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Innovation and Dynamic Productivity Growth in the Indonesian Food and Beverage Industry

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Abstract: This paper examines the relationship between innovation and dynamic productivity growth in the Indonesian food and beverage industry. Dynamic productivity growth is calculated using a Luenberger indicator, and innovation is represented by a process innovation. This research uses firm-level data for the period 1980–2015 sourced from the Indonesian Central Bureau of Statistics. This research uses a panel data regression model to estimate the relationship between innovation and dynamic productivity growth. This research finds that innovation is relatively low in the Indonesian food and beverage industry. Dynamic productivity growth declines steadily during the period of estimation. This research also found that innovation positively affected dynamic productivity growth only after the introduction of the competition law in Indonesia.

Keywords: dynamic productivity growth; innovation; competition law; food and beverage industry

JEL Classification: L11; L44; L51; M21; O31

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1. Introduction

The Indonesian food and beverage industry is a manufacturing sector that proceeds raw materials from agriculture, fisheries, and plantations into value-added products. Since 2010, the Indonesian food and beverage industry has contributed almost 20% of the GDP annually, making it a significant contributor to the Indonesian economy. In addition, the Indonesian Central Bureau of Statistics [1] reported that the food and beverage industry accounted for over half of all household spending. Given the importance of the industry, production security should be guaranteed. To secure production performance in the industry, firms should continually innovate in their operations (see [2]). For example, innovation in food production using robots or new improved machines may double production. Regarding innovation activities in the Indonesian manufacturing industry, Setiawan et al. [3] reported that only nine subsectors of the food and beverage industry were included in the twenty subsectors of the Indonesian manufacturing industry with the highest R&D expenditures during the periods 1994–1995 and 2017. Nevertheless, the percentage of R&D expenditures for those subsectors was still low, at less than 1% of their output. This indicates that innovation in the Indonesian food and beverage industry may still be low.

Regarding the impact of innovation on production performance, previous research has investigated the relationship between innovation and productivity growth. Geroski [4], Vivero [5], Huergo and Jaumandreu [6], and Mañez et al. [7] investigated the effects of innovation on productivity growth in the European manufacturing industry. Their research concluded that innovation positively affected productivity growth. On the contrary, Mansury and Love [8] found that innovation did not affect productivity growth in US business service firms. Previous research has suggested that the effect of innovation on productivity growth could be different between regions or sectors. A factor that may cause the different effects of innovation on productivity between regions or sectors can be economic institutional infrastructure (see [9]). Economic infrastructure institutions can be regulated, such as the competition law suggested by Setiawan et al. [10]. Setiawan et al. [10] found that the introduction of competition law in Indonesia since 1999 has decreased inefficiency allocative. The latter may suggest that the introduction of competition law, as an economic institution infrastructure can affect productivity growth. Thus, research investigating the effect of innovation on productivity growth in the Indonesian food and beverage industry is still relevant, especially including the effect of the introduction of Indonesian competition law.

Moreover, research investigating the effect of innovation on productivity growth is rarely found in the Indonesian food and beverage industry. Additionally, the effect of the introduction of competition law on the way innovation affects dynamic productivity growth, as well as the effect of competition law implementation on dynamic productivity growth, are rarely investigated in Indonesia. Previous research only investigated the impact of industrial concentration on R&D in the industry (see [3]). In addition, Setiawan [11] only investigated productivity growth and its determinants without including the impact of innovation on productivity growth. Setiawan et al. [10] also investigated only the effect of competition law's introduction on the price–cost margin. Thus, research investigating the impact of innovation on dynamic productivity growth, including the influence of the implementation of competition law, is important.

Previous research investigating the relationship between innovation and productivity growth also applied to static productivity growth. The adjustment costs of investments in quasi-fixed factors of production were not taken into account by static productivity growth. Failure to account for adjustment costs in productivity growth assessment, according to Kapelko et al. [12–14], Setiawan and Lansink [15], and Setiawan [11], may incorrectly ascribe adjustment costs to productivity growth. A cost that is either internally created, such as learning expenses, or externally generated, such as expansion planning fees, is referred to as a transaction or rearrangement cost [12,16,17]. Although adjustment costs are not visible, their impacts are expressed as increased input costs and/or reduced output levels. As a result, a study on the relationship between innovation and productivity growth using dynamic productivity growth is important.

