovations, then it must have a good local manpower, which is attractive for financial investments.

Meanwhile, for developed economies, research also plays a significant role because in the midst of globalization, the ability to create and acquire knowledge is as important as using this knowledge effectively towards value creation (Akcali & Sismanoglu, 2015). This is to ensure that developed countries would be able to sustain their growth and development trajectory.

Through our results, we have seen that the creation of knowledge is important for both developing and developed countries because of its resulting positive socio-economic benefits. We have reinforced the argument that indeed, research creates innovation that leads to increased productivity. Consequently, this allows an economy to experience increasing wealth, guaranteed employment, sustainable growth, enhanced quality of life (Akcali & Sismanoglu, 2015). That is, research is a conduit for an economic boom (Hall, 2019).

Globalization, international competition, and the pursuit for sustainable growth have made research more pronounced in most economies. Rising capabilities to create knowledge are keys to move innovation. From our empirical applications, we found evidence on the relationship between knowledge capital and economic growth, consistent with Kim (2003), Pegkas and Tsamadias (2014), Akcali and Sismanoglu (2019), and Hanushek and Woessmann (2020).

Conclusion

We used the 3-factor Cobb-Douglas function to estimate the effects of physical capital, knowledge capital, and labor force on RGDP of selected developing and developed ASEAN+3 economies. Correcting previous researches that used flow capital such as investments to represent stock capital, we probed the viability of utilizing the number of Scopus-published articles in top 7 subject areas to represent knowledge capital. Through this, we are able to truly analyze the effect of stock or accumulated capital in the output growth of countries. Moreover, to exclude other country-specific factors from affecting the estimates, the selected countries are regressed individually using their time series data from 1996 to 2018.

Although regressed individually, we saw a common trend among developing and developed economies. For developing economies such as the Philippines, Indonesia, Thailand, and Malaysia, knowledge capital is found to be insignificant in most of the equations. In the case that it is significant, the coefficient is very small. On the other hand, developed economies such as Japan, South Korea, and Singapore, knowledge capital is often significant with coefficients having bigger magnitudes. Hence, we surmise that higher and sustained levels of knowledge capital can stimulate GDP growth. However, regressions are inconsistent across economies.

Alternatively, it is also interesting to underscore that as far as causality and cointegration are concerned, only the developing economies of the Philippines and Indonesia have demonstrated such implying how R&D and R&I are critical for these economies in stimulating economic growth. Meanwhile, the results are the opposite for Malaysia, Thailand, Japan, South Korea, and Singapore who are now reaping the benefits of R&D and R&I that they have done in previous decades and continuously doing until the present time. Although research is still vital, it is not anymore the major driver of economic growth but rather moderating or mediating variable.

Given the intuitive empirical results we have generated, we construe that the viability of our chosen metric for knowledge capital is promising. However, further reconsiderations are still warranted to amplify our proposed metric's robustness. Thus, we suggest future researchers to try different regressions models and to expand the data sample in terms of years and the number of economies. It would also be interesting to establish whether R&D and R&I are principal explanatory, mediating, or moderating variables of economic growth. Likewise, estimating the same model using various measures for knowledge capital will allow for comparison and validation on the different peculiarities, advantages, and disadvantages of using different metrics for knowledge capital. To bridge the gap between separate regressions and panel data, it is recommended that future studies run both techniques and compare and contrast the results. Finally, it is also worth appealing to the EOE approach, highlighted by Eliasson (2001), in applying the endogenous growth theory using our metric for knowledge capital.

Declaration of Ownership

This report is our original work.

Conflict of Interest

None.

Ethical Clearance

This study was approved by our institution.

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Appendix

Appendix 1. *Parameter estimates for unrestricted and Harrod-Neutral models.*

Appendix 1a. The Philippines

Parameter Estimates using ARDL– the Philippines (unrestricted)

