Productivity Analysis of Manufacturing Industry in Laos and Lessons Learnt from Japan

Vanxay Sayavong

Visiting Research Fellow, Japan Center for Economic Research (JCER), Tokyo, Japan

Researcher, National Institute for Economic Research (NIER), Vientiane, Laos

Email: sai_vanxay48@yahoo.com

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Abstract

This study aims to assess the productivity of Lao economy and manufacturing industry based on qualitative and quantitative analysis. Firms in enterprise survey and economic census survey are used for quantitative analysis facilitated by Data Envelopment Analysis (DEA) and Tobit estimate. The study argues that Laos could develop the manufacturing industry further in the future since its share in GDP is small. Improving the productivity is crucial to develop manufacturing industry in the future. There is a room to improve the productivity via efficiency component since many existing firms achieved only 20－40 percent of their full efficiency. To end this, this study proposes that the policy interventions for short term should be prioritized in the areas of introduction of accounting system, credit access and international quality certification to manufacturing firms. Whereas, the infrastructure development and increasing market access are considered as the medium and long-term policy recommendation. The experience of Japan shows that economic growth was driven by manufacturing sector. With panel data, the sources of productivity growth for Japanese firms can be decomposed and analyzed. It reveals that although firms made technological progress boosting productivity but they were less efficient over time during the study periods, which implies that such technologies were underutilized. The case study of Japan indicates that the availability of statistics is essential to improve research on productivity analysis of Lao economy and industries in the future. Therefore, the statistics on Lao industries needs to be urgently improved especially Economic Census Survey.

Key words: Lao economy, Japanese economy, productivity, efficiency and scale efficiency

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1. Introduction

Over last two decades, the economies of low-income countries in Asia had grown going rapidly and did so their income per capita allowing them to lift up their positions from the list of low-income countries to higher income countries. As highlighted by the Asia Development Bank Outlook 2017, many developing economies in Asia such as China, India, Thailand and Indonesia have moved to higher income level from low to middle thanked to high economic growth. In terms of population, more than 90 percent of people in such developing economies, who used to be low-income group in 1991, now become middle-income. The success of many developing countries in Asia is the main contributor to the global success since they take up 80 percent of all middle-income economies. The high record of economic growth during the last two decades was predominantly attributed by capital investment and productivity growth (APO, p.77, 2016). Nevertheless, the economic development is without challenges in years ahead. Firstly, many developing countries in Asia may not be able to use the same growth model that heavily depends on capital investment for their transition to higher income level (ADB, 2017). Secondly, the sustainable economic growth has been threaten by the slowdown of productivity growth recently not only in advanced economies but also in emerging and low-income economies due to the recent global financial crisis (IMF, 2017 and OECD, 2016). Therefore, recovering and boosting the productivity growth are critical to sustain economic growth for developing countries.

Laos is with no exemption. Even though Laos has enjoyed high economic growth in the last two decades, which allows the income per capita reaching 1,730 US dollars in 2015 up from 210 US dollars in 1991; the growth has been slowdown in recent years. However, the good news is that Laos has already transited from low-income to low-middle country in 2015, along with other new members of ASEAN such as Cambodia, Myanmar and Vietnam, according to the World Bank. However, to maintain the position and transit to higher position are the challenges for Laos in the future. During the last two decades, high record of Lao economic growth was strongly influenced by a large inflow of foreign direct investment (FDI) especially in resource sector (mining and hydropower) since early 2000s. Since a large capital investment had increased through the channel of FDI, therefore; the growth of Laos was not doubtfully driven by capital investment mainly from resource sector. As a result, resource sector has a largest share of total export and highest rate in labor productivity. Its labor productivity is as high as for 12 times of non-resource sector. However, the employment in resource sector is less than 1 percent of total employment. This clearly shows the unsustainable income distribution among resource and non-resource sectors. At the same time, resource sector has a limited stock and is vulnerable to the commodity prices. In addition, the growth of resource sector has a drawback on non-resource sector through the channel of exchange rate called Dutch disease. With these reasons, heavily depending on resource industries leads to the unsustainability of Lao economy for long term. Hence, developing the non-resource sector especially manufacturing sector should be the alternative. In parallel, Lao government has an ambitious vision to upgrade the status of Laos to higher income level from low middle to high middle-income by 2030. To end this, the income per capita must be raised up by 4 times or from 1,730 US dollars in 2015 up to 6,920 US dollars in 2030[1].

Taking together, Laos needs higher quality/sustainable economic growth to accomplish the government's target. Therefore, it will be more sustainable if Lao economic growth and income per capital are driven by manufacturing sector rather than resource sector. This leads to the motivation of this study that aims to find ways to improve the manufacturing sector in Laos through productivity channel. To end this, three main objectives are set. The first objective is to understand the productivity of Lao economy and industries based on macro data. The second one is to find ways to improve the productivity of manufacturing sector in Laos based on the data from enterprise surveys and economic census survey. The application of Data Envelopment Analysis (DEA) as the quantitative analysis is used to assess the productivity growth, efficiency, scale efficiency and factors behind the efficiency. The final objective is to draw the lessons from the success of Japan in developing her manufacturing sector. Since Japan has been through several stage of development, lessons learnt from Japan is equally matter for this research.

This paper proceeds as follows. The background and identified problems are presented in the first section. Overviews of Lao and Japanese economies are summarized in the section 2 and 3 to capture the broad picture of their economic growth and productivity during the last two-three decades at the macro level. Visiting previous literature and their limitations are highlighted in section 4. Section 5 describes theoretical concept and methodology including data source for quantitative analysis. Econometric results for the case of Laos and Japan are reported and discussed in section 6. The last section is the conclusion.

2. Lao Economy

2.1. Economic Reform and Source of Growth

The Lao PDR is a land-locked and one of the least developed economies (LDCs) located in the Southeast Asian region. It population is around 6.5 million people with the growth rate of 1.45 annually over the last 10 years, according to the latest population census 2015. Although Laos has enjoyed high economic growth over the last two decades around 7 percent (Figure 1), but income per capita is among the lowest in the region. In 2015, income per capita of Laos is 1,704 US dollars lower than Vietnam and Thailand (1,990 and 5,720 US dollars respectively). The poverty rate as well as the inequality rate of income distribution is high among countries in the region as well. According to ADB basic statistics 2017, the poverty rate of Laos is 23.2 percent and the GINI coefficient indicator is 37.9 while the poverty and GINI in Cambodia, Thailand and Vietnam are 14 percent, 7 percent, 10.5 percent, 30.8, 37.6 and 37.9 respectively.

[1] This requires the real GDP growth at least 7.5 percent annually under the assumption of fixed exchange rate and GDP deflator growth rate at 8,300 Kip per US dollar and 5 percent per year. The population growth rate is also assumed to be less than 2 percent or between 1.2-1.8 percent.

FIGURE 1

Real GDP Growth of Laos

Source: Lao Bureau Statistics (LSB), Laos

The economic reform in Laos began in 1986 where the central planning system was replaced by the market-oriented system under the president of Kaysone Phomevihane. With the new system, Lao economy has gradually exposed to the global economy through several economic reforms such as trade, investment liberalization, agricultural reform, privatization, liberalization of price and exchange rate. As a result, tariff structure was gradually simplified and creation of foreign investment law was established in 1988. Later on, Laos has gained the Generalized System of Preference scheme (GSP) granted by developed countries especially European countries since 1990s. In 1997, Laos was accepted as a member of the Association of South East Asian Nations (ASEAN) and joined the ASEAN free trade agreement (AFTA) in 1998. Recently, another achievement of trade liberalization occurred when Laos has gained WTO membership on February 2013. WTO is expected to allows the Lao export sector to access a larger market along with other 158 members in terms of tariff rates (MFN), transparency and non-tariff barriers particularly in developing markets (Haddad et al. 2006).

Since early 1990s, Laos has enjoyed high economic growth on average of 7 percent annually although it faced slightly setbacks during 1997-1998 Asian Financial Crisis (AFC) and 2008-2009 Global Financial Crisis (GFC). Resource and manufacturing sectors are among the fastest sectors driving Lao economic growth since 2000s. This leads to a change of economic structure dramatically. For instance, the share of resource to GDP increased from 4.3 percent during 1998–2000 to 11.4 percent during 2013–15. Although manufacturing sector raised its share steadily from 8.0 percent to 10.1 percent respectively (Table 1) but it is still low when comparing with neighboring countries[2]. The share of service sector is dominant, however; most of them are small and medium enterprises. Despite the share of agriculture declined sharply, the majority of Lao

[2] Based on ADB key indicator 2017, the share of manufacturing to GDP at constant price in Laos was 8.5 percent in 2015 whereas the shares in Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Vietnam were relatively higher with 23 percent, 21.5 percent, 23 percent, 22.1 percent, 23.2 percent, 28.1 percent and 15.4 percent respectively.

population (66 percent) is still remained in such sector. Unlike, less than 1 percent of total employment works in resource industries, according to the Lao Expenditure and Consumption Survey (LECS 5).