Research on the relationship between innovation and dynamic productivity growth with the influence of competition law can generate important policy implications. Policymakers such as the Ministry of Economics, the Ministry of Industry, and the Ministry of Trade can facilitate firms' innovation if the innovation can secure the productivity growth of the industry. With this information, policymakers can design regulations and incentives to support firms' innovation in the industry and to improve their productivity growth. Additionally, the positive effect of competition law on dynamic productivity growth as well as on the way innovation affects dynamic productivity growth may suggest that policymakers, such as the Indonesian Competition Commission, strengthen the effectiveness of competition law in Indonesia.

Based on the previous background, this research freshly investigates the relationship between innovation and dynamic productivity growth in the Indonesian food and beverage industry. This research also has novelty with respect to the application of dynamic productivity growth in relating innovation to productivity growth. Moreover, this research also includes the influence of competition law on the effect of innovation on productivity growth. Both novelties can be useful for firms and policymakers.

The following is a breakdown of the paper's structure. The second section is devoted to a review of the literature. The modeling approach is described in Section 3. Section 4 presents the data description, and Section 5 contains the presentation of the empirical model and outcomes. The final section summarizes and draws conclusions from the findings.

2. Literature Review

Research investigating the relationship between innovation and productivity growth has been conducted previously among countries and sectors. The innovation measures are mostly sourced from the survey. According to OECD-EUROSTAT [18], a firm is said to implement product innovation if a new and improved product has been introduced in the market. A firm is said to implement process innovation if a new and improved manufacturing process is used within the production process. Due to data unavailability, most of the previous research defined innovation as the process innovation. For example, Geroski [4] investigated the relationship between firm entry, innovation, and productivity growth in 79 industries in the UK during the period 1976–1979. Innovation was measured by the annual count of major innovations constructed by SPRU at Sussex. The research found that innovation activity increased productivity growth. Vivero [5] also investigated the relationship between innovation and productivity growth of firms in Spain. The research used two measures of innovation, i.e., R&D intensity and the number of process innovations that a firm obtained in a year. The research found that innovation positively affected static productivity growth. Mañez et al. [7] investigated the effect of process innovation on the total factor productivity growth of small and medium enterprises in Spanish manufacturing during the period 1991–2002. Process innovation was defined as a modification of the productive process using a question in the survey. The research concluded that the introduction of process innovation increased productivity growth. Huergo and Jaumandreu [6] investigated the impact of (process) innovations on productivity growth. The research used 2300 Spanish firms surveyed during the period 1990–1998. They defined process innovation as activities related to the modification of the productive process (affecting machines, organization, or both). The research concluded that process innovation affected productivity growth. Rochina-Barrachina et al. [2] investigated the effect of process innovation using a sample of Spanish manufacturing firms during the period 1991–1998. The data on the process innovation was sourced from the survey, where the process innovation was assumed to occur if the firms answered positively to the question on whether the firms introduced some important modifications to the productive process. The research concluded that process innovation increased the total factor productivity growth. In contrast to other previous research, Mansury and Love [8] concluded that innovation did not affect productivity growth. They investigated the impact of innovation on the productivity and growth of US business service firms. They used a questionnaire to collect data on innovative firm activities. Later research may suggest that an investigation of the relationship between innovation and productivity growth may still be relevant.

Regarding the ambiguous effect of innovation activity on productivity growth, previous research suggested that the ambiguous effect could be caused by a poor economic institution in the country that might affect the effectiveness of innovation in improving productivity growth (see [9]). Poor economic institutions, i.e., monopolization and cartelization, may significantly create higher uncertainty about the benefits of having more innovation since innovation activity may increase the costs of developing new products and services. Thus, innovation may inversely affect productivity growth in countries with poor economic institutions. For example, the monopolization or cartelization of a sector by a few companies may negatively affect the productivity growth of other companies with more innovation in the same sector since market power is still owned by the monopolists. Thus, the implementation of competition law in Indonesia in 1999 is hypothesized to turn the effect of innovation into a positive effect on productivity growth.

Regarding the effect of the competition law on productivity growth, Setiawan et al. [10] found that the introduction of competition might lower the inefficiency allocative, i.e., lower the price–cost margin. The lower inefficiency allocative may increase productivity growth since firms will increase capacity utilization to get higher returns.

Dynamic productivity growth can also be affected by other variables, such as foreign ownership and export activity. For example, Setiawan [11] suggested that foreign ownership had a positive effect on dynamic productivity growth. Additionally, Kimura and Kiyota [19] also found that exports could increase the productivity growth of firms.

This research still applies the measure of innovation as a modification of the productive process because of data unavailability of product innovation. This research does not use R&D to measure innovation since the R&D data were only available for a few years (less than 5 years with no consecutive years). In addition, the adjustment cost from the investment in quasi-fixed input, which is attributed to the productivity growth measure, is taken into account in this study, which was not taken into account in earlier similar research.

