The Economic Implications of Knowledge-Capital Accumulation to Japanese Industry Output

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JAPAN'S ECONOMIC GROWTH HAS captivated many scholars to investigate the drivers of growth.[1] Japan was able to undergo industrial take-off era and has since enjoyed a mature economy.[2] After the Second World War, Japan was left devastated, both in terms of social development and economy. In 1950s, Japan nevertheless succeeded to recover its economy situation, particularly owing to the close collaboration between the Japanese government and its corporate executives to boost the economic development through industrialization.

Such economic development has impacted Japan's global economic reputation, particularly with regards to Japan's efficacy to undergo the "catch-up phase" of the economic revolution by transforming its industry, and Japan's rapid economic growth that has been sustained for decades. How Japanese economic system was able to catch up with Western

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1 Gaofeng Han, Kaliappa Kalirajan, and Nirvikar Singh, "Productivity, Efficiency and Economic Growth: East Asia and The Rest of The World," *The Journal of Developing Areas* 37(2): 2004.

2 T. Ozawa, *Japans Technological Challenge To The West, 1950-1974: Motivation and Accomplishment* (Cambridge: MIT Press Books, 2003)

economies had been a popular topic of scholarly works,[3] particularly with the focus on the output rate of the Japanese industry. Such magnificent output rate was shown by the pattern of Japan's economic growth,[4] as the fast growing of output contributed to a substantial portion in gross domestic products (GDP).[5] In short, the driver of Japan's economic growth was the output of its industry. Ozawa[6] argued that the output of Japanese industry was the result of Japan's efficient and effective production process. Based on this argument, this article observes further Japanese industry's production process, in order to scrutinize the economic base for creating such output, particularly, the observation how the industrial supportive policy and the production system is applied in Japan. This article argues that such analysis can be useful for policy makers and corporate executives in other countries.

Research Objectives

Many studies on output in Japan have been immensely conducted in years.[7] Those studies, however, were not constructed in an integrated framework. Some of them were focused on physical capital or knowledge capital per se and others only examined the importance of certain factor input that influences economic growth. Morikawa[8] and Storm &

3 Richard Katz, *Japan, The System That Soured: The Rise and Fall of The Japanese Economic Miracle* (New York: ME Sharpe, 1998)

4 M. Coccia, "What Is The Optimal Rate of R&D Investment to Maximize Productivity Growth?," *Technological Forecasting and Social Change* 76(3): 2009.

5 Wataru Souma, Yuichi Ikeda, Hiroshi Iyetomi, and Yoshi Fujiwara, "Distribution of Labour Productivity in Japan Over the Period 1996-2006," Economic Discussion Paper, Institut fuer Weltwirtschaft, No. 2009-2 (2009).

6 Ozawa, *Japans Technological Challenge to the West.*

7 See, among others, Chih-Kai Chen, "Causal Modeling of Knowledge-Based Economy," *Management Decision* 46(3): 2008; Kyoji Fukao, Tomohiko Inui, Hiroki Kawai, and Tsutomu Miyagawa, "Sectoral Productivity and Economic Growth in Japan, 1970–98: an Empirical Analysis Based on the JIP Database," in Takatoshi Ito and Andrew K. Rose (Eds.), *Growth and Productivity in East Asia, NBER-East Asia Seminar on Economics, Volume 13* (University of Chicago Press, 2004); Dale W Jorgenson, Masahiro Kuroda, and Mieko Nishimizu, "Japan-US Industry-Level Productivity Comparisons, 1960–1979," *Journal of the Japanese and International Economies* 1(1): 1987; J. M Letiche, "Differential Rates of Productivity Growth and International Imbalance," *The Quarterly Journal of Economics* 69(3): 1955; Tsutomu Miyagawa, Yukie Sakuragawa, and Miho Takizawa, "Productivity and Business Cycles In Japan: Evidence From Japanese Industry Data," *Japanese Economic Review* 57(2): 2006; and Bart Van Ark and Dirk Pilat, "Productivity Levels in Germany, Japan, and the United States: Differences and Causes," *Brookings Papers on Economic Activity: Microeconomics* (2): 1993. Other relevant references are given in the following footnotes.

8 Masayuki Morikawa, "Labor Unions and Productivity: An Empirical Analysis Using Japanese Firm-Level Data," *Labour Economics* 17(6): 2010.

Naastepad,[9] for example, were concerned mainly on labor input. Griffith, Redding, & Reenen[10], Griliches & Mairesse,[11] and Odagiri and Iwata[12] focused on the research and development (R&D) activities. Kuroda and Nomura,[13] and Miyagawa and Kim[14] focused on non-information technology (non-IT) capital stock. Hayashi and Nomura,[15] and Miyagawa, Ito, and Harada[16] focused on information technology (IT) capital stock. These studies are limited in terms of comprehensive framework for only taking a certain input and ignoring other critical ones. This article views that it is not sufficient for a study to only be concentrated on one input to exploit the output generation process, as it cannot capture the utter phenomenon of output generation. This article seeks to apply the Cobb Douglas production function, which is to analyze the contribution of each input in a set of combined factor inputs, by examining which factor input amongst research activities, labor or capital has a larger influence on output. The dynamic of output is measured in integrated factors, and the progress in understanding the output source will improve the computation of Cobb Douglas production function, which is the objective of this study.

Output Growth Theory: Neoclassical Growth Theory and New Growth Theory

Economic performance is often identified with the output growth. The output itself cannot be haphazardly observed; rather, it must be precisely measured. The production function method is used to measure the output

9 Servaas Storm and C. W. M. Naastepad, "Labor Market Regulation and Productivity Growth: Evidence For Twenty OECD Countries (1984–2004)," *Industrial Relations: A Journal of Economy and Society* 48(4): 2009.

10 Rachel Griffith, Stephen Redding, and John Van Reenen, Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries, *Review of Economics and Statistics* 86(4): 2004.

11 Zvi Griliches and Jacques Mairesse, "R&D and Productivity Growth: Comparing Japanese and US Manufacturing Firms," in Charles R. Hulten (Ed.), *Productivity growth in Japan and the United States*, (University of Chicago Press, 1991), pp. 317-348.