TABLE 1

Change of Economic Structure (%)

Sub-sector	1998−2000	2013−2015
Agriculture	45.4	24.7
Resource	4.3	11.4
Manufacturing	8.0	10.1
Construction	5.8	7.1
Service	36.6	46.6
Real GDP	100	100

Source: Lao Bureau Statistics (LSB)

Table 2 shows that service sector such as wholesale and retail in particular covered a major part of economic growth. At the same time, the contribution from agriculture was getting smaller since the late of 1990s. Resource (mining and electricity) and construction sectors played an important part to overall growth though their growths were highly fluctuated during the study periods. This is because the construction sector is strongly engaged with resource projects such as hydropower projects. In contrast, manufacturing sector had played an increasing role steadily. In particular, there was an increase of foreign direct investment (FDI) in special economic zones (SEZs) since the early of 2010s. For instance, some investment of well-known international firms could be observed in the zones such as Nikkon (components of camera), Toyota Corporation (components of automobile) and Essilor (sunglasses). Up to the end of 2016, Lao government has established 12 special economic zones (SEZs) and there are 295 firms in total operating in the Zones (Phonvisay, Thipphavong and Manolom, 2017). For this reason, the prosperity of manufacturing sector can be expected in the future, which would contribute strongly to the economic development of Laos in terms of income generation consequently. Still, however, it believes that resource sector will contribute powerfully to the economic growth of Laos in the near future as several constructions of hydropower plants are under the pipeline. By 2020, Laos will have more than 90 power plants in total with an additional new 52 plants[3].

TABLE 2

Sources of Growth by Sector (%)

Sub-sector	2001−2005	2006−2010	2011−2015
Agriculture	0.71	1.34	0.83
Mining	0.77	1.16	0.38
Manufacturing	0.70	0.86	0.93
Construction	0.11	0.47	0.99

[3] https://laotiantimes.com/2017/01/10/laos-latest-electricity-facts/

Electricity and water	0.02	0.25	0.62
Wholesale and retail trade	2.32	1.50	1.56
Hotel and restaurant	0.02	0.05	0.05
Finance and insurance	0.13	0.62	0.42
Real estate	0.12	0.11	0.30
Transportation and communication	0.46	0.38	0.51
Service activities	0.40	0.44	0.45
Others	0.52	0.71	0.89
Real GDP	6.27	7.90	7.93

Source: Author based on data from Lao Bureau Statistics (LSB)

Looking at another dimension of growth analysis through input growth, Table 3 found that the capital investment had been the main source of growth since 1991; its contribution was more than 70 percent on average or subsidizing 4.8 percent points to total economic growth. In addition, its trend had slightly increased in recent years from 3.63 percent points in the first period to 5.9 percent points. The inflow of foreign direct investment (FDI) in resource sector was considered as the main source. During 2001–2015, electricity generation and mining sectors had attracted the largest investment from FDI, more than 60 percent of total approved investment or around 5.6 billion US dollars[4]. The capital inflow is expected to be crucial for Lao economic growth in the near future because of several large investment projects from FDI are under the pipeline. The contribution from productivity (TFP) seems to be indifferent from labor factor at around 1.13 percent points since 2001. Probably, the decline of productivity growth from 1.47 to 0.85 is more interesting that might pose a challenge for Lao economic growth in the future.

TABLE 3

Sources of Growth by Production Factor (%)

Factor	2001–2005	2006–2010	2011–2014
Capital Growth	3.63	5.91	5.93
Labor Growth	1.24	1.04	1.08
TFP Growth	1.47	1.02	0.85
Real GDP Growth	6.33	7.98	7.87

Source: Author based on data from Penn World Table version 9.0, Feenstra, Robert & Marcel (2015).

2.2. Productivity of Lao Economy

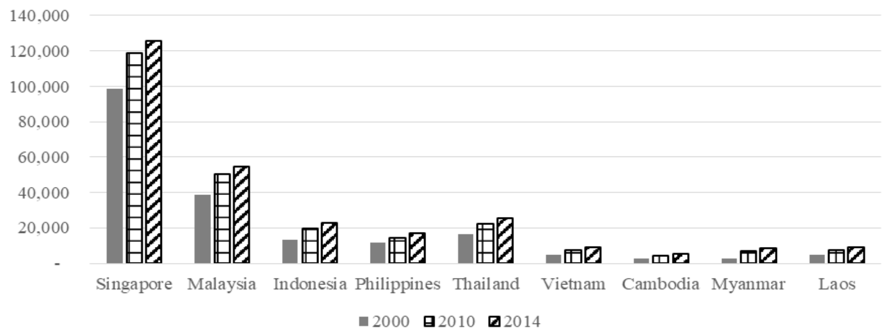
Laos performs well among CLMV countries in terms of labor productivity as shown in Figure 2. In 2014, the labor productivity of Laos was at 9,000 US dollars per worker which was slightly higher than Vietnam (8,900 US dollars), Myanmar (8,400 US

[4] http://www.investlaos.gov.la/images/Statistics/rpt_Invest_Summary_Sector1A_2011-2015.pdf

dollars) and Cambodia (5,400 US dollars) respectively. However, labor productivity growth of Myanmar was among the fastest along with China, 8.9 percent and 8.7 percent annually during 2000－2014. For Laos, labor productivity grew at 4.6 percent annually slightly higher than Vietnam and Cambodia. When comparing to old ASEAN members such as Singapore, Malaysia, Thailand, Philippines and Indonesia, Laos is much lack behind. For instance, according to TDRI (2015, p. 25), Lao worker is less competitive in manufacturing, agriculture and service for 3.6, 6.5 and 3.5 times compared to Thailand.

FIGURE 2

Per-worker Labor Productivity Levels-GDP at Constant Basic Prices per Worker, using 2011PPP, Reference Year 2014



Unit: US dollars
Source: APO Productivity Database 2016

When comparing labor productivity by sub-sectors within Lao economy and their growths in three different years reported in Table 4, it is clearly seen that labor productivity of resource sector was extremely high and much higher than other sectors. Its labor productivity was more than 49 times of the labor productivity of agriculture sector, and 12 times of service and manufacturing sectors. When accounting this evidence, the national labor productivity as mentioned earlier might not reflect the realities of Lao economy where is substantially influenced by resource sector. In terms of growth, the national labor productivity grew relatively at high level with around 5.8－6.3 percent annually. However, labor productivity in service sector was likely on the downtrend as the same as agriculture. Whereas the growth of labor productivity in resource and construction sectors was sharply high during 2008－2013. The labor productivity of manufacturing sector increased steadily from 4 percent to 10 percent between two periods.

TABLE 4

Labor Productivity by Sector in Laos and Growth Rate (%)

Sector	Labor productivity (Million Kip) 2003	2008	2013	Annual Growth rate (%) 2003－2008	2008－2013
Resource	164.1	152.0	238.3	-1.5	11.4
Manufacturing	9.9	11.9	17.8	4.0	10.0

Agriculture	3.9	4.6	4.8	3.3	1.1
Construction	12.0	10.9	22.6	-1.9	21.6
Service	16.7	22.0	25.1	6.3	2.8
Real GDP	7.3	9.6	12.3	6.3	5.8

Note: Productivity = Real value added / Number of employ (person).
Source: Author based on data from LEC 3&5 for employment statistics. Real value added by sector is from Lao Bureau Statistics (LSB)

3. Japanese Economy

The success of Japanese high economic growth after World War II is well known in literature. As a result, Japan became a position of high-income country by taking a short time period. For instance, according to World Bank Database, income per capita increased for more than 45 times within 30 years or jumped up from 610 US dollars in 1962 to 30,190 US dollars in 1992. Later on, the Japanese growth model had passed to the other East Asian economies (Ito, 1996). Many countries in Southeast Asian including Thailand, Malaysia, Indonesia, Vietnam, Cambodia and Laos have also followed Japanese growth model. Even though Japan is now not as used to be, but its past success is worthy to learn. This leads to the main purpose of this section that reviews Japan during the peak time especially the post-period of World War II in order to draw out the lesson learnt as well as the drawback for Laos.

FIGURE 3

Real GDP Growth of Japan (%)

Source: Statistics Bureau, Statistics Japan, Ministry of Internal Affair and Communication. http://www.stat.go.jp/english/data/chouki/03.htm

Japan had enjoyed high economic growth since late 1950s until 1970s with 9 percent annually (Figure 3). The economy of Japan was led by manufacturing sector as the productivity growth of this sector in terms of labor productivity was as high as 6.5 percent during 1960s－92, higher than any other sectors. During this period, the economic structure of Japan had been changed from basic manufacturing (textiles and toys) to advanced manufacturing (electronics, steel, and ships) in the 1970s; and more advanced manufacturing industries (automobiles and semiconductors) in the 1980s (Ito, 1996, p.227). Accordingly, the share of manufacturing sector in GDP became larger from 28 percent in 1955 to 38 percent in 1975. In addition, it had contributed about 2.5 percent points to total economic growth of Japanese economy during 1956－1973. The robust of manufacturing industries had also enabled the other sectors such as distribution service, finance, energy, transportation and construction to grow as well (Takada, 1999). Therefore, it is fairly to conclude that the manufacturing sector is fundamentally central for economic growth of Japan.