Regarding previous research, this research hypothesizes that the effect of innovation and other variables on dynamic productivity growth can be written in the equation (1). The trend variable is included in the equation (1) following the research of Setiawan [11] to reconfirm the trend of dynamic productivity growth.

$$DTFPG = \mathrm{f}(Innov, Foreign, Export, Law, InnovLaw, Trend) \quad (1)$$

where $\frac{\partial DTFPG}{\partial Innov} > 0$ or $\frac{\partial DTFPG}{\partial Innov} < 0$, $\frac{\partial DTFPG}{\partial Foreign} > 0$, $\frac{\partial DTFPG}{\partial export} > 0$, $\frac{\partial DTFPG}{\partial Law} > 0$, $\frac{\partial DTFPG}{\partial InnovLaw} > 0$, and $\frac{\partial DTFPG}{\partial Trend} < 0$ or $\frac{\partial DTFPG}{\partial Trend} > 0$. *DTFPG* is the dynamic productivity growth, *Innov* is the process innovation, *Export* is the export activity of the firm, *Foreign* is the foreign ownership, *Law* is the dummy to reflect the period of competition law implementation, *InnovLaw* is the interaction variables between dummy of competition law and innovation, and *Trend* is the trend variable.

3. Modelling Approach

This research defines process innovation as the expenditures for purchasing and repairing machines and equipment to significantly improve the process of production (see [18]). The use of expenditures to measure process innovation can be better than the R&D measure since the expenditures can reflect the actual use of the new improved process of production (see also [5]). The expenditure on R&D may not directly be implemented in the process of production. This research applies the ratio of innovation to the output of firms as the final measure of innovation.

The shift in firm productivity growth over time is represented by dynamic productivity growth. Current decisions have an impact on future productivity, according to this dynamic productivity concept. This dynamic measure takes into account investment-related adjustment costs, which, in static models, could be wrongly attributed to improvements in technological efficiency and production. The intertemporal connection of production choice in this dynamic framework is provided by the adjustment costs related to changes in the level of quasi-fixed elements [13,14]. A Luenberger indicator of dynamic productivity gain in practice can be used to calculate it. The Luenberger indicator was created using the idea of a dynamic directional distance function. The function is based on production technology at time t, and it can be written as $V_t(y_t{:}k_t) = \{(x_t, I_t)$ can produce y_t, given $k_t\}$. The vector of outputs (y_t) is formed using the vector of inputs (x_t) and quasi-fixed input (k_t), with the gross investment in k_t (I_t). Silva and Stefanou [20] and Silva et al. [21] both cited the following qualities as being included in the production input requirement list. The intertemporal connection of production choice in this dynamic framework is derived from the adjustment costs associated with changes in the level of quasi-fixed components [13,14]. Using a Luenberger indicator of dynamic productivity development, it can be practically estimated. The production input requirement set is considered to have the following characteristics in accordance with Silva and Stefanou [20] and Silva et al. [21]: The closed, nonempty set *Vt(yt:kt)* has a lower bound, is positive monotonic in variable inputs x_t, and is negative monotonic in gross investments I_t. Its output levels rise with the quasi-fixed inputs k_t and are freely dispensable. It also has a strictly convex set. The feature connected to the gross investment, which suggests that there is a positive cost when there is an investment in quasi-fixed inputs, plainly demonstrates the incorporation of the adjustment costs.

The input-oriented dynamic directional distance function is first applied to estimate the dynamic technical inefficiency using directional vectors for inputs to estimate dynamic productivity growth (gx) and investment (gI) or $\overset{\rightarrow i}{D}_t(y, K, x, I; g_I, g_x)$:

$$\overset{\rightarrow i}{D}_t(y, K, x, I; g_I, g_x) = \max\{\beta \in \Re : (x_t - \beta g_x, I_t + \beta g_I) \in V_I(y_t : K_t)\},$$
$$g_x \in \Re^N_{++},\ g_I \in \Re^F_{++}, (g_x, g_I) \neq \left(0^F, 0^N\right) \quad (2)$$

If $(x_t - \beta g_x, I + \beta g_I) \in V_t(y_t : k_t)$ for some β, $\overrightarrow{D}^i_t(y, K, x, I; g_I, g_x) = -\infty$, otherwise. The directional distance function (x_t, I_t) provides the maximum translation in the direction defined by the vector (g_x, g_I), maintaining the translated input combination inside the set $V_t(y_t{:}k_t)$. Firm i's dynamic technical inefficiency is represented by the coefficient of β.