12 Hiroyuki Odagiri and Hitoshi Iwata, "The Impact of R&D On Productivity Increase in Japanese Manufacturing Companies," *Research Policy* 15(1): 1986.

13 Masahiro Kuroda and Koji Nomura, "15 Technological Change and Accumulated Capital: a Dynamic Decomposition of Japan's Growth," in E. Dietzenbacher and M. L. Lahr (Ed), *Wassily Leontief and Input-Output Economics* (Cambridge: Cambridge University Press, 2004), p. 256.

14 Tsutomu Miyagawa and Young Gak Kim, "Measuring Organization Capital in Japan: An Empirical Assessment Using Firm-Level Data," Japan Center for Economic Research Discussion Paper No. 112 (2008).

15 Fumio Hayashi and Koji Nomura, "Can IT be Japans Savior?" *Journal of the Japanese and International Economies* 19(4): 2005.

16 T. Miyagawa, Y. Ito, and N. Harada, "The IT Revolution and Productivity Growth in Japan," *Journal of the Japanese and International Economies*, 18(3): 2004.

from different sources. By applying production function, one can analyze the output changes on the basis of simultaneous developments in inputs.[17] The standard production function is known as the neoclassical growth model, also called the Cobb-Douglas function. Nonetheless, seminal papers conducted by Solow in 1956 and 1957 formalized the basic function and embedded a basic function to national account data. Solow's papers have been largely referred to by other scholars, and the Solow neoclassical growth function has since been applied as the basis of growth analysis.[18]

The essential concept in neoclassical growth production function is the combination of labor (L), the stock of capital (C) and the output (P). An increase in L or K will lead to an increase in output (P) as follows:

$$P = a \times K \times L$$

The basic neoclassical model positions P as the result of the function form consisting of labor and capital. Neoclassical production function model is presumed to provide constant returns to scale and to imply diminishing returns to each input integrated in output generation.

The Cobb Douglas production function has received enormous critics, one of which is from the conceptual side of the method. The Douglas production function statistical works is considered futile for its general focus on neoclassical growth theory, while, in contrast, the capital is considered to have a wider meaning to a series of heterogeneous investment. Investment is broadly defined as intangible expenditures including research and development accumulated as knowledge capital or a net addition to the stock of knowledge capital,[19] thus, here, the emphasis on capital knowledge is known as new growth theory.

New growth theory incorporates knowledge capital in the Cobb Douglas production function. Knowledge capital is denoted as research and development activity. Thus, new growth theory consists of three primary inputs in production function model: capital, labor and knowledge capital, where P is as a measure of output or output, K as a measure of physical capital, L as the labor input and R as the knowledge capital[20].

17 Dana Hájková and Jaromír Hurník, "Cobb-Douglas Production Function: The Case of a Converging Economy," *Czech Journal of Economics and Finance (Finance auver)* 57(9-10): 2007.

18 Kevin J. Stiroh, "What Drives Productivity Growth?," *Economic Policy Review* 7(1): 2001.

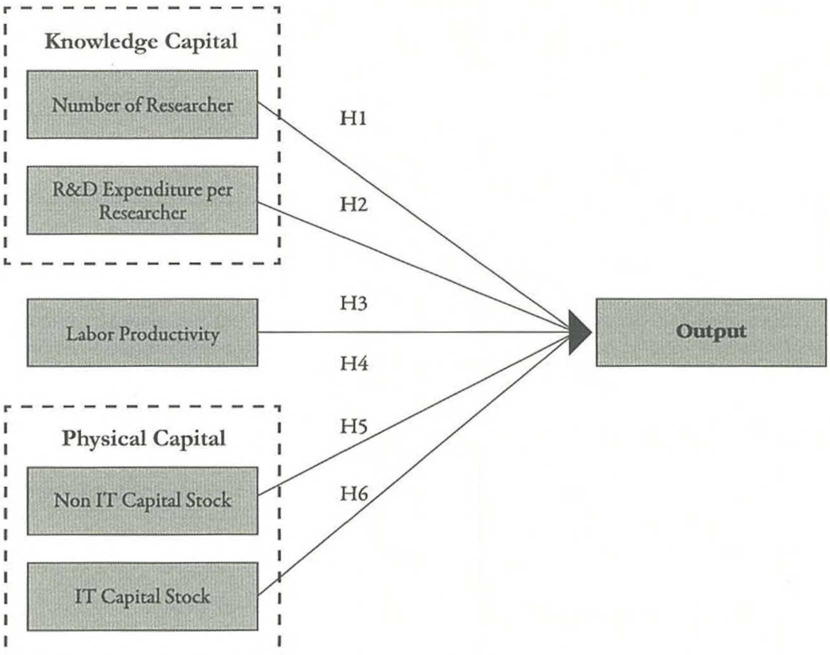
19 Zvi Griliches, Issues in Assessing the Contribution of Research and Development to Productivity Growth," *Bell Journal of economics* 10(1): 1979.

20 Katharine Wakelin, "Productivity Growth and R&D Expenditure in UK Manufacturing Firms," *Research policy* 30(7): 2001.

$$P = A \times K \times L \times R$$

In private companies, research and development activities are often considered as capital, albeit intangible, which reflects the need to increase the input value, which leads to the increase of output.[21] Thus, output is seen as the accumulation of investment on inputs.

Figure 1. Research Methodology



Hypotheses and Research Variables

The hypotheses of this study are developed based upon the following arguments. In knowledge capital, the industry output is calculated from the intellects of the human capital, which give a critical value in output generation.[22] Meanwhile, the role of investment on research and development is essential in output generation in order to ensure the

21 Jose Miguel Benavente, "The Role of Research and Innovation In Promoting Productivity in Chile," *Economics of Innovation and New Technology* 15(4-5): 2006.