The success of Japanese economy especially manufacturing was conditional to a number of favorable conditions. One of them is Korean War where the exports of Japan had expanded rapidly during Korean War in mid of 1950s to facilitate the US military (Lucien, 2004). This had encouraged the growth of Japanese manufacturing industries during this time. The exports included ships, tanks, jeeps, aircraft, textile, metal, chemical, transportation, machinery and electricity (Sugita, 2003, p.99). Secondly, the competition policy rather than industrial policy was believed to strengthen the productivity of domestic industries especially the automobile and electronics (Hatta, 2016). The competition policies, the establishment of Fair Trade Commission in 1947 and trade liberalization in 1960s for instance, had shaped the ways of doing business of private companies to be more competitive internationally. The internal development of industries such as lifetime employment and main bank system were regarded as main factors for that shape and the expansion of industries (Ito, 1996). During the period of economic boom, for example, Japanese firms formed a long-term relationship with the guarantee of a job for life and rewards in the forms of return and position to their workers. Therefore, workers were willing to work harder. Because of hard working, the productivity of the firms had improved gradually. Similar to the main bank system where the banks were not just being the lenders but played a role on monitoring the performance of firms as a part of investors. The successful industries include electronics, automobile, electrical equipment and textiles. Whereas industrial policies provided by the ministry of International Trade and Industry (MITI) such as selective industries and subsidies is doubtful because some targeted industries such as coal, petrochemical, oil refining and aluminum had failed to grow as expected (Ito, 1996, p.226). Other favorable conditions such as high saving rate, education and monetary policy are also considered but less significant. Therefore, the details for these favorable conditions are not investigated.

Based on the availability of data since 1970s, Table 5 indicates that capital investment and productivity are the main two sources of Japanese economic growth. After the crisis of oil's price in 1973, the economy had been slowdown and did so the productivity. The economy got even worse after the bubble economy in early 1990s. The demand shock was claimed as one of main factors that leads to the slowdown of productivity growth of Japan after 1991, which consequently resulted to labor hoarding, idling of capital stock, and a decline of return rate on capital (Fukao, 2013). Later on, the outward of Japanese investment or shifting their production sites to oversee such as China, Thailand and other countries in Southeast Asia region was also believed to back up the decline of Japanese productivity (Saito, 2015). As a result, the spillovers of R&D from large firms to smaller firms got smaller in Japan since not only their supply chains and factories were relocated but also the R&D activities. Fortunately, the productivity and quality of labor had strongly kept the economic growth in recent years thanks to the productivity improvement made by large firms.

TABLE 5

Sources of Growth by Factors (%)

Factor	1970－80	1980－90	1990－2000	2000－2012
Man-hours Growth	0.3	0.4	-0.6	-0.5
Labor Quality Growth	0.9	0.6	0.5	0.5
Capital Quantity Growth	2.2	1.6	1.0	0.1
Capital Quality Growth	-0.5	0.4	0.1	0.1
TFP Growth	1.7	1.3	0.0	0.5
Real GDP Growth	4.6	4.3	1.1	0.7

Source: The Japan Industrial Productivity Database 2015 (JIP Database 2015), Research Institute of Economy, Trade and Industry (RIETI), Japan.
http://www.rieti.go.jp/en/database/JIP2015/index.html.

4. Literature Review

This section devotes to the previous empirical studies on productivity analysis in Lao and Japanese literature. In particular, the studies related to productivity/total factor productivity grounded on the quantitative analysis are the focus. Since there are several studies of Japanese literatures were carried out in previous years, only some studies are selected for review.

4.1. Lao Literature

Honestly, it is relatively hard to find the previous studies on productivity of Lao manufacturing industry based on quantitative method such as DEA or stochastic production frontier analysis. Several studies can be found in the case of agriculture but very rare in the case of manufacturing industry. To my best knowledge, one research is only found, it is the research by Vixathep (2011). Under his research, Data envelopment analysis (DEA) is used to analyze the growth of productivity (TFP) for 33 garment firms during 2004-2005. The key finding reveals that the productivity (TFP) of sampling garment firms decreased by －40 percent during the studied periods. Such large decline is mainly from a decrease of technical progress because of the demand shock as claimed by the author. Moreover, the levels of technical efficiency are varied among firms but the gap is spread out over studied periods because of greater competition in the global market. In addition, the study finds an improvement of technical efficiency and TFP at the individual firms but worse for the whole sample. The author made a further analysis on efficiency model. The model includes factors such as age of firms, ownership, capital intensity and the ratio of managerial employee. As shown by the result, only the variable of staff share is in effect on the efficiency indicating there is a shortage of managerial employees in the garment firms. Therefore, raising a ratio of managerial employee is necessary for enhancing efficiency.

Other studies have slightly touched on the productivity analysis related to Lao economy. For instance, Kao (2013) estimates the total factor productivity (TFP) as an indicator of national productivity for 10 ASEAN countries during 1999−2001. For Laos, the study shows that total factor productivity (TFP) contributed around 1.024 percent points per year, 4.5 percent points from capital growth and 1.32 percent points from labor growth. Unfortunately, no lesson learns can be drawn from this study since it is lack of detailed analysis. Unlike, Nolintha and Yee (2015) use time series data of Lao economy during 1991−2010 based on the Ordinary Least Square (OLS) estimation. Based on their result, the growth of Lao economy is predominantly influenced by the capital input rather than labor input. TFP is claimed to contribute to output growth by 0.03 percent. In the other hand, the study indicates that there is a positive relationship between output per labor (labor productivity) and capital per labor (capital intensity). Finally, the study found the impact of FDI in resource sector on output growth.

These previous studies gave some insights on analysis of economic growth and productivity in Laos. However, the provision of policy recommendation is likely to be limited since a few numbers of policy variables are included in the model. In addition, the sample size is also small. Therefore, this study tries to overcome the gap of previous studies by applying a larger sample size and recruiting more policy variables.

As mentioned, there are more studies on agriculture applying the frontier and inefficiency model, which can be found on Boundeth, Naseki&Takeuchi (2012) and Viengpasith, Yabe & Sato (2012) in case of maize; Supaporn (2015) in the case of sugacane; Soukkhamthat & Wong (2016) in the case of cassava; Inthavong (2005) and Phetsamone (2012) in the case of rice production. Since this study aims only on the manufacturing industry, they are not in review.

4.2. Japanese Literature

Since the focus on this research is the productivity analysis on Lao industries, a few previous studies in Japan are selected for review. It is well-understood that many studies on raising industrial and firm productivity were carried in the past and some are ongoing especially the research program[5] initiated by Research Institute of Economy, Trade and Industry (RIETI). One of the studies that is directly related to this research is the study of 'Explaining Japan's unproductive two decades' by Fukao (2013). This study tried to unveil the reasons behind the slowdown of productivity of Japanese economy particularly in manufacturing and non-manufacturing sectors in the last two decades. The result found that the productivity (TFP) growth of both sectors had declined after 1991 due to demand shocks leading to labor hoarding and idling of capital stock, a decline of return rate on capital. This is because that capital ratio to GDP had accelerated but the return rate of capital had dropped at the same time. The author also claims that United States had enjoyed higher growth of return rate of capital and did so the productivity mainly because the acceleration of ICT investment which is contrasted to Japanese counterpart. Another interesting analysis is that large firms had improved in productivity in recent years whereas small and medium firms were still far behind. Therefore, the gap between two was getting wider. This incidence was

[5] The ongoing research program on raising industrial and firm productivity is during FY 2016−2019. The competed research program was during FY 2011−2015. There are several research topics under the research program. More details can be found on http://www.rieti.go.jp/en/projects/program/pg-05/.

explained by the different accumulation of ICT and intangible investment between two groups and less spillovers of R&D from large firms to smaller firms since many large firms have expanded and relocated their supply chains, factories and their R&D activities to oversee. To raise the productivity in manufacturing sector, the author suggests that easing the regional logistics, enhancing tree trade agreement and reducing corporate tax especially for new Japanese and multilateral businesses are essential.

Similarly, Saito (2015) assesses the current state of the productivity of Japanese manufacturing industry. He found that although the productivity of Japanese manufacturing sector (labor productivity) is still among top countries in the front stage comparing to other OECD countries based on the recent report in 2012 but the position is not as it used to be in 1990s. He highlights three causes for the decline of labor productivity in manufacturing sector, namely; (1) outward investment or shifting production sites abroad, (2) high cost of non-manufacturing sector, (3) low usage of ICT capital and (4) low turnover rate of unproductive firms or low rate of introduction of new business – poor indicator of doing business especially starting business.

Fortunately, Japanese manufacturing industry is still more productive in terms of TFP when compared to Korea and China although Korean firms have improved their productivity dramatically during the study periods (Fukao, at el 2008). It is because Korean firms especially new entries of small and medium firms had over invested in the tangible fixed assets and R&D resulting in low return rate to capital and R&D (Kim and Keiko 2013). When comparing Japanese labor productivity with the United States, Fukao (2007) found that the productivity of manufacturing industry in Japan took only one fifth of the United States. Low productivity in the labor-intensive industries such as textile was claimed as one of the main reasons attributed to such low labor productivity.