Equation	Constant	$\ln K_t$ $\ln CPSK_t$	$\ln W_t$ $\ln TKC7_t$	$\ln(K_t + W_t)$ $\ln(CPSK_t + TKC7_t)$	$\ln L_t$ $\ln LBFR_t$	R^2	Durbin-Watson (DW)	Breush-Godfrey LM (p)
the Philippines (at first differencing); dependent variable: $D.\ln Y_t$ ($D.\ln RGDP_t$)								
10	-4.02079 (1.990123) [0.059]	0.139843 (0.1249) [0.453]	–	–	0.7321801 (0.160044) [0.197]	0.9979	2.1668	0.6325
11	-2.361829 (1.461502) [0.124]		0.0606781 (0.043247) [0.179]		0.5243327 (0.182830) [0.011]	0.998	2.423974	0.0445
12	-1.6883 (2.3488) [0.028]	0.00897 (0.219321) [0.5390]	0.07514 (0.05919) [0.224]	–	0.54802 (0.22614) [0.028]	0.998	2.2081	0.5821
13	-3.9675 (1.907753) [0.052]	–	–	5.094702 (3.83021) [0.200]	-4.734233 (3.716903) [0.219]	0.997	2.1723	0.6240

Standard errors are in ( ); *p*-values are in [ ].

Parameter Estimates using Ordinary Least Squares – the Philippines (Harrod-Neutral)

Equation	Constant	$\ln K_t/L_t$ $\ln CPSK_t/\ln LBFR_t$	$\ln W_t/L_t$ $\ln TKC7_t/\ln LBFR_t$	$\ln[(K_t + W_t)/L_t]$ $\ln[(CPSK_t + TKC7_t)$ / $\ln LBFR_t]$	R^2	Durbin-Watson (DW)	Breush-Godfrey LM (p)
the Philippines (at first differencing); dependent variable: $D.\ln(Y_t/L_t)$ ($D.\ln RGDP_t//\ln LBFR_t$)							
14	0.1747686 (0.2957228) [0.562]	-2.589219 (4.511321) [0.573]	–	–	0.9909	1.3921	0.2087
15	0.3588619 (0.3621595) [0.336]	-0.24793 (0.145401) [0.108]	0.10077 (0.05087) [0.065]		0.9943	1.6360	0.4667
16	0.8065807 (0.2556701) [0.005]	–	–	0.0565579 (0.0460314) [0.235]	0.9931	1.3972	0.2089

Standard errors are in ( ); *p*-values are in [ ].

Appendix 1b. Indonesia

Parameter Estimates using ARDL – Indonesia (unrestricted)

Equation	Constant	lnK_t lnCSK_t	lnW_t ln$TKC7_t$	ln(K_t+ W_t) ln($CPSK_t$+$TKC7_t$)	lnL_t ln$LBFR_t$	R^2	Durbin-Watson (*DW*)	Breush-Godfrey LM (*p*)
Indonesia (at first differencing); dependent variable: D.lnY_t (D.ln$RGDP_t$)								
10	3.969432 (1.629696) [0.027]	-3.424387 (0.181263) [0.0000]	–	–	0.378906 (0.134632) [0.012]	0.9995	1.870716	0.9425
11	-12.65443 (6.043812) [0.218]	-	-0.021558 (0.100134) [0.832]	–	1.238368 (0.495837) [0.024]	0.9846	1.698101	0.6826
12	4.133953 (1.438156) [0.012]	-3.3575897 (0.158479) [0.000]	-0.016003 (0.016793) [0.357]	–	0.2538132 (0.126526) [0.065]	0.9997	1.698101	0.6826
13	-11.93055 (5.148583) [0.034]	–	–	5.230095 (2.216472) [0.031]	-0.008327 (0.002727) 0.005	0.9930	0.517083	0.0001

Standard errors are in ( ); *p*-values are in [ ].

Parameter Estimates using ARDL – Indonesia (Harrod-Neutral)

Equation	Constant	lnK_t/L_t lnCSK_t/ln$LBFR_t$	lnW_t/L_t ln$TKC7_t$/ln$LBFR_t$	ln[(K_t+ W_t)/L_t] ln[($CPSK_t$+ $TKC7_t$) / ln$LBFR_t$]	R^2	Durbin-Watson (*DW*)	Breush-Godfrey LM (*p*)
Indonesia (at first differencing); dependent variable: D.ln(Y_t/L_t) (D.ln$RGDP_t$//ln$LBFR_t$)							
14	6.492644 (0.0101961) [0.000]	1.013852 (0.0030673) [0.000]	–	–	0.9289	1.705664	0.5160
15	6.480728 (0.0994385) [0.000]	1.015202 (0.0116327) [0.000]	-0.0013947 (0.0115724) [0.905]		0.9998	1.70033	0.5016
16	3.956721 (0.0396396) [0.000]	–	–	1.243787 (0.0168085) [0.000]	0.9964	0.0839079	0.0000

Standard errors are in ( ); *p*-values are in [ ].