22 Barry Bozema and Elizabeth Corley, "Scientists' Collaboration Strategies: Implications for Scientific and Technical Human Capital," *Research Policy* 33(4): 2004.

growth sustainability in firms.[23] Labor input is either in labor-intensive industry and in capital intensive industry. O'Mahony and Timmer[24] and Balk[25] stated that output in labor-intensive industry is highly derived from the labor function. Meanwhile, in capital intensive industry, the labors' role is diminished as stated by Creamer and Bernstein[26] that the reduction of man-hours is associated with the emergence of intensifying capital. The continuous exaggeration of capital diminishes the need to have greater amount of man-hour. Finally, the growth of output is also built upon the rapid accumulation in physical capital including IT capital assets.[27]

Table 1. Hypotheses

Relationship	Hypotheses	Descriptions
Research and development and industry output.	H1	The number of researchers is positively related to output.
Research and development and industry output.	H2	R&D Expenditure per researcher is positively related to output.
Labor input and industry output.	H3	Labor input is positively related to output in labor intensive industry.
Labor input and industry output.	H4	Labor input is negatively related to output in capital intensive industry.
Capital stock and industry output.	H5	Non IT capital stock is positively related to output.
Capital stock industry output.	H6	IT capital stock is positively related to output.

One model of production function is used to examine the role of several factor inputs, namely research and development activities, labor input, non IT capital stock and IT capital stock to output. P is a measure of value

23 Valdemar Smith Mogens Dilling-Hansen, Tor Eriksson, and Erik Strøjer Madsen, "R&D and Productivity in Danish Firms: Some Empirical Evidence," *Applied Economics* 36: 2004.

24 Mary O›Mahony and Marcel P. Timmer, "Output, Input and Productivity Measures at the Industry Level: The Euklems Database," *The Economic Journal* 119: 2009.

25 Bert M Balk, "On the Relationship Between Gross Output and Value Added Based Productivity Measures: The Importance of the Domar Factor," Centre for Applied Economic Research Working Paper No. 5 (2003).

26 Daniel Creamer and Martin Bernstein, "Introduction to Capital and Output Trends in Manufacturing Industries, 1880-1948," *Capital and Output Trends in Manufacturing Industries*, 1880-1948 (Cambridge: NBER, 1954), pp. 1-14.

27 Stiroh, "What drives productivity growth?" pp. 37-59.

added or output of industry i at time t, K is a measure of physical capital, L denotes the number of man-hours performed and R is a knowledge capital. A is a constant and α, β, and γ refer to the elasticity of output regarding physical capital, labor, and knowledge capital, respectively.

$$Pit = A\ Kit\alpha Lit\beta Rit\gamma$$

$$\text{Log}(P) = A + \alpha \log(K) + \beta \log(L) + \gamma \log(R)$$

Output is defined as the correlation of produced goods or produced services and the input (utilized resources) in production function process. It is also defined as added value embedded in goods or services.[28] The indicator of output is value added of goods or services in million yen in current prices. Meanwhile, research and development is defined as a creative work undertaken on a systematic basis purposely to increase the knowledge stock including knowledge of man, culture and society.[29] R&D activity is measured by two indicators: the number of researchers employed in R&D department; and the amount of intramural R&D expenditure in R&D sector in million yen in current prices. The labor input, furthermore, refers to an index used as a representative measure of the working force. Man-hour in annual standard per 1000 workers is commonly used as an indicator to demonstrate labor input.[30]

Furthermore, non IT capital stock is defined as physical assets or tangible items, such as company's production equipment, liquid funds, product stock and other properties.[31] The indicator of non-IT capital stock refers to the amount of non-IT capital stock in million yen in current prices. Lastly, IT capital stock include computers and peripherals, computer software, communications and other related equipments.[32]

28 Stefan Tangen, "Demystifying productivity and performance." *International Journal of Productivity and Performance Management* 54(1): 2005.

29 See OECD, "Main Science and Technology Indicators" (Paris: OECD Publishing, 2011); and G.M.Grossman & E.Helpman, *Inovation and Growth in the Global Economy* (The United States: MIT Press, 1993).

30 See Charles W. Cobb and Paul H. Douglas, "A Theory of Production," *The American Economic Review* 18(1): 1928; and Richard Disney, Jonathan Haskel, and Ylva Heden, "Restructuring and Productivity Growth in UK Manufacturing," *The Economic Journal* 113(489): 2003.

31 See Joel G Siegel, Nick A. Dauber, and Jae K. Shim, The Vest Pocket CPA (New Jersey: John Wiley & Sons, 2005); and John Downes and Jordan Elliot Goodman, *Dictionary of Finance and Investment Terms* (New York: Barron's, 2010).

32 See Nicholas Bloom, Raffaella Sadun, and John Van Reenen, "Americans do IT better: US Multinationals and the Productivity Miracle," National Bureau of Economic Research Paper No. 13085 (2007); and Barry P. Bosworth and Jack E. Triplett, "What's New About the New Economy? IT, Economic Growth and Productivity," *International Productivity Monitor* 2: 2001.

The indicator of non-IT capital stock is the amount of non IT capital stock in million yen in current prices.

Data Collection and Analysis

This study involves 13 (thirteen) industries (See Table 2). The selection of a variety of industries is critical as former studies concerning with output growth were only focused on manufacturing sector[33]. The purpose of this study, therefore, is to examine the behaviour of output in five (5) different sectors: service, manufacturing, and traditional (agriculture, forestry, and fisheries), construction and mining. The selection of these industries has been based upon the presence of data and their important role in Japan's economy. The categorization of industries, meanwhile, was based on Japanese industrial classification system. The data collected in this study in consideration to their availability, are taken from 1970 to 2008. There are two sources used to collect the data of variables, Research Institute of Economy, Trade and Industry (RIETI) Japan Industrial Productivity (JIP) Database 2011 and Japan Statistics Official.