Although the studies reviewed above are informative on Japanese productivity analysis, however; the sources of productivity growth is unclearly identified. Unlike, this study attempts to explicitly decompose the sources of productivity growth for Japanese manufacturing sector into three sources, namely; (1) technological change, (2) efficiency change and (3) scale efficiency change based on the panel data compiled from the database of EALC 2010[6].

5. Theoretical Concept, Methodology and Data Source

5.1. Theoretical Concept

The aim of this section is to understand the concept of productivity and sources of its change. To do so, this section is principally built on the literature of Coelli, et al (2005) and Balk (2001). Accordingly, productivity is measured by output per unit of input such as output per worker or working hour or per hectare. However, such measurement has limitations since not only a unit of labour or single input is used to produce the output but, in realities, it also involves factors of capital and materials (Coelli, et al, 2005, p.62). Therefore, output per single unit could lead to misinterpretation of productivity analysis. Therefore, multifactor productivity (MFP) or total factor productivity (TFP) are more desirable in use as an indicator for productivity analysis. TFP or MFP is where all

[6] More details on the database is discussed in 5.3. Data Source

inputs are taken into account in measuring productivity. According to Coelli, et al (2005, p.62), total factor productivity (TFP) is defined by “a ratio of aggregate output produced relative to aggregate input used”. For instance, a simple calculation of TFP is via profitability ratio of a firm by a ratio of revenue (real term) to input cost (real term). Other methods include Hicks-Moorsteen TFP (HM TFP) Index and growth accounting where the former is to compare output growth to input growth. Therefore, when output growth is higher than input growth or HMTFP index is greater than 1 would signal the evidence of productivity improvement. The later method is popularly and widely used to separate the sources of output growth normally into three sources that are from labour growth, capital growth and TFP growth. Nevertheless, these calculations are without limitations when a further analysis of sourcing the productivity or TFP growth over time is made.

Fortunately, following to Balk (2001), the change of productivity between two periods can be breakdown into four sources. These sources are (1) technological change (TC), (2) efficiency change (EC), (3) scale efficiency change (SEC) and (4) output mixed effect (OME) or input mixed effect (IMO). Since the fourth has to dial with the prices of multiple output and inputs, only former three are considered as seen in equation 1.

$$\text{TFP Change} = \text{Technical Change} * \text{Efficiency Change} * \text{Scale Efficiency Change} \qquad (1)$$

Where,

- Technological change (TC) refers to the shift of production technology between two periods.
- Efficiency change (EC) exists when a firm is able to improve production efficiency between two periods or the ability to use available technology or more efficient use of inputs closer to the technology frontier.
- Scale efficiency change (SEC) refers to the improvement (scale efficiency) in the scale of operations of the firm and its move towards technologically optimum scale of operation between two periods.
- Note that the change productivity and its component is in the form of Malmquist index.

The implicit form of mathematic formula can be found as:

$$TFPC^{s,t}(x_s, x_t, q_s, q_t) = \left[\frac{d_o^t(x_s, q_s)}{d_o^s(x_s, q_s)} \times \frac{d_o^t(x_t, q_t)}{d_o^s(x_t, q_t)}\right]^{0.5} \times \left[\frac{d_o^t(x_t, q_t)}{d_o^s(x_s, q_s)}\right] \times \left[SEC_o^s(x_s, x_t, q_s) SEC_o^t(x_s, x_t, q_s)\right]^{0.5} \qquad (2)$$

Where

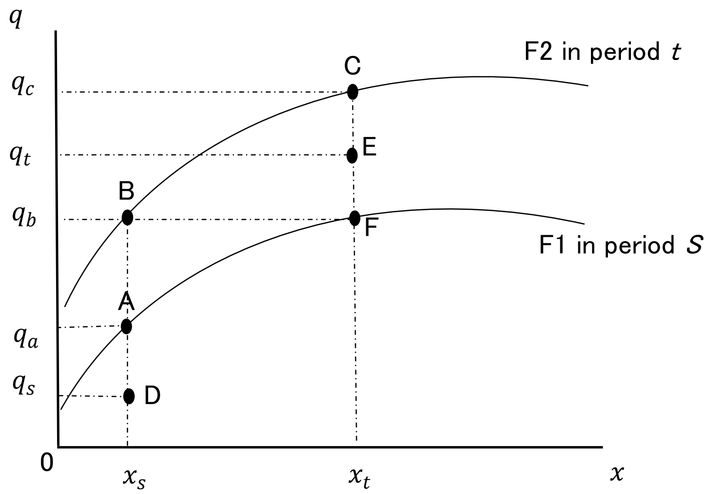
- $TFPC^{s,t}(x_s, x_t, q_s, q_t)$ is TFP change between period S and T

- $\left[\frac{d_o^t(x_s,q_s)}{d_o^s(x_s,q_s)} \times \frac{d_o^t(x_t,q_t)}{d_o^s(x_t,q_t)}\right]^{0.5}$ is technological change or technological progress[7] between period *S* and *T*
- $\left[\frac{d_o^t(x_t,q_t)}{d_o^s(x_s,q_s)}\right]$ is efficiency change between period *S* and *T*
- $[SEC_o^s(x_s,x_t,q_s)SEC_o^t(x_s,x_t,q_s)]^{0.5}$ refers to the scale efficiency change between period *S* and *T*

The explanation of a change for the each component is given in Figure 4. Figure 4 explains the production function of a firm as an example in two periods (*S* and *T*) where the vertical axis presents output (*q*) and the horizontal axis refers to the input (*x*). F1 is defined as the production frontier or production technology for the first period (*S*) and F2 refers to the production frontier for the second period (*T*).

FIGURE 4

Measuring Productivity Change



Source: edited Coelli, et al (2005, p.71) and Balk (2001, p.169)

At first, a firm produces an actual output of q_s in the first period (*S*) at point D by using an input of x_s with technology (F1). Similarly, in the second period (*T*), an actual output of q_t is produced at point E using an input of x_t with technology (F2). Since the actual outputs produced at both periods by the firm are below the potential outputs on production frontiers (F1 and F2), output losses due to inefficiency occur in both periods. Then, the efficiency can be measured in period *S* and *T* for the firm. The efficiency level denoted by $d_o^s(x_s,q_s)$ in period *S* is $\left(\frac{q_s}{q_a}\right)$ or $\left(\frac{D}{A}\right)$ and the efficiency level denoted by $d_o^t(x_t,q_t)$ in period *T* is $\left(\frac{q_t}{q_c}\right)$ or $\left(\frac{E}{C}\right)$. Note that the efficiency lies between 0 and 1 where 1 refers full efficiency. Thus, the efficiency change (EC) is the ratio of efficiency level in period *T* to period *S* or $\left(\frac{q_t/q_c}{q_s/q_a}\right)$.

[7] Note that the notation of technical change is used to refer the technological change in some literature. In this study, they are used interchangeable.

Next, the change of technological progress can be identified as the change of output due to any changes in technology is $\left(\frac{q_b}{q_a}\right)$ under the choice of using input x_s. If the choice of using input x_t is selected, then productivity gain due to the technological change can be calculated as $\left(\frac{q_c}{q_b}\right)$. The technological change $\left(\frac{q_b}{q_a}\right)$ under the choice of input x_s is denoted as $\left[\frac{d_o^t(x_s,q_s)}{d_o^s(x_s,q_s)}\right]$ and the technological change $\left(\frac{q_c}{q_b}\right)$ under the choice of input x_t is denoted as $\left[\frac{d_o^t(x_t,q_t)}{d_o^s(x_t,q_t)}\right]$. Since it is difficult to select the choice of using inputs, an average of these two choices is considered. Therefore, the technological change is defined as

$$\left[\frac{d_o^t(x_s,q_s)}{d_o^s(x_s,q_s)} \times \frac{d_o^t(x_t,q_t)}{d_o^s(x_t,q_t)}\right]^{0.5} or \left[\left(\frac{q_b}{q_a}\right) \times \left(\frac{q_c}{q_b}\right)\right]^{0.5}$$

For the scale efficiency change, according to Coelli et al., (2003, p.77), the concept is that "the scale efficiency of a given firm is then measured using the output distance of the observed input-output vectors relative to the *variable returns-to-scale* (VRS) frontier and from the cone technology or the constant returns-to-scale (CRS) technology that is generated from the observed VRS technology". Under the CRS technology, a firm has fully scale efficiency or equal to 1.

The scale level of efficiency change SEC_0^t based on the frontier 2 as a reference defines as

$$SEC_0^t(x_t, x_x,\ q) = \frac{SE_0^t(x_t,\ q)}{SE_0^t(x_s,\ q)}$$

$$SE_0^t = \frac{E_t^*(x,q)}{E_t(x,q)}$$

The scale level of efficiency SEC_o^s based on the frontier 1 as a reference defines as

$$SEC_0^s(x_t, x_s,\ q) = \frac{SE_0^s(x_t,\ q)}{SE_0^s(x_s,\ q)}$$

$$SE_0^s = \frac{E_t^*(x,q)}{E_t(x,q)}$$

Where

SE is scale efficiency index

$E^*$is efficiency level under the VRS whereas E is efficiency level under CRS production function.