By incorporating a dynamic directional distance function, the static Luenberger indicator of productivity growth from Chambers et al. [22] is transformed into dynamic productivity growth. Using the constant return-to-scale assumption, the dynamic Luenberger productivity growth indicator (*DTFPG*) can be expressed as follows:

$$\begin{aligned} DTFPG = \tfrac{1}{2}\{[\overrightarrow{D}^i_{t+1}(y_t, k_t,\ x_t, I_t; g_x,\ g_I) - \overrightarrow{D}^i_{t+1}(y_{t+1}, k_{t+1},\ x_{t+1}, I_{t+1}; g_x,\ g_I)] \\ +[\overrightarrow{D}^i_t(y_t, k_t,\ x_t, I_t; g_x,\ g_I) - \overrightarrow{D}^i_{\mathrm{t}}(y_{t+1}, k_{t+1},\ x_{t+1}, I_{t+1}; g_x,\ g_I)]\} \end{aligned} \tag{3}$$

The *DTFPG* indicator provides the arithmetic average of the productivity change measured by technology at time $t + 1$ (the first two terms in (3)) and the productivity change measured by technology at time t (the last two terms in (3)). The positive (negative) value of DFPG indicates whether productivity increased (decreased) between time t and time $t + 1$.

Using the dynamic directional distance function, Lansink et al. [23] split the dynamic productivity growth from the Luenberger indicator into components of dynamic technical change (*TCH*) and dynamic technical inefficiency change (*TEI*) under *CRS*:

$$DTFPG = \Delta TCH + \Delta TEI \tag{4}$$

Dynamic technical change (*TCH*), which occurs between time t and time $t + 1$, denotes a change in the technology of dynamic production brought on by the reduction of variable inputs and an increase in investments. It is calculated using the following formula:

$$\begin{aligned} \Delta TCH = \tfrac{1}{2}\{[\overrightarrow{D}_{t+1}(y_t, k_t, x_t,\ I_t;\ g_x, g_I) - \overrightarrow{D}_t(y_t, k_t, x_t,\ I_t;\ g_x, g_I)] \\ +\overrightarrow{D}_{t+1}(y_{t+1}, k_{t+1}, x_{t+1},\ I_{t+1};\ g_x, g_I) - \overrightarrow{D}_t(y_{t+1}, k_{t+1}, x_{t+1},\ I_{t+1};\ g_x, g_I)\} \end{aligned} \tag{5}$$

The difference in technology (the frontier) between time t and time $t + 1$, as assessed at time t and time $t + 1$'s input and output, is referred to as dynamic technical change.

Furthermore, the difference between dynamic technical inefficiency at time t and time $t + 1$ is used to calculate the dynamic technical inefficiency change under *CRS*:

$$\overrightarrow{D}^i_t(y_t, k_t, I_t; g_x, g_I) - \overrightarrow{D}^i_{t+1}(y_{t+1}, k_{t+1}, I_{t+1}; g_x, g_I) \tag{6}$$

Equation (6), unlike the last two terms in (3), calculates the changes in dynamic technical inefficiency at periods t and $t + 1$. To assess dynamic scale inefficiencies, both *CRS* and *VRS* are used to estimate dynamic technical inefficiency. Kapelko et al. [13,14] used a primal perspective to divide dynamic technical and scale inefficiency change into:

$$\begin{aligned} \Delta VTEI = \overrightarrow{D}^i_t(y_t, k_t, I_t; g_x,\ g_I|VRS) - \overrightarrow{D}^i_{t+1}(y_{t+1}, k_{t+1}, I_{t+1}; g_x,\ g_I|VRS) \\ \Delta SE = [\overrightarrow{D}^i_t(y_t, k_t, I_t; g_x, g_I \mid CRS) - \overrightarrow{D}^i_t(y_t, k_t, I_t; g_x, g_I|VRS)] \\ -[\overrightarrow{D}^i_{t+1}(y_{t+1}, k_{t+1}, I_{t+1}; g_x, g_I \mid CRS) - \overrightarrow{D}^i_{t+1}(y_{t+1}, k_{t+1}, I_{t+1}; g_x, g_I \mid VRS)] \end{aligned} \tag{7}$$

The dynamic technical inefficiency changes under VRS and the dynamic scale inefficiency changes are represented by $\Delta VTEI$ and ΔSE, respectively. The difference in the firm's position in terms of *CRS* and *VRS* dynamic technologies over the two time periods was measured by dynamic scale inefficiencies.