Table 2. List of Industries

No	Industry	Sector
1	Transport and Telecommunication Service Industry	Transport (Railway, Road Transportation, Water Transportation and Air Transportation) Communication Postal Activities
2	Chemical Products industry	Chemical Fertilizers Basic Inorganic Chemicals Basic Organic Chemicals Organic Chemicals Chemical Fibres Miscellaneous Chemical Products
3	Construction Industry	Construction
4	Petroleum Products Industry	Petroleum Products
5	Rubber Products Industry	Rubber Products

33 Souma, Ikeda, Iyetomi, and Fujiwara, "Distribution of Labour Productivity in Japan Over the Period 1996-2006."

No	Industry	Sector
6	Pharmaceutical Products Industry	Pharmaceutical Products
7	Iron and Steel Products Industry	Pig Iron and Crude Steel Miscellaneous Iron and Steel
8	Agriculture, forestry, and fisheries Forestry Fisheries Industry	Agriculture, forestry, and fisheries Forestry Fisheries
9	Other Transport Equipment Products Industry	Other Transport Equipment
10	Pulp and Paper Products Industry	Pulp, Paper and Coated and Glazed Paper Paper Products Printing, Plate Making for Printing & Bookbinding
11	Mining Industry	Mining Products
12	Fabricated Metal Products Industry	Fabricated Metal Products
13	Motor Vehicles Products Industry	Motor Vehicles Motor Vehicles Parts and Accessories

To analyze the data, this study uses two (2) statistical methods. Natural logarithm is the first method applied to all data. It was employed as many time series variables have overall trends of exponential growth logarithm.[34] Natural logarithm method is aimed both to transform the data to proportional differences and to obtain linearity in logs.[35] The second method is multiple regression analysis applied to understand the relation between independent variable and dependent variable, and to explore the forms of this relationship.[36] Meanwhile, all variables categorized as capital stock including IT capital stock and non-IT capital stock are not computed in depreciation model, based on consideration that those variables have been computed previously by RIETI (Research Institute of Economy, Trade and Industry).

34 See Nathaniel L. Beck and Jonathan N. Katz, "What To Do (and not to do) with Time-Series Cross-Section Data," *American Political Science Review* 89(3): 1995; and Charles I Jones, "Time Series Tests of Endogenous Growth Models," *The Quarterly Journal of Economics* 110(2): 1995.

35 See D. Gujarati, *Essentials of Econometrics 3rd Edition* (New York: Macmillan Publishing Company, 2006); and A.Gelman & J.Hill, *Data Analysis Using Regression and Multilevel/ Hierarchical Models* (Cambridge: Cambridge University Press, 2007)

36 J. S. Armstrong, "Illusions in Regression Analysis," *International Journal of Forecasting*, 2012.

Research Findings: Interrelationship among Knowledge Capital, Labor, Physical Capital and Output

To test the model and hypothesis, a multi regression analysis method was employed to compute all variables. Tables 3 and 4 show a summary of multiple regression results for production function model. Noted here, it is only variables with a significant p-value of 0.05 are being included.

Table 3. Regression Result (Model and Coefficient Summary)

Equation	Transport & Telecommunication Service Industry	Chemical Products Industry	Petroleum Products Industry	Construction Industry	Rubber Products Industry	Pharmaceutical Products Industry
Numbers of Researchers	-	.834	-	-	.916	.954
R&D expenditure	.215	-	.410	.335	.376	.596
Labor	.204	-	-	.320	.249	-
Non-IT Capital Stock	.846	-	.300	-	.563	-
IT Capital Stock	-	-	-	.451	-.392	-
R Square	.985	.898	.962	.952	.971	.972
Adjusted R Square	.983	.882	.926	.945	.967	.967
D-W Score	1.154	1.292	2.061	1.757	1.342	1.117

Table 4. Regression Result (Model and Coefficient Summary)

Equation	Iron & Steel Products Industry	Mining Industry	Motor Vehicle Products Industry	Other Transport Equipment Products Industry	Pulp & Paper Products Industry	Fabricated Metal Products Industry	Agriculture, Forestry & Fisheries Industry
Numbers of Researchers	-	-	.730	-.149	-	.116	.151
R&D expenditure	.535	.420	.463	.504	.822	.539	.254
Labor	-.741	.706	-	597	-	.176	1.057
Non-IT Capital Stock	-	-	.324	.598	.946	.324	.381
IT Capital Stock	-.793	-	-.501	.569	-.886	.143	.516
R Square	.752	.782	.984	.914	.901	.988	.858
Adjusted R Square	.715	.749	.982	.901	.886	.987	.837
D-W Score	1.243	.924	1.390	1.177	1.628	1.575	1.140

This study found that the miracle of Japanese economy has gradually decreased in the last two decades, as Japan has been undergoing the substantial decrease of output, which impacted on the pace of GDP growth. In the second half of 1980's to the early 1990's, GDP growth started to slow down. Furthermore, in the beginning of 1990's Japan's GDP growth declined, which caused Japan to experience the worst GDP growth compared to major OECD countries.[37] This phenomenon is known as "the lost decade," as it is Japan's first economy stagnation since the economy crisis in the end of World War II.[38] The situation worsened when Japan was hit by the Asian 1997 financial crisis, during which the economy of Japan and other East Asian countries collapsed.[39] In 2007, Japan was again exposed to economy recession, as the global financial crisis originating from the housing bubble in the United States had impacts on

37 T. Hoshi and A. K. Kashyap, *Corporate Financing and Governance in Japan: The Road to the Future* (MIT Press, 2004).

38 Naomi N. Griffin and Kazuhiko Odaki, "Reallocation and Productivity Growth in Japan: Revisiting the Lost Decade of the 1990s," *Journal of Productivity Analysis* 31(2): 2009.

39 Steven Radelet and Jeffrey D. Sachs, "The Onset of the East Asian Financial Crisis," *In Currency Crises* (The United States: University of Chicago Press, 2000), pp. 105-162.

Japan.[40] The 2007 global financial crisis exposed the economy severity in Japan: delicate in one side and unstable on the other side. Each of Japan's industry sectors, however, responded differently, and established different recovery patterns in coping with the crisis.

Research and Development (R&D) and Output

Are sectors that are more excellent in promoting R&D activities able to obtain higher output? This study agrees with the view that the constant introduction of new technology can be a driver for the rapid economic growth in East Asian Economies.[41] The knowledge capital and experiences embedded in researcher interrelate and act in synergetic ways in affecting the long-running productivity by exploiting innovation.[42] The number of researchers, to this point, shows the supply of human capital and this is perceived as a critical variable in generating the output. The accumulation of knowledge and skills can empower the researcher to spur the innovation. Thus, the industry sector that has a larger number of researchers acquire better capability in absorbing and adopting new ideas and technology. As stated by Nelson and Phelps,[43] researchers are the critical factor in R&D activities for possessing an ability to develop new ideas from their knowledge assets. The development of new ideas is vital to increase the level of innovation or technological advancements.