Then, the change of scale efficiency is the average of changes for two methods as below.

$$[SEC_o^s(x_s,x_t,q_s)SEC_o^t(x_s,x_t,q_s)]^{0.5}$$

5.2. Methodology

Two approaches are widely applied to estimate the production frontier and components of total factor productivity (TFP) namely Data Envelopment Analysis (DEA) and Stochastic Frontiers Analysis (SFA). While DEA uses the linear programming, the stochastic frontier is dependent on the econometric methodology. In this study, DEA method is used for the analysis since it provides no requirement of econometric estimation, no need to specify a functional from for the production function, and no need to conduct conventional test of hypotheses for the distance function or frontier (Coelli et al., 2003). Moreover, the estimation can be simply carried out by DEAP version 2.1. The details of DEA method can be referred to the paper by Coelli (1996) as well as the discussion of differences between two methods on Coelli et al., (2005).

For the purpose of analysis, two steps are carried out where the first step is the estimation of production frontier that involves the traditional inputs and outputs in order to estimate the efficiency scores (TE) for individual firms. Note that TE scores are between $0-1$ where 1 means 100 percent or full potential output on frontier. Then the second step is proceeded for efficiency effect model based on the econometrics via Tobit estimate. Tobit method is used rather than OLS is because it can compromise the truncated data (McCarty and Yaisawarng, 1993). The efficiency model is aimed to investigate the factors behind different efficiency across firms. The factors are related to firm's specifics such as managerial and organizational structure, and external environments such as infrastructure, exchange rate, subsidies, other related the export and investment. The implicit efficiency model is specified as following:

$$TE_i = \delta_0 + \sum_j \delta_j z_{ij} + \varepsilon_i \qquad (3)$$

Where,

- TE_i is the efficiency score (TE) for firm i
- δ_0 and δ_j are unknown parameters
- z_{ij} are firm-specifics (managerial and organizational structure) and environmental conditions such as infrastructure, exchange rate, subsidies, other related the export and investment promotion.
- ε_i is error term

5.3. Data Source

- *Laos Case Study*

This study used two types of datasets for the analysis of productivity and efficiency in Laos. Both are cross sectional data. Note that cross sectional data refers to when the several firms can be observed at one point in time only. The first type of dataset is the enterprise survey conducted by the World Bank whereas the second type of dataset is the economic census survey by Lao Statistics Bureau (LSB). Enterprise surveys were carried out in 2006, 2009, 2012 and 2016[8]. These surveys, except the enterprise survey 2006, use the stratified random sampling design to capture the different subdivisions of

[8] Note that the data collections on firms' information such as sale, capital and labor were recorded in 2004, 2008, 2011 and 2015 for the enterprise survey 2006, 2009, 2012 and 2016 respectively.

population and covers the diversity of establishments. Industry, size of employment and region are used to identify the level of stratification for sampling firms. International Standard Industrial Classification (ISIC) is used for the definition of industries. Total samples for each survey are 303, 360, 379 and 368 firms in service and manufacturing sectors within 4－6 provinces including Vientiane capital city of Laos. Only enterprises with 5 employees and above were selected for the survey. Since manufacturing industry is the focus of this study, only firms in manufacturing sector is used. Unfortunately, due to large missing data of interested information for the enterprise survey in 2012, only enterprise surveys of 2006, 2009 and 2016 are utilized. In addition, the weights cannot be incorporated for the efficiency analysis as well because the enterprise survey of 2006 was conducted without using the survey design. Furthermore, missing values for key variables are the major concerns leading to the reduction of sample size in use. The statistics of variables for production frontier and efficiency model is presented in Table 6.

TABLE 6

Statistics Summary of Enterprise Survey

Variable	Obs	Mean	Std. Dev.	Min	Max
		Production Frontier			
Sale *(Thousand Kip)*	382	4,280,000	18,000,000	13,000	281,000,000
Capital *(Thousand Kip)*	382	7,460,000	43,300,000	474	674,000,000
Material *(Thousand Kip)*	382	970,000	4,900,000	474	66,100,000
Labor *(Person)*	382	74.81	165	5	1,400
		Efficiency Model			
Time	382	2009	4.24	2006	2016
Location	382	0.4634	0.4993	0.0000	1.0000
Size	382	1.7094	0.7646	1.0000	3.0000
Foreign ownership	382	0.1178	0.3228	0.0000	1.0000
Export Intensity	382	0.6309	0.4832	0.0000	1.0000
Age of Firm (log)	382	4.9945	2.6581	0.0000	7.6029
Capital Intensity (log)	382	17.3531	1.3378	11.4591	22.4217
International Certificate	382	0.0707	0.2566	0.0000	1.0000

Note: international certificate of recognized quality includes ISO 9000-1 or ISO 2008
Source: Enterprise survey, World Bank

In addition, the dataset from economic census survey in 2012/13 is also used. Economic census 2012/13 is the second survey in Laos undertaken by Lao Statistics Bureau (LSB) during 10-30 May 2013 while the first survey was back in 2006[9]. It is the nationwide survey including all establishment regardless whether they are registered. The establishments include profit and non-profit institutions in economic related sectors. Therefore, institutions such as military, police and family business are excluded. Regarding to profit institution, there are 126,913 establishments in total. In which,

[9] The data on key variables such as sale was collected in a range interval between maximum and minimum levels. Therefore, the first economic census can not be utilized.

105,874 establishments were in service sector which shares the largest (85 percent of total establishments). There are 15,573 establishments in manufacturing sector running up as the second largest (12 percent in share). The remains are agricultural, construction, electricity and mining sectors. With respected to establishments in manufacturing sector, about 85.9 percent of establishments are micro enterprises. Micro-enterprise refers to a firm who employs labor less than 5 persons. For consistency with the enterprise survey for analysis, the establishments with employees of less than 5 persons are removed.

Similar to the enterprise survey, International Standard Industrial Classification (ISIC) is applied to classify the definition of industries. Again, the statistics of variables is summarized in Table 7. Note that since the data collection is different from the enterprise survey, some different variables for efficiency model are observed.

TABLE 7

Statistics Summary for Economic Census Survey

Variable	Obs	Mean	Std. Dev.	Min	Max
		Production Frontier			
Sale *(Thousand Kip)*	974	34,900	41,200	200	200,000
Capital *(Thousand Kip)*	974	6,060,000	137,000,000	150	4,240,000,000
Material *(Thousand Kip)*	974	2,140,000	36,700,000	136	1,000,000,000
Labor *(Person)*	974	14.68	26.33	5	456
		Efficiency Model			
Location	974	0.2721	0.4453	0.0000	1.0000
Size	974	1.4343	0.5222	1.0000	3.0000
Capital Intensity (log)	974	16.1207	1.7252	10.1779	23.8716
Age of Firm (log)	789	1.5955	0.8716	0.0000	3.6109
Age of Manager (log)	854	3.7645	0.2431	2.9444	4.3694
Education of Manager (log)	934	1.5783	0.4130	0.0000	1.9459
Foreign ownership	974	0.0041	0.0640	0.0000	1.0000
Join-venture ownership	974	0.0431	0.2032	0.0000	1.0000
Using accounting system	974	0.3265	0.4692	0.0000	1.0000
Access to credit	974	0.2864	0.4523	0.0000	1.0000
Using TI	971	0.2019	0.4016	0.0000	1.0000

Source: Economic Census Survey, Lao Statistics Bureau (LSB), Laos

- Japanese Case Study

The study applies the panel data of Japan manufacturing firms during 1985－2007 constructed from the East Asian Listed Companies (EALC) Database 2010, called EALC 2010. Note that panel data is when several firms (identical firms) excluding the exist and new entries are observed over time. EALC 2010 is the updated version constructed by a study group comprised of Japan center for economic research (JCER), Hitotsubashi university center for economic institutions (CEI), CENU center for China and Asian Studies, and the center for corporate competitiveness of Seoul National

University. The first version is the EALC 2007. The database of EALC 2010 includes Japanese, Chinese, South Korean and Taiwanese firms listed on the stock exchanges in each individual country covers different industries including manufacturing. It contains the annual of capital stock, labor cost, intermediate input and production in both real and nominal term of local currency (Japanese Yen). Note that the real term value is adjusted by price index of 2000. Also, labor input in man-hours is incorporated. This database is purposely used to compute the productivity database for international comparison. Fukao, at el (2008) is one of international comparative studies that used EALC 2007 to construct and compare TFP levels at the industrial levels for Japan, South Korea and China from 1985–2005.

Based on the aim of this study, data on manufacturing industries[10] from EALC 2010 for Japan is only considered for productivity analysis. The panel data is constructed for 871 firms over 23 years or during 1985 to 2007. So that, there are 20,033 observations in total. Unluckily, efficiency model can not be executed due to the unavailable information related to firm's characteristics and environmental conditions as the same case of Laos. The statistics on key variables is summarized in Table 8.