Additionally, using the dynamic directional distance function, data envelopment analysis is used to assess dynamic technical inefficiency:

$$
\begin{gathered}
\overset{\rightarrow i}{D}_t(y_t, k_t, x_t, I_t; g_x\,,\ g_I\,|C) = \max_{\beta,\,\gamma}\beta \\
\text{s.t.} \\
y_{tm} \le \sum_{j=1}^{J} \gamma^j y^j_{tm}\,,\ m = 1,\ldots,\ M; \\
\sum_{j=1}^{J} \gamma^j x^j_{tn} \le x_{tn} - \beta g_{x_{tn}},\ n = 1,\ldots,\ N; \\
I_{tf} + \beta g_{I_{tf}} - \delta_f K_{tf} \le \textstyle\sum_{j=1}^{J} \gamma^j \left(I^j_{tf} - \delta_f K^i_{tf}\right),\ f = 1\,,\ldots,\ F; \textstyle\sum_{j=1}^{N} \gamma^j = 1; \\
\gamma^j \ge 0,\ j = 1,\ldots,\ J.
\end{gathered}
\tag{8}
$$

where a vector of variable weights is indexed by γ, the depreciation rate is indexed by δ, the outputs are indexed by m, the inputs are indexed by n, the firms are indexed by j, and the quasi-fixed inputs are indexed by f. According to Kapelko et al. [13,14], the value of the directional vector of investments (g_I) is determined by the depreciation rate (0.2) multiplied by the value of the fixed assets, and the value of the directional vector of inputs (g_x) is determined by the actual value of the inputs.

Dynamic productivity growth can be characterized as follows in terms of the breakdown of the dynamic Luenberger indicator of productivity growth:

$$DTFPG = \Delta TCH + \Delta VTEI + \Delta SE \tag{9}$$

The *DTFPG*ǀ's positive (negative) value implies an increase in production (decrease). Additionally, the positive (negative) DTFG components denote positive (negative) dynamic productivity development.

The relationship between innovation and dynamic productivity growth is derived from the mathematical equation as written in Equation (1) and estimated using Equation (10) as follows:

$$DTFPG_{it} = \beta_i + \alpha_1 Innov_{it} + \alpha_2 Foreign_{it} + \alpha_3 Export_{it} + \alpha_4 Law_{it} + \alpha_5 InnovLaw_{it} + \alpha_6 Trend_{it} + e_{it} \tag{10}$$

where i and t index firm and year, respectively. Equation (10) is estimated using a panel data regression model, either applying fixed-effect or random effect models, based on the Hausman [24] test. A multicollinearity test is applied to the model using the variance inflation factor (VIF). The model suffers from a multicollinearity problem if the VIF for each variable exceeds 10. Moreover, the *Levin* et al. [25] test is applied to test whether all variables were stationary at the level form. The Breusch–Godfrey test is also applied for the autocorrelation problem.

4. Data

The data for this study comes from an Indonesian manufacturing survey conducted by the Indonesian Central Bureau of Statistics. The data relates to the five-digit level of the 2009 *Klasifikasi Baku Lapangan Usaha Indonesia* (KBLI), which is analogous to the International Standard Industrial Classification (ISIC) system. Moreover, dynamic productivity growth could only be provided until 2015, when this research was conducted. The Indonesian Central Bureau of Statistics published a different format of manufacturing survey data after 2015, which made it difficult to estimate the dynamic productivity growth at the firm and ISIC levels.

Because subsectors with fewer than 30 observations were combined into groups of comparable products or groupings at the four-digit ISIC level, this study employed 44 subsectors from the original data set, which originally included around 96 subsectors. For example, the subsector of 10390 was a combination of the subsectors of 10391, 10392 and

10399. This research used subsectors as the basis for calculating the dynamic productivity of firms. Firm-level data was applied for the final estimation of the relationship between innovation and dynamic productivity growth. Panel-data regression estimation was also based on the combination of firm and year data.

Using two variable inputs-raw materials and labor-as well as one quasi-fixed element or input-capital in machinery and equipment, where associated investment was distinguished-this study calculates dynamic productivity growth. Output was defined as the value of the gross output produced by a firm following Setiawan et al. [26,27] and Setiawan and Lansink [15], deflated by the wholesale price index (WPI). The WPI of machinery (excluding electrical products), transport equipment, and residential and non-residential buildings deflated capital in machinery and equipment. Additionally, this research used the labor efficiency unit to measure labor, as also applied by Setiawan et al. [26].