As shown from Tables 3 and 4, six of thirteen industries show positive relationship between the number of researchers and the output growth. Those six industries are in the following product sectors: chemical, rubber, pharmaceutical, motor vehicle, fabricated metal and agriculture, forestry, and fisheries. Meanwhile, the negative and insignificant correlation between researchers and output growth is found in seven industries in the following product sectors: transport and equipment, transport and telecommunication, petroleum and coal, construction, iron and steel, mining and, pulp and paper. The decreasing role of researchers to output

40 Warwick J. McKibbin and Andrew Stoeckel, "The Global Financial Crisis: Causes and Consequences*," *Asian Economic Papers* 9(1): 2010.

41 Marcel P. Timmer, "Climbing the Technology Ladder Too Fast? New Evidence on Comparative Productivity Performance in Asian Manufacturing," *Journal of the Japanese and international economies* 16(1): 2002.

42 James S. Dietz and Barry Bozeman, "Academic Careers, Patents, and Productivity: Industry Experience as Scientific and Technical Human Capital," *Research Policy* 34(3): 2005.

43 Richard R. Nelson and Edmund S. Phelps, "Investment in Humans, Technological Diffusion, and Economic Growth," *The American Economic Review* 56(2): 1996.

growth is caused by the intensification of R&D collaboration among firms or sectors. Japanese government initiates and stimulates the inter-firm works amongst private firms, public laboratories and research institutes.[44] Here, an immense increase in collaborative research in Japan has led to the rapidly declining role of human capital in R&D activities.[45]

Additionally, as seen in Tables 3 and 4, the amount of R&D expenditure is highly related to the output growth. Twelve out of thirteen industries demonstrate the positive correlation between the amounts of R&D expenditure and industry's output. This study finding is similar with other studies affirming that R&D spending is positively correlated to firms' output.[46] The focal role of R&D expenditure in creating innovation is the power to provide bulk investment that can create the dynamic capabilities of companies sourced from R&D activities. This capability in long term can increase the sustainability of industrial production. In new growth theory, R&D activities are perceived to be capable of increasing the innovation through human capital accumulation. For this, constant returns to capital occur, simultaneously stimulating the long run output. The R&D of a company, regardless of industry, can be expanded to other companies. This triggers the accumulation of knowledge stock to all companies in the industry. In this regard, the role of R&D in knowledge capital does not encounter the law of diminishing returns, as the new growth theory takes intangible assets a factor input that is accountable for long run endogenous growth.[47]

The government of Japan appears to be strongly committed to bolstering R&D activities by making appropriate R&D policies in Japanese industry. It explains the rationale and role of Japan Government to be involved in R&D activity. This involvement purposely is to increase the R&D investment returns, notably on industry's output. The important initial policy issued by Japan Government is the heavily imported and digested western technology into Japan. The government of Japan promoted R&D through a policy on technology import, which was

44 Jiang Wen and Shinichi Kobayashi, "Exploring Collaborative R&D Network: Some New Evidence in Japan," *Research Policy 30*(8): 2001.

45 George Seaden and André Manseau, "Public Policy and Construction Innovation," *Building Research & Information* 29(3): 2001.

46 See John E. Ettlie, "R&D and Global Manufacturing Performance," *Management Science* 44(1): 1998; Kiyohiko Ito and Vladimir Pucik, "R&D Spending, Domestic Competition, and Export Performance of Japanese Manufacturing Firms," *Strategic Management Journal* 14(1): 1993; and Peter J. Sher and Phil Y. Yang, "The Effects of Innovative Capabilities and R&D Clustering on Firm Performance: The Evidence of Taiwan›s Semiconductor Industry," *Technovation* 25(1): 2005.

47 Stiroh, "What Drives Productivity Growth?"

issued in the early of post-war era.[48] However, at the same time, they developed an active domestic R&D culture. By conducting agile in-house R&D, the government encouraged Japanese industries to learn and digest from imported technology and modify it with domestic technology. The combination of foreign and domestic technology was diffused to across industries in Japan. Later, the government of Japan established a policy concerning patent system by providing incentive for industrial firms, which an assurance for companies to put high investment on in-house R&D. At the same time, the government of Japan also stimulated the R&D and technology diffusion.[49] A study by Sakakibara[50] found high eagerness of Japanese firms to share knowledge, particularly to those possessing complementary knowledge. To ensure that public policy represents the interests of companies and industries, the government of Japan constantly built close relationship with business sector, which reflected the role of the business sector in issuing certain industrial policies such as R&D promotion policies.

Nonetheless, R&D investment also has high degree of uncertainty. Thus, the result of R&D activities cannot be immediately yielded. O'Mahony and Vecchi,[51] in their study on Japanese industry, found that R&D process is affected by many factors such as business cycles fluctuations. In this way, the result of R&D activities is varied and cannot be straightforwardly enjoyed by the firms or industry. For example, positive but insignificant coefficient between R&D expenditure to industry's output appeared in chemical products industry. However, O'Mahony and Vecchi acknowledged the existence of the massive under-reporting of financial statement in Japan, which results in the lack of information of the exact amount of R&D expenditure in certain Japan industries. This may cause the insignificant correlation between R&D expenditure and output growth in chemical products industry. On the other hand, Stiroh[52] offered a different perspective by arguing that positive R&D return is difficult to obtain due to the existence of simultaneous practice and utility

48 See R. Belderbos, "Entry Mode, Organizational Learning, and R&D in Foreign Affiliates: Evidence from Japanese Firms," *Strategic Management Journal*, 24(3): 2003; and Edwin Mansfield, "Industrial R&D in Japan and the United States: A Comparative Study," *The American Economic Review*, 1988.

49 Wesley M. Cohen, Akira Goto, Akiya Nagata, Richard R. Nelson, and John P. Walsh, "R&D Spillovers, Patents and the Incentives to Innovate In Japan and the United States," *Research Policy* 31(8): 2002.