TABLE 8

Statistics Summary for EALC 2010

Variable	Obs	Mean	Std. Dev.	Min	Max
Output *(million Yen)*	20,033	158,000,000	479,000,000	132,455	12,400,000,000
Capital *(million Yen)*	20,033	64,400,000	188,000,000	11,443	3,060,000,000
Material *(million Yen)*	20,033	127,000,000	395,000,000	294,618	9,910,000,000
Labor *(man-hours)*	20,033	4,972,257	12,000,000	11,052	165,000,000

Source: East Asian Listed Companies (EALC) Database 2010, the Japan Center for Economic Research, the Hitotsubashi University Center for Economic Institutions, the CENU Center for China and Asian Studies, and the Center for Corporate Competitiveness of Seoul National University

[10] Industrial codes of 6 to 25 are only considered. The list of industrial codes can be found in Table 15 in Appendix.

6. Empirical Results

6.1. Case Study of Lao Manufacturing industry

Due to the limitations of data and the capacity of DEAP version 2.1[11], only the efficiency and scale efficiency are analyzed for samples in enterprise and economic census surveys. Firstly, the result for enterprise survey is presented as following.

- *Enterprise Survey*

Generally, the efficiency level of firms in surveys is relatively low with 20－40 percent of the frontier. At the same time, the scale efficiency is below full-scale optimization. This should suggests that there are more spaces to progress the efficiency of firms as well as scale efficiency. The result also shows both means of technical and scale efficiency for firms are varied across times which indicates that, for instance, the change of the mean efficiency is seen to be improved slightly over the study period (Table 9). However, the efficiency in recent years had declined from 44.6 percent in 2008 to 35.3 percent. For the change of scale efficiency, the mean of scale efficiency index is on the decline from 0.733 in 2004 to 0.702 in 2015. Such decline of both indicators could be partially affected by the external or demand shocks such as the global financial crisis in 2008. Nonetheless, there is a need for caution on the analysis of changes in efficiency and scale efficiency during the study periods since the datasets are cross sectional data and sample sizes for each survey are small which might not be convincible to represent manufacturing industry.

TABLE 9

Efficiency and Scale Efficiency (Mean) for Enterprise Survey

Year	Efficiency Level	Scale Efficiency Index	No. Sample
2004	0.258	0.733	191
2008	0.446	0.761	85
2015	0.353	0.702	109

Note that the suffix of ES refers Enterprise Survey whereas EC refers to Economic Census Survey.
Source: Author's estimation

To find the ways to improve the efficiency of firms, efficiency model is used shown in Table 10. Overall, the model is significant at 1 percent level and the value of log likelihood is also high indicating that the models are good enough to represent the dataset. The finding indicates that firms in small and medium size are less efficient than large firms by 75 percent and 61.2 percent respectively. This implies that the size of firm affects the operational efficiency, so that firms can be more efficient if their size is

[11] DEAP 2.1 can apply the Malmquist DEA method to only the panel data to estimate the indices of total factor productivity (TFP) change, technological change, efficiency change and scale efficiency change. Therefore, with the cross sectional data, the change of productivity and technology can not be estimated by DEAP 2.1. However, it is possible to estimate the technological and productivity change for cross sectional datasets in two different periods if the econometric method was used.

larger. Secondly, firms who has the international certificate of recognized quality such as ISO 9000-1 or ISO 2008 are more efficient than who has not by 42.1 percent. Because the international recognized quality certification requires firms to improve their managerial and operating system by themselves in order to meet the requirement of markets[12], therefore; firms with international recognition performs better than firms without. The reverse relationship between capital intensity and efficiency might indicates that the return from capital per worker is declining across firms. This should reflect an over-supply of capital for a worker resulting in less efficient or it means workers use capital input not efficiently. Another possible reason is that the capital investment is under-utilized because of the declining orders or decrease of demand (Vixathep, 2011, p. 104). For this reason, it is not recommendable for firms to increase the ratio of capital to labor to prevent a further loss of efficiency unless the skills of labors are enhanced to exploit the new investment efficiently. This result is similar to the previous study for the case of garment industry. However, it should not be the main concern since the coefficient is relatively small.

Although the coefficients for other firm's specifics such as foreign ownership, export intensity and age of firm have expected signs, they are insignificant to influence the variation of efficiency. Hence, firms are not different in efficiency under these firm's characteristics. For instance, foreign firms are indifferently efficient compared to domestic firms because many of foreign firms are sub-contact and spend less on R&D or innovation activities. The typical example is the garment industry where many garment firms are medium with sub-contact production. The process of their production is simply regarded as Cut-Make-Trim (CMT) for the orders overseas. Therefore, foreign firms invest little in R&D and human development as the same as domestic firms (Nolintha and Jajri, 2014). Similarly, the location effect shows no sign of influence on efficiency. The model also includes the time trend, which shows that the time trends are positive in both years compared to the year 2004.

TABLE 10

Efficiency Model for Enterprise Survey

Independent Variable	Coefficient	Std. Err.	t-statistics
Time2009	1.270**	0.555	2.290
Time2016	1.111**	0.546	2.040
Location	-0.119	0.103	-1.160
Small Size	-0.750***	0.155	-4.840
Medium Size	-0.612***	0.154	-3.980
Foreign Ownership	0.070	0.162	0.430
Export Intensity	0.141	0.164	0.860
Age of Firm (log)	0.108	0.098	1.100
Capital Intensity (log)	-0.067*	0.038	-1.770
International Certificate	0.421**	0.213	1.980
Constant term	-1.129	0.999	-1.130

[12] More details on international certification can be found on https://www.iso.org/home.html

Log likelihood	-529.8
Prob > chi2	0.000
Number of observation	382

Note: ***, **, and * denote significance at the 1%, 5% and 10% level respectively.
Source: Author's estimation

- *Economic Census Survey*

The efficiency mean of sample in census survey is 22.5 percent, which is slightly lower than the ones in enterprise surveys. The efficiency means across firms in sub-industries are varied. Table 11 shows that the efficiency levels of firms in electrical and garment industries are higher than firms in other industries. Whereas, firms in basic metal, rubber plastic, food, beverage, tobacco and wood processing industries are among least efficient comparatively. Note that the efficiency levels for firms in motor vehicles, electronic and leather industries should be inconvincible for analysis since the standard deviations are relatively high. Although there is a need to be careful for interpretation because of small samples in some sub-industries, the analysis gives some hinds on different efficiency among different manufacturing industries at least. Such differences in efficiency across firms are due to different conditions such as firm's characteristics and environmental conditions that are latter investigated in efficiency model.

TABLE 11

Efficiency Level (Mean) for Firms in Sub-sector in 2012

No.	Sub-sector	No. sample	Efficiency Score (TE)	Std. Err.
1	Motor vehicles and trailers	2	0.6250	0.2653
2	Electrical equipment	2	0.5535	0.0152
3	Leather and related product	3	0.4510	0.2256
4	Textile	2	0.4022	0.0693
5	Chemical and pharmacies	13	0.3774	0.0842
6	Computer and electronics	11	0.3713	0.1205
7	Wearing apparels	126	0.3537	0.0275
8	Coke and refined petro	13	0.3298	0.0768
9	Other non-metallic miner	6	0.2767	0.0755
10	Printing	22	0.2536	0.0489
11	Basic metal	63	0.2525	0.0289
12	Furniture and other manufacturing	234	0.2228	0.0131
13	Wood and processing	24	0.2041	0.0459
14	Food, beverage and tobacco	70	0.1941	0.0270
15	Rubber and plastic product	381	0.1639	0.0090
16	Fabricated metal product	2	0.1182	0.0207

Source: Author's estimation

Factors behind the efficiency across firms in economic census survey is reported in Table 12. It finds some similar and contrast results with the previous model for the enterprise survey. Firstly, it similarly finds that small and medium firms are less efficient than larger one. The values of their coefficients between two models are also closed. Secondly, the foreign firms are also insignificant along with the age of firms on efficiency. However, the location effect and capital intensity are plausible. Both of their coefficients are significantly positive. This is because that the economic census survey covers samples in more locations, where the development of infrastructure in non-capital cities are much different from the capital city. Such differences in infrastructure development appear to influence the efficiency across firms. These results interpret the importance of infrastructure development and the availability of capital to workers for production efficiency. However, the capital intensity should again not be the main concern for firms since its coefficient is relatively small.

More interesting results that can be drawn are that firms who uses accounting system and access to credit are more efficient than who doesn't by 31.6 percent and 18.8 percent respectively. Surprisingly, the report of economic census survey 2015 shows that more than 80 percent of all manufacturing establishments operates without accounting system (Table 5.1, p.71). If so, following the result of efficiency model, one way that could enhance the production efficiency of firms is to introduce the standard accounting system into firm's management; assuming other conditions constant. Similarly, the efficiency can be enriched if firms could access to credit. Unfortunately, human capital measured by age and education of managers shows no evidence of effect on efficiency.