Appendix 1c. Malaysia

Parameter Estimates using ARDL – Malaysia (unrestricted)

Equation	**Constant**	**lnK_t** lnCSK_t	**lnW_t** ln$TKC7_t$	**ln(K_t+ W_t)** ln($CPSK_t$+ $TKC7_t$)	**lnL_t** ln$LBFR_t$	R^2	**Durbin-Watson (*DW*)**	**Breush-Godfrey LM (*p*)**
Malaysia (at first differencing); dependent variable: D.lnY_t (D.ln$RGDP_t$)								
10	-3.153836 (1.36273) [0.035]	-0.5350707 (0.395735) [0.196]	–	–	0.2055374 (0.215517) [0.355]	0.9909	2.008264	0.9210
11	-3.828125 (2.976735) [0.218]	-	-0.12752 (0.068158) [0.081]	-	0.4035626 (0.196383) [0.058]	0.9926	2.59622	0.0042
12	-4.129612 (3.466639) [0.255]	-0.5629013 (0.364308) [0.146]	-0.141568 (0.068095) [0.058]	–	0.3418768 (0.199321) [0.110]	0.9938	2.59622	0.0042
13	-2.759352 (1.38252) [0.064]	–	–	-4.813175 (3.326386) [0.168]	4.394756 (2.884131) 0.148	0.9911	1.952299	0.9172

Standard errors are in ( ); *p*-values are in [ ].

Parameter Estimates using ARDL – Malaysia (Harrod-Neutral)

Equation	**Constant**	**lnK_t/L_t** lnCSK_t/ln$LBFR_t$	**lnW_t/L_t** ln$TKC7_t$/ln$LBFR_t$	**ln[(K_t+ W_t)/L_t]** ln[($CPSK_t$+ $TKC7_t$) / ln$LBFR_t$]	R^2	**Durbin-Watson (*DW*)**	**Breush-Godfrey LM (*p*)**
Malaysia (at first differencing); dependent variable: D.ln(Y_t/L_t) (D.ln$RGDP_t$//ln$LBFR_t$)							
14	-0.1641084 (0.214354) [0.454]	-0.8098213 (0.242627) [0.004]	–	–	0.9289	1.786628	0.6479
15	-0.8210161 (0.270032) [0.008]	-0.6252121 (0.199198) [0.007]	-0.1085787 (0.051946) [0.054]		0.9610	1.749946	0.2914
16	-0.1562624 (0.6677398) [0.818]	–	–	-6.760069 (1.838519) [0.002]	0.9320	1.815129	0.7050

Standard errors are in ( ); *p*-values are in [ ].

Appendix 1d. Thailand

Parameter Estimates using ARDL – Thailand (unrestricted)

Equation	Constant	**lnK_t** lnCSK_t	**lnW_t** ln$TKC7_t$	**ln(K_t + W_t)** ln($CPSK_t$ + $TKC7_t$)	**lnL_t** ln$LBFR_t$	R^2	Durbin-Watson (*DW*)	Breush-Godfrey LM (*p*)
Thailand (at first differencing); dependent variable: D.lnY_t (D.ln$RGDP_t$)								
10	-6.640568 (8.717709) [0.458]	0.6602972 (0.874024) [0.462]	–	–	-0.332783 (0.597156) [0.586]	0.9809	1.900079	0.8516
11	5.318966 (5.431655) [0.342]	–	-0.040467 (0.102967) [0.699]	–	0.0919198 (0.398641) [0.821]	0.9900	2.120219	0.2986
12	19.47668 (5.75625) [0.005]	-2.769373 (0.630367) [0.001]	0.135581 (0.075240) [0.095]	–	0.0189266 (0.278344) [0.947]	0.9966	2.120219	0.2986
13	-8.236363 (10.25478) [0.434]	–	–	6.208554 (9.572298) [0.526]	-5.94877 (8.89418) 0.514	0.9809	1.815496	0.6256

Standard errors are in ( ); *p*-values are in [ ].