50 Mariko Sakakibara and Lee Branstetter, "Do Stronger Patents Induce More Innovation? Evidence From the 1988 Japanese Patent Law Reforms No. w7066," National Bureau of Economic Research, 1999.

51 M.O'Mahony & M.Vecchi, "R&D, Knowledge Spillovers and Company Productivity Performance," *Research Policy* 38(1):35-44, 2009.

52 Stiroh, "What Drives Productivity Growth?"

of similar ideas and knowledge in many companies. The homogeneity in R&D activities across firms in industry delineates the rate of return on knowledge capital.

With regards to labor input and output, Kim and Lau[53] and Collins, Bosworth, and Rodrik[54] argued that one of the most essential determinants of economic growth miracle in Asian countries is labor. However, this study found that labor gives a different contribution to output growth, particularly in industry. Labor is positively related to output growth in labor-intensive industries; while on the other hand, it is negatively related to output growth in capital-intensive industries. The positive correlation occurred in seven out of eight industries categorized as labor-intensive industry, which are are engaged in product sectors of rubber, transport and telecommunication, construction, mining, other transport, fabricated metal and agriculture, forestry, and fisheries. Labor becomes an essential determinant in these industries for being perceived as primary input.

On the other hand, in the motor vehicle industry, a study found that labor does not show any positive and significant correlation to output growth, mainly due to the transformation of motor vehicle products industry in Japan into more capital intensive industry, considering the involvement of advanced technology in this industry to generate the output.[55] Further, the utilization of advanced technology itself is an attempt to offset higher labor cost. Economic pressures such as the increase in wages, in fact, have discouraged companies from making large investment on labor; hence, technology advancement becomes a more important factor to substitute the role of labor in generating output.[56]

All capital-intensive industries demonstrate negative and significant correlation between labor and output growth. These are chemical, petroleum, iron and steel, pharmaceutical, and pulp and paper industries. The output growth in capital-intensive industry is relied highly on physical and knowledge capital. In these industries, the number of workers tend to decrease as a consequence of the intensifying capital investment strategy. Capital investment is manifested into the utilization of sophisticated

53 J. I. Kim and L. Lau, "The Sources of Economic Growth in the East Asian Newly Industrialized Countries," *Journal of the Japanese and International Economies* 8(3): 1994.

54 Susan M. Collins, Barry P. Bosworth, and Dani Rodrik, "Economic Growth in East Asia: Accumulation Versus Assimilation," *Brookings Papers on Economic Activity* (2):1996.

55 Julius Spatz and Peter Nunnenkamp, "Globalization of the Automobile Industry: Traditional Locations Under Pressure?" KielerArbeitspapiere No. 1093, 2002).

56 David Haugh, Annabelle Mourougane, and Olivier Chatal, *The Automobile Industry in and Beyond the Crisis (Organisation for Economic Co-operation and Development, 2010).*

technologies, accompanied by the advancement of operational methods.[57] In this regard, technology and physical capital have more substantial roles in generating output than that of labor in capital intensive industry.

In non-IT capital stock and output, this study conducted a test on the correlation between physical capital (non-IT capital stock) and output growth. Only seven out of thirteen industries portray a positive and significant correlation between non-IT capital stock and output growth. These seven industries are transport and telecommunication, petroleum, motor vehicle, other transport equipment, pulp and paper, and fabricated metal industries. In contrast, an insignificant and negative relationship occurred in six industries engaged in products of chemical, construction, pharmaceutical, iron and steel, mining, and motor vehicle. Such correlation existed as Japan not only enjoyed the rapid increase of physical capital asset but also simultaneously experienced a declining rate of returns in physical capital.[58] In other words, the law of diminishing marginal returns has taken place in these industries when the addition of one or more factors in production process yields lower per-unit returns, while all other aspects remain constant. The diminishing marginal return is caused by several factors, namely, managerial problems, limited capacity of organization, the increase of the variable factor, fixed productive capacity of the firm, and economic environment such as under consumption. Principally, diminishing marginal returns significantly lessened the output in several Japanese industries after decades of investment rate.[59]

With regards to IT capital stock and output, a similar finding was also found in the test that this study conducted on IT capital stock to output growth. Of thirteen industries, only four industries, engaged in the products of construction, other transport equipments, fabricated metal, agriculture, forestry and fisheries, have positive and significant correlation between IT capital stock and output growth. In these industries, the ratio of information and communication technology (ICT) and IT equipment increases as they play a critical role in manufacturing industry. The process-based view stated that IT equipment has created a competitive advantage by advancing the operational efficiency in both

57 See Jay M. Berman, «Industry Output and Employment Projections to 2012.» Monthly Labor Review 127, no. 2 (2004); and Alexander J. Yeats, *Shifting Patterns of Comparative Advantage: Manufactured Exports in Developing Countries* No. 165 (The World Bank, 1989).

58 Keiko, Ito and Kyoji Fukao, "Foreign Direct Investment and Trade in Japan: an Empirical Analysis Based on the Establishment and Enterprise Census for 1996," *Journal of the Japanese and International Economies* 19(3): 2005.

59 Todd A. Knoop, *Recessions and Depressions: Understanding Business Cycles: Understanding Business Cycles* (ABC-CLIO, 2009).

production and business process.[60] This enhanced process system then leads to a better firm performance, which in turn stimulates the growth of productivity. On the other hand, negative and insignificant correlation between IT capital stock to output growth was found in five industries dealing with the product sectors of pharmaceutical, rubber, iron and steel, pulp and paper, motor vehicle, transport and telecommunication, chemical, petroleum, and mining. The insignificant role of IT capital to output growth can be explained by previous IT studies. Weill and Broadbent[61] argued that it needs more time to benefit from IT equipment and infrastructure due to a lagging probability in the returns on IT capital investment. In order to obtain the maximum result on IT investment, a company needs to improve the skills and performs several exercises that can make a smoother infrastructure implementation possible.[62] Moreover, the maximum utilization and implementation of IT equipment is mediated by some important organizational factors. As stated by Aral and Weill[63] and Broadbent, Weill, and Neo[64], the return on IT investment relies highly on the company policies regarding the an integration of business unit and IT equipment. The incorporation of IT equipments requires proper capabilities of labours to operate them.[65] Moreover, the maximum utilization of IT equipment depends upon the management capabilities, strong cross-functional IT, and decent business skills.[66] IT strategy should support the overall strategic goals of the organization. The correlation between IT capital stock to output cannot be yielded simultaneously.