TABLE 12

Efficiency Model for Economic Census Survey

Independent variable	Coefficient	Std. Err.	t-statistics
Location	0.155*	0.086	1.800
Small Size	-0.806**	0.340	-2.370
Medium Size	-0.568*	0.335	-1.700
Capital Intensity (log)	0.062**	0.024	2.570
Age of Firm (log)	0.018	0.044	0.410
Age of Manager (log)	0.132	0.164	0.810
Education of Manager (log)	-0.121	0.102	-1.190
Foreign ownership	0.519	0.664	0.780
Join-venture ownership	0.203	0.201	1.010
Using accounting system	0.316***	0.095	3.350
Access to credit	0.188**	0.081	2.310
Using TI	0.148	0.120	1.240
Constant term	-2.838***	0.812	-3.500
Log likelihood	-874.15		
Prob > chi2	0.000		
Number of obs	649		

Note: ***, **, and * denote significance at the 1%, 5% and 10% level respectively.
Source: Author's estimation

6.2. Case Study of Japanese Manufacturing Industry

With richer data of panel, the change of productivity and its components at firm level can be easily estimated for the sample. However, because firm's specifics are not observed in the database, the efficiency model can not be constructed like in the case of Laos. Table 13 shows the result on the growth of productivity, technology, efficiency and scale efficiency. In general, the total factor productivity of firms had improved by 1.1 percent annually during the study periods. Such improvement was mainly from the contribution of technological progress whereas the technical efficiency brought the productivity downturn and not much contribution from scale efficiency. In particular, the contribution from technology was extraordinarily high during the period of 2001−2007 with more than 5 percent points. This should imply that firms had invested more on new technologies or innovation such as information communication of technology (ICT) or R&D during this period. Following to Inoue and Koguchi (2017), and Fukao (2013), Japanese manufacturing sector especially large firms had achieved high productivity during 1995−2015 due to the investment of ICT capital and intangible investment-innovative property, software and database.

TABLE 13

Growth of Productivity and its Components (Mean) in Sub-periods

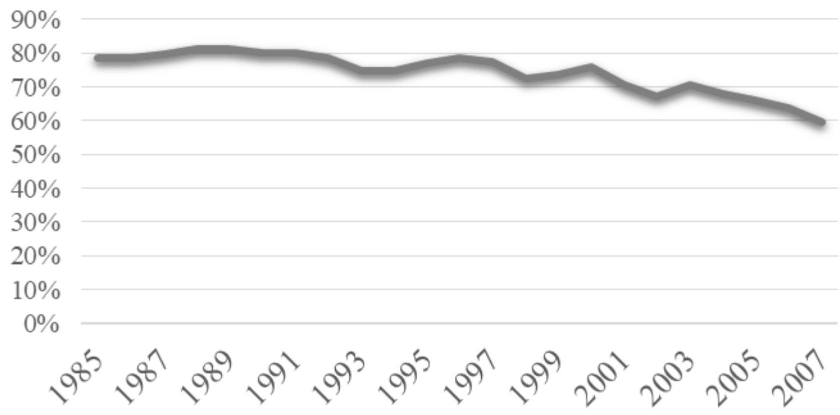
Sub-period	Technologies	Efficiency	Scale Efficiency	Total Factor Productivity (TFP)
1986−1990	0.1%	0.5%	0.2%	0.8%
1991−1995	1.1%	-0.8%	-0.2%	0.1%
1996−2000	1.0%	-0.3%	0.4%	1.2%
2001−2007	6.2%	-3.6%	-0.2%	2.0%
Mean	2.4%	-1.3%	0.0%	1.1%

Note that the annual change is reported in Table 16 in Appendix
Source: Author's estimation

In contrast, firms did poorly in utilizing the technologies, which leads to decline of contribution from efficiency component to the productivity growth. Such decline was due low investment on human development and organizational structure (Fukao, 2013). This prevents firms to catch up to the space of technological progress. It suggests that to utilize the technologies efficiently, there is a call for firms to invest more on human development and organizational structure. Figure 5 displays that the efficiency level had declined explicitly from 80 percent in late of 1980 to 68 percent in 2000s. The most decline in efficiency during the study periods were firms in industries of wood product, leather, paper and allied, textile mill products, printing and publishing products, primary metal, and instruments.

FIGURE 5

Efficiency Level (Mean) during 1985-2007



Source: Author’s estimate

Since the decline of technical efficiency is the drawback for productivity growth, further information on efficiency for firms in sub-sectors should be useful to what extension. Table 14 delivers the report of efficiency level by ranking for firms in sub-industries during 2003－2007. Interesting to know that firms in the industries related to electrical and electronic, miscellaneous, non-electrical machinery, petroleum and coal, instrument, printing and publishing, food, furniture and wood, and transport equipment were among top ten in efficiency. In contrast, firms in the industries of textile, metal, leather, stone, and glass were the least efficient firms. In fact, firms in electrical and electronic, miscellaneous, non-electrical machinery industries are used to be at the bottom ten of the least in efficiency during the late of 1980s, which implies that firms in these industries had improved their managerial and organizational efficiency over time.

TABLE 14

Efficiency Level (Mean) by Firms in Sub-sector during 2003－2007

No.	Sub-sector	No. Sample	Efficiency Score (TE)	Std. Err.
1	Electrical and electronic machinery	78	0.817	0.004
2	Miscellaneous manufacturing	19	0.706	0.018
3	Non-electrical machinery	26	0.705	0.004
4	Petroleum and coal products	4	0.698	0.041
5	Instruments	5	0.668	0.009
6	Printing, publishing, and allied products	17	0.653	0.015
7	Food and kindred products	9	0.649	0.006
8	Furniture and fixtures	130	0.633	0.011
9	Transportation equipment and ordnance	7	0.624	0.008
10	Lumber and wood products	1	0.622	0.021
11	Apparel	43	0.621	0.010
12	Chemicals	74	0.616	0.004

13	Fabricated metal	45	0.614	0.007
14	Motor vehicles	133	0.614	0.006
15	Rubber and miscellaneous plastics	124	0.612	0.006
16	Leather	68	0.611	0.027
17	Stone, clay, and glass products	19	0.599	0.006
18	Textile mill products	27	0.590	0.015
19	Paper and allied products	31	0.550	0.009
20	Primary metal	11	0.541	0.006

Source: Author's estimation

7. Conclusion and Implication

Laos is one of developing countries with high economic growth. However, such high growth is heavily weighted with physical capital mainly from resource sector. As a result, labor productivity of resource sector is surprisingly extremely high distorting the measurement of national labor productivity as well as income per capita. Also, under the resource led growth, Lao economy is unsustainable in terms of income distribution, limited stock of resource and easily exposed to external shocks such as commodities' prices. In parallel, Lao government has an ambitious vision to upgrade the income of Lao people to another level by 2030. This means that Lao economy needs a strong growth at least 7.5 percent annually. Therefore, it is a big challenge for Laos to sustain the economic growth and achieve the government's target in the future. Developing manufacturing industry through productivity is an alternative option to improve economic growth, income level and income distribution in the sustainable way. The current knowledge and understanding on productivity of Lao economy and manufacturing industry are limited since only few literatures were carried. Therefore, this study aims to add an additional value into the existing literature by investigating the productivity of Lao economy and manufacturing industry based on qualitative and quantitative analysis.

The study finds that there is a space for Laos to develop its manufacturing industry since the share of manufacturing in GDP is small and mainly labor intensive industry. Based on the Data Envelopment Analysis (DEA) for enterprise survey, the efficiency as well as scale efficiency seems to be declining in recent years. Overall, including the sample in economic census survey, the efficiency level was low around 20-40 percent of frontier. With this evidence, there is a room to improve the efficiency. To do that, this study suggests that the areas of infrastructure development, firm's size, introduction of accounting system, credit access and international quality certificate recognition should be the focus. To what extent, promoting the use of accounting system, credit access and international certificate should be prioritized in the short term whereas the infrastructure development and increasing the size of firm through larger market access are considered for the long term priorities. Finally, it is unfortunate to inform that the technological progress can't be investigated due to limited data and the capacity of statistical software.

The experience of Japan shows manufacturing industry had been the leading driver of economic growth since early 1950s. Economic reforms such as competition policy and trade openness were believed to strengthen the manufacturing industry to become more productive. With panel data, the sources of productivity growth for Japanese firms can be decomposed and analyzed. The result indicates that the slowdown of productivity growth was mainly from the deterioration of efficiency meaning that Japanese firms were less efficient since late 1980s. However, there was strong contribution from technological progress made by firms. The most efficient firms during 2003-2007 were in the industries of electrical and electronic, miscellaneous, non-electrical machinery, petroleum and coal, instrument, printing and publishing, food, furniture and wood, and transport equipment. Case study of Japan has an implication for Laos, as to improve research on productivity analysis of Lao economy and industries in the future, the statistics needs to be improved especially Economic Census Survey. For instance, the panel data should be constructed and more quantitative information on investment in hardware such as machinery, software such as information communication of technology (ICT), human resource such as skills of labor, and research & development (R&D) should be captured in the survey questionnaire.

8. References

Adler. G, Duval. R, Furceri. D, Celik. S.K, Koloskova. K and Marcos. P.R (2017), 'Gone with the Headwinds: Global Productivity', IMF staff discussion note. http://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2017/04/03/Gone-with-the-Headwinds-Global-Productivity-44758

Asian Productivity Organization (2016), *APO Productivity Databook 2016*, http://www.apo-tokyo.org/publications/wp-content/uploads/sites/5/APO-Productivity-Databook-2016.pdf.