Parameter Estimates using ARDL – Thailand (Harrod-Neutral)

Equation	Constant	**lnK_t/L_t** lnCSK_t/ln$LBFR_t$	**lnW_t/L_t** ln$TKC7_t$/ln$LBFR_t$	**ln[(K_t+W_t)/L_t]** ln[($CPSK_t$+ $TKC7_t$) / ln$LBFR_t$]	R^2	Durbin-Watson (*DW*)	Breush-Godfrey LM (*p*)
Thailand (at first differencing); dependent variable: D.ln(Y_t/L_t) (D.ln$RGDP_t$//ln$LBFR_t$)							
14	0.1717654 (0.3813309) [0.658]	-0.2472478 (0.5413998) [0.654]	–	–	0.9601	1.636029	0.7267
15	-0.6132867 (0.299961) [0.059]	-0.4635824 (0.347684) [0.202]	-0.0647069 (0.0847558) [0.457]		0.9858	1.80725	0.6129
16	0.0652139 (0.4728132) [0.892]	–	–	-2.812096 (5.78783) [0.633]	0.9602	1.627723	0.7152

Standard errors are in ( ); *p*-values are in [ ].

Appendix 1e. Japan

Parameter Estimates using ARDL – Japan (unrestricted)

Equation	Constant	**lnK_t** ln$CPSK_t$	**lnW_t** ln$TKC7_t$	**ln(K_t+ W_t)** ln($CPSK_t$+ $TKC7_t$)	**lnL_t** ln$LBFR_t$	R^2	**Durbin-Watson (*DW*)**	**Breush-Godfrey LM (*p*)**
			Japan (at first differencing); dependent variable: D.lnY_t (D.ln$RGDP_t$)					
10	16.31388 (8.030774) [0.059]	0.5732221 (0.184897) [0.007]	–	–	-3.452345 (0.972111) [0.003]	0.9411	2.110068	0.7126
11	23.16103 (9.146932) [0.021]	–	0.1671987 (0.076826) [0.044]	-–	-3.857447 (0.986700) [0.001]	0.9313	2.124309	0.3085
12	16.98603 (9.758314) [0.102]	0.5381387 (0.329617) [0.123]	0.0143443 (0.109878) [0.898]	–	-3.436647 (1.010602) [0.102]	0.9412	2.110068	0.7126
13	7.020153 (7.092153) [0.338]	–	–	-12.37664 (3.933808) [0.007]	6.993898 (3.381664) 0.056	0.9643	2.135208	0.5929

Standard errors are in ( ); *p*-values are in [ ].

Parameter Estimates using ARDL – Japan (Harrod-Neutral)

Equation	**Constant**	**lnK_t/L_t** lnCSK_t/ln$LBFR_t$	**lnW_t/L_t** ln$TKC7_t$/ln$LBFR_t$	**ln[(K_t+ W_t)/L_t]** ln[($CPSK_t$+ $TKC7_t$) / ln$LBFR_t$]	R^2	**Durbin-Watson (*DW*)**	**Breush-Godfrey LM (*p*)**
			Japan (at first differencing); dependent variable: D.ln(Y_t/L_t) (D.ln$RGDP_t$/ln$LBFR_t$)				
14	-0.5389874 (0.2738689) [0.065]	0.3625545 (0.1556881) [0.065]	–	–	0.9495	2.077443	0.6704
15	-0.7398058 (0.739932) [0.331]	0.4285894 (0.2760283) [0.139]	-0.0351156 (0.1196862) [0.773]		0.9497	2.135208	0.5929
16	-1.481765 (0.6261623) [0.029]	–	–	1.551456 (0.6362098) [0.025]	0.9506	2.050454	0.7140

Standard errors are in ( ); *p*-values are in [ ].

Appendix 1f. South Korea

Parameter Estimates using ARDL – South Korea (unrestricted)

Equation	**Constant**	**lnK_t** lnCSK_t	**lnW_t** ln$TKC7_t$	**ln(K_t+ W_t)** ln($CPSK_t$+ $TKC7_t$)	**lnL_t** ln$LBFR_t$	R^2	**Durbin-Watson (*DW*)**	**Breush-Godfrey LM (*p*)**
South Korea (at first differencing); dependent variable: D.lnY_t (D.ln$RGDP_t$)								
10	24.0523 (7.712626) [0.007]	1.235891 (0.330729) [0.002]	–	–	-0.389545 (0.597007) [0.523]	0.9899	1.808124	0.4300
11	6.648534 (5.185059) [0.217]	–	0.2258074 (0.089369) [0.022]	–	0.8037904 (0.588460) [0.190]	0.9874	1.808124	0.4380
12	25.72621 (9.324695) [0.015]	1.412176 (0.617932) [0.037]	-0.052749 (0.154347) [0.737]	–	-0.556467 (0.784728) [0.489]	0.9899	1.808124	0.4380
13	32.49681 (11.07165) [0.010]	–	–	-14.05289 (7.1632222) [0.069]	11.37941 (6.16666) 0.085	0.9902	1.361156	0.0173

Standard errors are in ( ); *p*-values are in [ ].