The raw materials included the entire cost of materials, including energy, which was deflated by the WPI of raw materials reported by the Indonesian Bureau of Central Statistics. Furthermore, the investment variable was formulated as new fixed asset acquisitions minus fixed asset sales.

The variables used to estimate dynamic productivity growth are described statistically in Table 1, along with the factors that influence dynamic productivity growth, such as innovation. The coefficient of variation for each variable was more than 1. This indicated that the variables varied significantly across years and firms. The variables of capital and investment were the variables with the highest coefficient of variation. A few outliers in each variable were removed for each subsector and year, but this would still not remove the variation of the variables in the panel data.

Table 1. Descriptive statistics of the variables applied in the analysis of the Indonesian food and beverage industry (firm-level of 44 subsectors), 1980–2015.

Variable	Mean	Standard Deviation	Coefficient of Variation
Material (million Rupiah)	160.480	1555	9.690
Labor efficiency units	163.006	633.001	3.883
Capital (million Rupiah)	371.554	2.50×10^4	67.285
Output (million Rupiah)	208.244	1708.324	8.203
Investment (million Rupiah)	81.965	9911	120.917
Innovation (Innov)	0.022	0.109	6.056
Foreign (%)	3.128	15.973	5.106
Export	0.225	0.418	1.858

Source: Indonesian Bureau of Central Statistics and authors' calculation. Unbalanced panel data with n = 95,177.

From Table 1, it can be seen that the average innovation was 0.022 during the period 1980–2015. This indicates that the average modification expenditure for machines and equipment was 2.2% relative to the output of a firm. Furthermore, the firms had about 3.128% foreign ownership, on average, during the same period. Moreover, the average dummy variable for export activity was 0.225, close to 0. This indicated that most of the firms in the Indonesian food and beverage industry were not involved in export activities and had small foreign ownership.

5. Results and Discussion

Table 2 shows that the dynamic productivity growth of the firms in the industry experienced a declining trend. The average dynamic productivity growth was 0.260% during the period 1981/1980–2015/2014. The dynamic productivity growth was 1.75% in the interval period of 1981/1980–1985/1984 and it reached to −6.190% in the interval period of 2011/2010–2015/2014. The dynamic productivity growth declined continually after the interval period of 1996/1995–2000/1999 when the Indonesian crisis happened in 1997–1998. The dynamic productivity growth was the highest during the interval period of 1991/1990–1995/1994 reaching to 5.560%. The latter period was the era of an overheating economy in Indonesia. During the period from 1981/1980 to 2015/2014, the averages of technical inefficiency change, technical change, and scale efficiency change were 0.027, −0.028, and 0.005, respectively. The technical change was the component that made the highest contribution to the negative dynamic productivity growth compared to the technical inefficiency change and scale inefficiency change. This may indicate that technological progress in the industry slowed during the period of estimation. In addition, the declining trends of technical inefficiency change and scale efficiency change may be a sign that the industry may experience lower competitiveness in the long run.

Table 2. Trend of average dynamic productivity growth (TFPG) and innovation ratio for 44 subsectors, 1980–2015.

Interval Period	TFPG (%)	TIC (%)	TC (%)	SEC (%)	Innovation Ratio
1981/1980–1985/1984	1.750	0.021	−0.014	0.011	0.0246
1986/1985–1990/1989	1.100	0.043	−0.046	0.014	0.0211
1991/1990–1995/1994	4.560	0.042	−0.013	0.016	0.0144
1996/1995–2000/1999	2.780	0.066	−0.058	0.020	0.0508
2001/2000–2005/2004	2.250	0.024	−0.004	0.002	0.0150
2006/2005–2010/2009	−4.410	0.034	−0.069	−0.009	0.0141
2011/2010–2015/2014	−6.190	−0.043	0.004	−0.021	0.0149
1981/1980–2015/2014	0.260	0.027	−0.028	0.005	0.0221

Source: authors' calculation.

From Table 2, it is also seen that higher or lower innovation was not always positively related to higher or lower dynamic productivity growth. For example, there was higher average dynamic productivity growth in the interval period of 1991/1990–1995/1994, but innovation was lower in that interval period. Additionally, the highest average dynamic productivity growth was in the interval period of 1996/1995–2000/1999, but the highest dynamic productivity growth was in the interval period of 1991/1990–1995/1994. Moreover, the trend of the two variables mostly moved in the opposite direction during consecutive interval periods.