Balk. B.M (2001), 'Scale efficiency and productivity change', *Journal of Productivity Analysis*, 15, pp. 159-183. https://www.researchgate.net/publication/226254717_Scale_Efficiency_and_Productivity_Change.

Boundeth. S, Nanseki. T and Takeuchi. S (2012), 'Analysis on technical efficiency of maize farmers in the northern province of Laos', African Journal of Agricultural Research, Vo.7, pp.6579-6587. http://www.academicjournals.org/journal/AJAR/article-full-text-pdf/F6A24CD38967.

Coelli. T.J (1996), 'A guide to FRONTIER version 4.1: a computer program for stochastic frontier production and cost function estimation', CEPA Working Paper 96/07, Center for Efficiency and Productivity Analysis, University of New England.

Coelli. J.T (1996), 'A guide to DEAP Version 2.1: a data envelopment analysis (computer) program', *CEPA Working Papers.* No.8, Department of Econometrics, University of New England, NSW 2351, Australia.

Coelli.J.T, Rao. D.S.P, O'Donnel. C.J and Battese. G.E (2005), *An Introduction To Efficiency and Productivity Analysis,* Second Edition, Springer Science and Business Media, Inc.

Feenstra. R.C, Inklaar. R and Marcel P.T (2015), 'The next generation of the Penn World Table', *American Economic Review*, 105(10), 3150-3182.

Fukao. K (2013), 'Explaining Japan's unproductive two decades', RIETI Policy Discussion Paper Series 13-P-022, Research Institute of Economy, Trade and Industry (RIETI).

Fukao. K, Inui. T, Kabe. S and Liu. D (2008), 'An international comparison of the TFP levels of Japanese, South Korean, and Chinese Listed Firms', *Seoul Journal of Economics*, Vol. 21, No. 1, Institute of Economic Research, Seoul National University.

Haddad. M, Fane. G, Nuansavanh. K, Brenton. P and Schuler. P (2006), 'Building export competitiveness in Laos: background report', World Bank.

Kao. C (2013), 'National Productivity of the Southeast Asian Countries', *European Scientific Journal*, Vol.1, ISSN: 1857-7881.

Kim.Y and Keiki. I (2013), ‘R&D investment and productivity: a comparative study of Japanese and Korean firms’, RIETI Discussion Paper Series 13-E-043, Research Institute of Economy, Trade & Industry (RIET).

Inthavong. H.K (2005), ‘Factors influencing rice production efficiency in Ban Home, Lao’, Master Thesis of Science, Department of Agricultural Economics, McGill University. http://digitool.library.mcgill.ca/webclient/StreamGate?folder_id=0&dvs=1492586541682~739&usePid1=true&usePid2=true.

Inoue. T and Koguchi. T (2017), *Japan’s Non-manufacturing Sector must seek to utilize AI&IoT Technologicaies-breaking away from Existing Operations is crucial*, Japan Center for Economic Research (JCER). https://www.jcer.or.jp/eng/research/policy.html.

Ito.T (1996), ‘Japan and the Asian Economies: A “Miracle” in Transition’, *Brookings Papers on Economic Activity, 2:1996*. https://www.brookings.edu/wp-content/uploads/1996/06/1996b_bpea_ito_weinstein.pdf.

McCarty. T.A and Yaisawarng. S (1993). ‘Technical efficiency in New Jersey School Districts’ in Fried HO and SS Schmidt (eds.) *the Measurement of Productive Efficiency: Techniques and Applications*, Oxford U.K.: 271-287.

Nolintha. V and Yee. S.L (2015), ‘Lao PDR’s economic growth: the role of capital accumulation and the natural resource sector’, *Reitaku International Journal of Economic Studies*, Vol. 22.

Nolintha. V and Jajri. I (2014), ‘The garment industry in Laos: technological capacities, global production chains and competitiveness’, *Asia Pacific Business Review*, Vol. 22.

Phetsamone.T (2012), ‘The role of agricultural extension services on rice production efficiency in Laos - a case study on Bolikhanh district, Bolikhamxai province’, A master thesis of science, Kyushu University. http://worldfood.apionet.or.jp/Research%20by%20Graduate%20Students/pdf%20Dissertations/Mr.%20Thanasack%20Phetsamone.pdf.

Phonvisay. A, Thipphavong. V and Manolom. T (2017), ‘Cross-border impact of Thailand’s SEZs on Laos’ SEZs and collaboration in the midst of regional integration’, *Lao Trade Research Digest*, Vol 6, pp. 42-66.

Saito. J (2015), *How productivity is the Japanese manufacturing sector?*, Japan Center for economic research (JCER), https://www.jcer.or.jp/eng/research/pdf/saito20150703e.pdf.

Soukkhamthat. T and Wong. G.Y (2016), ‘Technical efficiency analysis of small-scale cassava farming in Lao PDR’, *Asian Journal of Agriculture and Development*, Vol.13, No.1.

Sugita. Y (2003), *Pitfall or Panacea: The Irony of US Power in Occupied Japan 1945-1952*, Routledge, New York&London.

Supaporn. P (2015), ‘Determinants of technical efficiency of sugarcane production among small holder farmers in Lao PDR’, *American Journal of Applied Sciences*, 12(9): 644-649. http://thescipub.com/PDF/ajassp.2015.644.649.pdf.

Takada. M (1999), ‘Japan’s economic mirac le: underlying factors and strategies for the growth’, IR 163 Professor Wylie.
http://www.lehigh.edu/~rfw1/courses/1999/spring/ir163/Papers/pdf/mat5.pdf.

Thailand Development Research Institute Foundation (TDRI) (2015), ‘Lao People’s Democratic Republic: support for the human resource development strategy’, ADB Technical Assistance Consultant’s Report, Project Number: 46068.
https://www.adb.org/sites/default/files/project-document/173734/46068-001-tacr.pdf.

Viengpasith. V, Yabe. M and Sato. G (2012), ‘Analysis of Technical efficiency of smallholder maize farmers in Northern Lao PDR: case study of Parlay district, Sayabouly province’, Laboratory of Environment Economics, Department of Agricultural and Resource Economics, Faculty of Agriculture, Kyushu University. http://catalog.lib.kyushu-u.ac.jp/handle/2324/22085/p309.pdf.

Vixathep. S (2011), ‘Efficiency and productivity change in Lao garment industry: a nonparametric approach’, *Journal of International Cooperation Studies*, Vol.19, No.1.

9. Appendix

TABLE 15

List of Industries on EALC Database 2010

Indus Code	Industry Name
1	Agriculture
2	Coal mining
3	Metal and nonmetallic mining
4	Oil and gas extraction
5	Construction
6	Food and kindred products
7	Textile mill products
8	Apparel
9	Lumber and wood products
10	Furniture and fixtures
11	Paper and allied products
12	Printing, publishing and allied products
13	Chemicals
14	Petroleum and coal products
15	Leather
16	Stone, clay and glass products
17	Primary metal
18	Fabricated metal
19	Non-electrical machinery
20	Electrical and electronic machinery
21	Motor vehicles
22	Transportation equipment and ordnance
23	Instruments
24	Rubber and miscellaneous plastics
25	Miscellaneous manufacturing
26	Transportation
27	Communications
28	Electrical utilities
29	Gas utilities
30	Trade
31	Finance, insurance, and real estate
32	Other private services
33	Public service

Source: East Asian Listed Companies (EALC) Database 2010, the Japan Center for Economic Research, the Hitotsubashi University Center for Economic Institutions, the CENU Center for China and Asian Studies, and the Center for Corporate Competitiveness of Seoul National University

TABLE 16

Technology, Efficiency, Scale Efficiency and Productivity Change (Mean) during 1986-2007

Year	Technological Change (TC)	Efficiency Change (EC)	Scale Efficiency Change (SEC)	TFP Change (TFPC)
1985	-	-	-	-
1986	-0.7%	-0.4%	-1.0%	-2.1%
1987	-3.1%	2.0%	2.1%	1.0%
1988	0.1%	1.8%	0.5%	2.4%
1989	1.9%	0.0%	-0.2%	1.7%
1990	2.2%	-1.1%	-0.2%	0.8%
1991	0.7%	-0.2%	-0.4%	0.1%
1992	1.1%	-2.1%	-0.7%	-1.7%
1993	5.9%	-4.9%	-1.4%	-0.6%
1994	-0.5%	0.3%	1.5%	1.3%
1995	-1.6%	3.0%	0.1%	1.5%
1996	-0.7%	1.8%	0.8%	1.9%
1997	3.3%	-1.5%	-0.9%	0.9%
1998	4.9%	-6.5%	-0.1%	-1.9%
1999	-1.1%	2.0%	1.3%	2.2%
2000	-1.2%	2.9%	1.1%	2.9%
2001	6.0%	-7.3%	0.4%	-1.3%
2002	8.6%	-5.6%	0.1%	2.7%
2003	-1.1%	5.5%	-0.1%	4.2%
2004	9.1%	-4.1%	-1.5%	3.2%
2005	5.0%	-2.8%	0.2%	2.3%
2006	6.6%	-4.2%	-1.0%	1.1%
2007	9.0%	-6.8%	0.5%	2.1%
Mean	2.4%	-1.3%	0.0%	1.1%

Source: Author’s estimation