Parameter Estimates using ARDL – South Korea (Harrod-Neutral)

Equation	**Constant**	**lnK_t/L_t** lnCSK_t/ln$LBFR_t$	**lnW_t/L_t** ln$TKC7_t$/ln$LBFR_t$	**ln[(K_t+ W_t)/L_t]** ln[($CPSK_t$+ $TKC7_t$) / ln$LBFR_t$]	R^2	**Durbin-Watson (*DW*)**	**Breush-Godfrey LM (*p*)**
South Korea (at first differencing); dependent variable: D.ln(Y_t/L_t) (D.ln$RGDP_t$//ln$LBFR_t$)							
14	3.828133 (1.174668) [0.004]	0.7069542 (0.2355115) [0.008]	–	–	0.9756	1.41306	0.0187
15	4.192401 (1.370556) [0.007]	0.5555 (0.3663853) [0.148]	0.0784997 (0.1433878) [0.591]		0.976	1.417312	0.0047
16	1.116858 (0.500607) [0.039]	–	–	2.027688 (1.219794) [0.114]	0.9683	1.575699	0.1979

Standard errors are in ( ); *p*-values are in [ ].

Appendix 1g. Singapore

Parameter Estimates using ARDL – Singapore (unrestricted)

Equation	Constant	$\ln K_t$ $\ln CSK_t$	$\ln W_t$ $\ln TKC7_t$	$\ln(K_t + W_t)$ $\ln(CPSK_t + TKC7_t)$	$\ln L_t$ $\ln LBFR_t$	R^2	Durbin-Watson (*DW*)	Breush-Godfrey LM (*p*)
Singapore (at first differencing); dependent variable: $D.\ln Y_t$ ($D.\ln RGDP_t$)								
10	-0.3659677 (2.507731) [0.886]	-0.2583479 (0.933035) [0.786]	–	–	-0.007303 (0.143185) [0.960]	0.9880	1.79622	0.5894
11	2.371026 (1.854286) [0.218]	–	0.112361 (0.052931) [0.049]	–	-0.014965 (0.120722) [0.218]	0.9904	2.00679	0.4373
12	1.332011 (1.777434) [0.466]	-2.795004 (0.884425) [0.007]	0.2797661 (0.066875) [0.001]	–	0.0258809 (0.099124) [0.798]	0.9947	2.00679	0.4373
13	-0.1837908 (2.704602) [0.947]	–	–	0.0497858 (2.873268) [0.986]	-0.036784 (2.044576) [0.947]	0.9878	1.922188	0.9483

Standard errors are in ( ); *p*-values are in [ ].

Parameter Estimates using ARDL – Singapore (Harrod-Neutral)

Equation	Constant	$\ln K_t/L_t$ $\ln CSK_t/\ln LBFR_t$	$\ln W_t/L_t$ $\ln TKC7_t/\ln LBFR_t$	$\ln[(K_t + W_t)/L_t]$ $\ln[(CPSK_t + TKC7_t)/\ln LBFR_t]$	R^2	Durbin-Watson (*DW*)	Breush-Godfrey LM (*p*)
Singapore (at first differencing); dependent variable: $D.\ln(Y_t/L_t)$ ($D.\ln RGDP_t//\ln LBFR_t$)							
14	-0.1428631 (0.1581892) [0.379]	-0.7329779 (0.1832348) [0.001]	–	–	0.9534	1.602031	0.3122
15	0.0860014 (0.1527061) [0.581]	-0.7951766 (0.1536445) [0.000]	0.1366694 (0.0464804) [0.010]		0.9697	2.056821	0.5583
16	-0.9516927 (0.5416509) [0.097]	–	–	-2.569851 (0.6246161) [0.001]	0.9511	1.578081	0.2800

Standard errors are in ( ); *p*-values are in [ ].