Regarding the average dynamic productivity growth of the firms in Table 3, there were 10 subsectors with the highest average dynamic productivity growth of the firms. The subsector with the highest average dynamic productivity growth of the firms was subsectors of 10802 (animal feed concentrate), followed by subsectors of 10635 (corn milling and cleaning; rice and corn flour; and rice and corn starch) and 10296 (salted, dried, smoked, frozen, fermented, extracted, iced, and pulverized other aquatic biotas). From Table 3, it is also seen that only 4 of the 10 subsectors with the highest average innovation ratio were included in the 10 subsectors with the highest average dynamic productivity growth. The four subsectors included 10625 (other palm starch, glucose, and other starch processes), 10722 (brown sugar), 10425 (flour and other coconut processes), and 10223 (canned fish, water biota, and shrimp).

Table 4 shows the subsectors with the lowest average innovation and dynamic productivity growth of firms. Table 4 shows that ISIC 11050 (mineral water) was the subsector with the lowest average dynamic productivity growth, followed by 10710 (bakery product), and 10210 (meat processing). Moreover, none of the 10 subsectors with the lowest average innovation were included in the 10 subsectors with the lowest average dynamic productivity growth. This may indicate that innovation does not always boost dynamic productivity growth. Poor economic institutions in Indonesia may turn innovation into lower dynamic productivity growth.

Table 3. 10 (ten) subsectors with the highest average dynamic productivity growth and innovation for 44 subsectors, 1980–2015.

10 (Ten) Subsectors with Highest Average Dynamic Productivity Growth		10 (Ten) Subsectors with Highest Average Innovation	
ISIC	Dynamic productivity growth	ISIC	Innovation
10802	0.072	10721	0.055
10635	0.067	10425	0.046
10296	0.056	10722	0.044
10625	0.052	10431	0.042
10722	0.047	10760	0.039
10792	0.041	10625	0.036
11011	0.038	11050	0.035
10425	0.034	10223	0.035
10214	0.031	10550	0.034
10223	0.027	11070	0.032

Source: authors' calculation.

Table 4. 10 (ten) subsectors with lowest average dynamic productivity growth and innovation for 44 subsectors, 1980–2015.

10 (Ten) Subsectors with Lowest Average Dynamic Productivity Growth		10 (Ten) Subsectors with Lowest Average Innovation	
ISIC	Dynamic productivity growth	ISIC	Innovation ratio
11050	−0.045	10214	0.006
10710	−0.035	10390	0.008
10210	−0.034	10771	0.009
11070	−0.033	10790	0.009
10760	−0.031	10794	0.009
10431	−0.030	10631	0.009
10140	−0.027	10620	0.010
10315	−0.023	10792	0.010
10220	−0.019	10793	0.011
10312	−0.019	10740	0.012

Source: authors' calculation.

Table 5 provides an estimation of the effect of innovation on dynamic productivity growth using the innovation measure of the new machine and equipment expenditure ratio (innovation ratio). The model was estimated using a random effect model, since the Hausman test rejected the fixed effect model. Based on the VIF, there was no multicollinearity problem in the model because the VIF for each variable was less than 10. For example, the VIF for the Law variable was 4.01, which was the highest one. The estimations also applied White-heteroscedasticy consistent covariance, since the model suffered from the heteroscedasticity problem. All variables were stationary at the 5% critical level using the test of Levin et al. (2002). The Breusch–Godprey test suggested that there was no autocorrelation problem in the model at the 5% critical level.

Table 5. Results of the regression of innovation on dynamic productivity growth.

Independent Variable	Dependent Variable: Dynamic Productivity Growth (*DTFPG*)
	Coefficients
Intercept	0.025 *** (0.002)
Innov	−0.030 *** (0.007)
Export	0.005 *** (0.002)
Foreign	1.577×10^{-4} *** (3.91×10^{-5})
Law	0.017 *** (0.002)
InnovLaw	0.031 *** (0.011)
Trend	−0.002 *** (1.285×10^{-4})
p-value of Wald-statistics	0.000

Notes: *** denotes the significance of the test statistic at the 1% level. *Unbalanced panel data* with n = 95,177. Standard errors are in parentheses. Innov = Innovation ratio with a measure of the new machine and equipment expenditure ratio. HHI = Herfindahl–Hirschman Index. Foreign = foreign ownership. Export = dummy variable to reflect the export activity of a firm. Law = Dummy variable to reflect the period after the introduction of the competition law in 1999. Innov x Law = interaction between Innov and Law variables. Source: Authors' calculation.