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60 See John G. Mooney, Vijay Gurbaxani, and Kenneth L. Kraemer, "A Process Oriented Framework for Assessing the Business Value of Information Technology," *ACM SIGMIS Database* 27(2): 1996; and Christina Soh and M. Lynne Markus, "How IT Creates Business Value: a Process Theory Synthesis," ICIS, 1995.

61 P. Weill and M. Broadbent, *Levering the New Infrastructure How Market Leaders Capitalize on Information Technology* (Cambridge, The United States: Harvard Business School Press, 1998).

62 N.B.Duncan, "Capturing Flexibility of Information Technology Infrastructure: A Study of Resource Characteristics and Their Measure," *Management Information System* 12(2): 1995.

63 Sinan Aral and Peter Weill, "IT Assets, Organizational Capabilities, And Firm Performance: How Resource Allocations and Organizational Differences Explain Performance Variation," *Organization Science* 18(5): 2007.

64 Marianne Broadbent, Peter Weill, and Boon Siong Neo, "Strategic Context and Patterns of IT Infrastructure Capability," *The Journal of Strategic Information Systems* 8(2): 1999.

65 Luigi Paganetto, *Knowledge Economy, Information Technologies and Growth* (Ashgate, 2004).

66 See R. Berenbaum and T. J. Lincoln, "Integrating Information Systems With the Organisation," in T. J. Lincoln, Ed., "*Managing Information Systems for Profit*" (Chichester: John Wiley and Sons, 1990), pp.1-25; Michael J. Earl, *Management Strategies for Information Technology* (Prentice-Hall, Inc., 1989); and K. Hugh Macdonald, "Business Strategy Development, Alignment, and Redesign," *Corporation of the 1990s* (New York: Oxford University Press, 1991), pp.159-186.

Lessons for Indonesia

The Japanese experience shows how R&D activities represented in R&D expenditure affected the input growth in Japan. On the other hand, physical capital that had been known for its major contribution to input growth underwent the diminishing marginal returns. Knowledge capital is not subject to the law of diminishing returns. It is worth noting that human capital, compared to physical capital, has some distinctive characteristics. Human capital necessarily develops exponentially; it concedes that the accumulation nature of knowledge and experiences is able to produce some positive returns that offset the diminishing marginal returns. It can be concluded that, while physical capital keeps shrinking, the knowledge capital grows flourishingly. In addition, even in economic crisis and the downfall of Japanese industry, knowledge capital is proven to contribute positively to GDP growth.

Output growth has received a greater attention from economists and policy makers. Studies on the major driver in growth theories have taken place since the beginning of the 1980s, for example Krugman[67] and Romer[68]. Output analysis such as this study has theoretical implications. This study improves the understanding regarding the contribution of knowledge capital to the generation of output. This study also allows for further discussions on the influential value of technological learning and technical change. The technological capabilities is one of main factors in the existence of some differences between developed countries and developing countries, which are rooted in the divergence of economic growth.[69] Some developed countries have accumulated the vast pool of technological capabilities. Developing countries, meanwhile, have the opportunity to bridge the gap of technological capabilities by absorbing the knowledge from developed countries. The absorption process is carried out mostly by the diffusion of technologies. For example, in the industrial sector, a technical change in developing countries is the result of two major activities: first, developed countries initiated the innovation era; and second, the application of innovation is dispersed to other countries, including developing countries, in through the operating know how from MNE and technology imbedded in capital goods from import products.

67 P. Krugman, "The Myth of Asia's Miracle," *Foreign Affairs* 73(6): 1994.

68 Paul M. Romer, "The Origins of Endogenous Growth," *The Journal of Economic Perspectives* 8(1):1994.

69 See Jan Fagerberg, "Technological Progress, Structural Change and Productivity Growth: a Comparative Study," *Structural Change and Economic Dynamics* 11(4): 2000; and Daniele Archibugi, Jeremy Howells, and Jonathan Michie, *Innovation Policy in a Global Economy* (Cambridge: Cambridge University Press, 1999).

The diffusion, to some extent, contributes to promote and create the innovation system in developing countries.[70]

However, it is still a question to what extent developing countries can reap the benefit of technological diffusion, in particular if these countries desire to exploit the innovation without insisting the vast amount of cost of technological innovation. Rodrik[71] examined this situation by stating that the efficacy of diffusion is based on the initial capability of developing countries. Further, Archibugi et al[72] argued that only developing countries that have sufficient basic technological capabilities and fundamental know-how will have an opportunity to exploit developed countries' innovation and technologies. Additionally, those are the main requirements that allow a country to create an incremental innovation to achieve a higher performance beyond on what has formerly been achieved.

It is interesting to observe the experience of Indonesia in enjoying the advantage of technological diffusion from developed countries. Notably, Indonesia has undergone industrial transformation since the late 1980s. Previously, Indonesia was well known as a developing country whose economy was largely concentrated on agricultural sector, rather than industry. Under Soeharto regime, in the 1980s, Indonesia started to boost the manufacturing sector to offset the declining price of oil and gas. This industrial strategy was aimed at substituting the import products. Even though the import substitution strategy was carried out, the value from export sector was mainly driven by the exports of oil and products from mining sector. In 1980, oil and mining products accounted for 77.6 percent of the total exports value, which means that oil and mining products contributed to a substantial portion of exports sector.[73] Afterwards, the contribution of manufacturing sector is more deteriorated. The downfall of this sector was shown by how its contribution to Indonesia's GDP reached about 27.4 percent in 2004 but then dropped into 23 percent in 2012.[74] This was related to the inability of Indonesian manufacturing companies to compete with foreign companies, mostly in view of the

70 T. Ito and A. O. Krueger, "Introduction to Role of Foreign Direct Investment in East Asian Economic Development," *The Role of Foreign Direct Investment in East Asian Economic Development* Vol.9 (University of Chicago Press, 2000).

71 D. Rodrik, "Industrial Policy for the Twenty-First Century," unpublished paper prepared for UNIDO, September 2004.

72 Archibugi, Howells, and Michie, *Innovation Policy in a Global Economy.*

73 J. Jacob and A. Szirmai, "International Knowledge Spillovers to Developing Countries: the Case of Indonesia," *Review of Development Economics*, 11(3): 2007.

74 See "Indonesia Trapped in De-Industrialization: INDEF," *Tempo*, 8 November 2013; and Kelly Bird, "Concentration in Indonesia Manufacturing, 1975–93," *Bulletin of Indonesian Economic Studies* 35(1): 1999.

low technology capabilities and low-skilled labor. This gives an interesting background to observe the dynamic ability of Indonesia to absorb the technological innovation from developed countries.

This study views that there have been two influential previous studies on the influence of technological diffusion to Indonesia. The first was conducted by Todo and Miyamoto in 2006,[75] which focused on the role of R&D activities in knowledge spill-over, particularly to Indonesia. They revealed that the R&D activities enforced in foreign firms could increase and enlarge the knowledge spill-over to domestic companies. The knowledge spill-over increased in domestic firms mostly through the medium of the labor. Workers who work in R&D performing foreign companies gain higher load of knowledge. The knowledge is diffused to various approaches, namely, job turnover, work-related discussions and forward and backward connections. Todo and Miyamoto assured that there are positive knowledge spill-over from R&D performing foreign companies to domestic total factor productivity (TFP) growth. However, it is worth noting that Todo and Miyamoto stated that foreign direct investment (FDI) could be considered as a major medium of technology transfer as long as the FDI itself is linked to local R&D activities. Furthermore, they argued that Indonesia needed a long period to intensify the knowledge spill-over inconsideration to the significant gap of technology mastery between developed countries from where foreign firms originated and Indonesia.

In addition to Todo and Miyamoto research, Jacob and Szirmai also did a research on similar topic in 2007.[76] They investigated the degree of influence of the import products to knowledge spill-over in Indonesia. Rather than focusing on the influence of the existence of foreign firms in Indonesia to initiate the knowledge spill-over, Jacob and Szirmai focused on the influence of import products as the medium for technological learning. The research found positive correlation between the import products and technological learning in Indonesian manufacturing. They again stated that the increase exposure to international competition has led Indonesian companies to enhance the level of technology and be more eager to be engaged in learning. Yet, Jacob and Szirmai perceived a similar note that the degree of technological learning from the import products highly depended on the level of technology embedded in Indonesian

75 Y. Todo and K. Miyamoto, "Knowledge Spillovers from Foreign Direct Investment and the Role of Local R&D Activities: Evidence from Indonesia," *Economic Development and Cultural Change* 55(1): 2006.

76 Jacob and Szirmai, "International Knowledge Spillovers to Developing Countries: the Case of Indonesia."

companies. As argued by Narula and Dunning,[77] only by having initial domestic technological capabilities could domestic companies create distinctive and non-replicable assets of innovation from FDI-assisted development strategy.

The main debate in the discussion about technological learning in Indonesia is more about the economic implications of globalization towards developing countries.[78] The establishment of an ASEAN Economic Community (AEC) single market and production base with free flow of goods, services, investment and skilled labour, and freer flow of capital, which intensifies the competition among ASEAN countries, requires the readiness of Indonesia. The ability of Indonesian domestic firms to survive in these external challenges relies on the domestic technological capabilities. As found in the study by Todo and Miyamoto[79] as well as Jacob and Szirmai[80], both foreign firms and import products obtained success; however, they also stated that the extent of success itself is highly determined by both the level of domestic R&D activities and the number of skilled workers in Indonesia.

The main lesson for Indonesia is that there is the critical need to create knowledge-intensive and technology-intensive industry. However, it is important to note that the upgrade of knowledge and technology intensive-activities in Indonesia industry requires major efforts and investment. From the experiences of the Japanese industries, it can be comprehended that knowledge management is a very significant and inseparable determinant in industry's output growth. Therefore, the industrial policies that need to be created by the Indonesian government should focus not only on constructing knowledge and technology intensive industry, but also on the enhancement of knowledge management in industry.[81] The purpose of such industrial policy is to increase the ability for innovation that enables restructuring output growth, which consecutively leads to the rapidity of economic development.

The industrial transformation is unlikely to take place without government direction. The development of industry highly relies on the

77 R. Narula and J.H. Dunning, "Industrial Development, Globalization and Multinational Enterprises: New Realities For Developing Countries," *Oxford Development Studies* 28(2): 2000.

78 D. Archibugi and C. Pietrobelli, "The Globalisation of Technology and Its Implications For Developing Countries: Windows of Opportunity or Further Burden?," *Technological Forecasting and Social Change*, 70(9): 2003.

79 Todo and Miyamoto, "Knowledge Spillovers from Foreign Direct Investment and the Role of Local R&D Activities: Evidence from Indonesia."

80 Jacob and Szirmai, "International Knowledge Spillovers to Developing Countries: the Case of Indonesia."

81 N. Lacetera, *Corporate Governance and Innovation in the Pharmaceutical Industry: Some Further Evidence* (Universita Bocconi, 2001)

emergence of entrepreneurs, as entrepreneurship plays a focal role in economic growth, and entrepreneurs can bring the new technology and products to new market. To promote entrepreneurship, the government needs to subsidize investment in non-traditional industries. Hausman and Rodrik argued that governments should apply the "carrot" strategy, which is to provide supports for entrepreneurs. The "carrot" strategy can be in various forms, ranging from direct subsidy, trade protection, protection of intellectual property to the provision of venture capital. Further, Hausman and Rodrik warned that governments should only provide such a support to "original" entrepreneurs - not to the copycats, as the costs that burden the original entrepreneurs to create the innovation is a lot higher than the copycats.

Additionally, the development of industry also demands innovation. Rodrik noted that the scientific and technological capability of companies will not be related to productive dynamism, unless a bloated demand of innovation by the business sector takes place. To create such a demand, the government needs to establish a collaboration among the private sector, universities and research institutes and the government itself. With such collaboration, government would be able to uncover the most substantial obstacles, and the proper policy to remove those obstacles.