Table 5 shows that before the introduction of the competition law, innovation affected dynamic productivity growth significantly at 1%, with a coefficient of innovation ratio of −0.030. This indicates that an increase in the innovation ratio by 0.1 units decreased dynamic productivity growth by 0.003, ceteris paribus. After the introduction of the competition law, innovation affected dynamic productivity growth positively and significantly at the 1% critical level. The coefficient of innovation ratio after the introduction of competition law was 0.001 (= 0.031 − 0.030). This indicates that an increase in the innovation ratio by 0.1 units increased dynamic productivity growth by 0.0001 units, ceteris paribus. This may be in line with the finding of Silve and Plekhanov [9], which suggested that innovation could boost firm growth only in good-quality economic institutions. Process innovation that increases productivity growth, as suggested by Geroski [4], Huergo and Jaumandreu [6], Mañez et al. [7], and Rochina-Barrachina et al. [2], may occur in the Indonesian industry only if the business environment is competitive.

The export activity of the firm had a positive effect on dynamic productivity growth with a coefficient of 0.005. The coefficient was significant at the 1% critical level. This indicates that the firm with export activity had a higher dynamic productivity growth of 0.005 compared to the firm with no export activity, ceteris paribus. The result supports the findings of Kimura and Kiyota [19], who also found that exports positively affected productivity growth.

Foreign ownership had a coefficient of $1.577 * 10^{-4}$ and it had a significant effect on the dynamic productivity growth at the 1% critical level. This indicates that an increase in foreign ownership by 1% increased dynamic productivity growth by $1.577 * 10^{-4}$, ceteris paribus. This may support the findings of Xu, Liu, and Abdoh [28], which suggested that firms with foreign ownership were positively related to firm productivity.

Competition law implementation had a positive effect on dynamic productivity growth with a coefficient of 0.017. The coefficient was significant at the 1% critical level. This supports the finding of Buccirossi et al. [29], which concluded that competition policy had a positive impact on total factor productivity growth.

Moreover, the coefficient of the trend was −0.002, indicating that dynamic productivity growth declined by 0.2% every year during the period of estimation, on average. This was in line with Table 2, which shows how dynamic productivity growth declined continuously during the interval periods. This also supports the finding of Setiawan [11], who reported a declining trend of dynamic productivity growth, although the research had a different period of estimation.

This research implies that Indonesian policymakers should strengthen economic institutions to ensure that the business environment in Indonesia is conducive to competition and innovation (see also [30]). The economic institution covers not only competition law but also other economic institutions, such as property rights or patent law and the effective rule of law. Moreover, the government and the House of Representatives may also amend any regulations that restrict investment and innovation in Indonesia. With this higher quality of institutions, investment and innovation will increase with a greater effect on the rise of productivity.

Regarding the positive effect of export activity, the manager of a firm should choose an export-orientation strategy to increase the productivity of the firm. The Indonesian government should also facilitate firms in exporting their products to the global market, such as by providing the ease of having export licensing, technological assistance, process, and product innovation training, and credit assistance with low interest. The government should also facilitate the spillover effect of foreign investment, in addition to opening Indonesia's market for foreign investment. Thus, local firms can learn from the best practices of foreign firms.

6. Conclusions

This research investigated the effect of innovation on dynamic productivity growth, including the influence of competition laws on the way innovation affects dynamic productivity growth. This research found that average innovation expenditure was relatively small relative to the output of the firm. Innovation negatively affected dynamic productivity before the introduction of the competition law in 1999. Following the implementation of the competition law, the effect of innovation on dynamic productivity growth became positive. Additionally, dynamic productivity growth was higher after the implementation of the competition law.

Regarding the effect of other variables, export activity and foreign ownership positively affected dynamic productivity. Exposure to the world market and more foreign control may induce firms to be more productive. The trend variable also indicated that dynamic productivity was declining continuously, which could serve as a warning to Indonesian policymakers.

Because this study discovered that innovation had a positive impact on dynamic productivity growth only after the implementation of competition law, future research or theoretical foundations should not view innovation as a stand-alone variable impacting industrial performance. Further research may investigate other variables, such as regulations and other economic variables, that may moderate the effect of innovation on industrial performance. Additionally, innovation should be taken into account by both businesses and policymakers in terms of both costs and benefits. To reduce the potential negative impact of innovation on economic performance, a cost–benefit analysis should be carried out prior to the implementation of the innovation strategy and policy.

This research also recommends investigating the effect of product innovation on productivity growth in future research. This can be relevant since product innovation is delivered directly to the consumer, which may have a different impact on productivity growth. Furthermore, this research may also suggest considering the endogeneity problem in the variable of innovation in future research, which may change the estimation strategy.

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