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Technological Progress in Indonesian Food Processing

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ABSTRACT
Technological progress is a critical factor in Society 5.0. Firm technological progress reflects the advancement in firm knowledge. This current study analyzes the key determinants of technological progress in 393 Indonesian food processing companies to assess the readiness to pursue Society 5.0. Adopting the knowledge spillover framework in the endogenous growth theory, this study shows the importance of internal (firm age and firm size) and external factors (export orientation and import intensity) to enhance technological progress. The results from dynamic panel data GMM estimations confirm that firm age, export, and import intensity trigger technological advancement, while firm size does not significantly affect technological progress. These findings suggest the involvement of Indonesian food processing firms in export and import activities in preparing to face Society 5.0.
Keywords: *Technological progress, food processing firms, society 5.0.*

1 INTRODUCTION

Technological progress is a critical factor in Society 5.0 and Industry 4.0 (Holroyd 2020). In preparation for this super-smart society and high-efficiency industry, manufacturing firms, as key players in the Indonesian economy, must advance their technology Muhardi et al. (2020). The technological advancement appears in capital-intensive and labor-intensive firms, such as those in the food processing sector Hidayatno et al. (2019). As the largest sub-sector of the manufacturing industry in terms of the number of firms, the food processing industry is fascinating to study concerning the current technological progress and its determinants. A study on the determinants of technological progress in food processing firms provides insight into the key factors facing Society 5.0 and Industry 4.0.

Studies on firm-level technological progress stand on the ground of endogenous growth theory. Technology is one of the knowledge for accelerating the production process to achieve a higher number of outputs with given input factors (Režný & Bureš 2018). Empirical studies on the determinants of a firm's technological advancement focus on internal and external factors (Cai et al. 2020, Seenaiah & Rath 2018, Zhu et al. 2019). The internal factors affecting a firm's technology can be firm age (Akinwale et al. 2018, Pellegrino & Piva 2020, Seenaiah & Rath 2018) and firm size (Akinwale et al. 2018, Iza 2020). While, external factors are export (Cai et al. 2020, Zhu et al. 2019) and import (Wen et al. 2020, Yasar & Rejesus 2020).

The empirical studies on a firm's technological progress focus primarily on the decomposition process of technology as one of the total productivity growth factors (Sugiharti et al. 2019, Suyanto et al. 2014, Yasin 2020). Studies on the determinants of technological progress are sparse, as empiri-

cal studies on Indonesian manufacturing evaluate more the determinants of total factorproductivity growth or the determinants of the other component of productivity, namely technical efficiency (Latif et al. 2019, Mazorodze 2020, Setiawan et al. 2019, Walheer & He 2020). This current study contributes to the literature by examining the critical determinants of technological progress in evaluating the readiness of Indonesian food processing firms in facing Society 5.0 and Industry 4.0. The research question is what the key determinants of firm-level technical efficiency in Indonesian food processing are. The novelty of this current study is twofold. Firstly, it focuses on technological progress rather than technical efficiency change, which is often neglected in the existing literature. Secondly, it studies firms in a specific manufacturing industry sector, which tend to be homogenous in technology.

1.1 *Firm age and technological progress*

The theoretical framework of firm-level technological progress is tracked back to the early neo-classical growth model. In the Solow-Swan model, technology is a mediating factor for production (Solow 1956; Swan 1956). Solow introduces technology as a residual in a production function known as Solow residual (Liu et al. 2012; Saidi 2019). In the earlier model, technology is assumed to be constant. The development of the endogenous growth model enables analysis of technology as an endogenous variable affecting output and is affected by several firms' internal and external factors (Lucas 1988; Režný & Bureš 2018; Romer 1994). Two pivotal firms' internal factors that provide significant effects are firm age and firm size, whereas two key firms' external factors that affect technological progress are export and import.

Some empirical studies show a positive effect of firm age on technological progress. Akinwale et al. 2018, who study Nigerian Oil firms, find that an older firm has more chances to improve its technology. A similar finding provides by (Pellegrino & Piva 2020) in analyzing Italian companies that manufacturing firms turn out to be more effective in translating technological acquisition. In contrast, (Seenaiah & Rath 2018) stipulate that firm age negatively affects innovation technology. From this debate, the current study proposes a hypothesis as follows:

H1: Firm age positively affects technological progress.

1.2 *Firm size and technological progress*

Firm size is another key internal factor affecting technological progress. (Akinwale et al. 2018) show that firm size has a significant positive effect on firm-level technological capability. A study on slow-growing and fast-growing economies (Iza 2020) also finds similar evidence that a bigger size firm with age of less than five year tends to have a stepper slope concerning technological progress. In contrast, (Behrens & Trunschke 2020) reveal that innovation as a representation of technology decreases with firm size. From these inconclusive findings, the current research put forwards a hypothesis

H2: Firm size positively affects technological progress.

1.3 *Export orientation and technological progress*

One of the key external factors that clearly affects the firm-level technological progress is export. A firm that exports its products receives a technology transfer from foreign firms through knowledge spillovers (Deng et al. 2020). Similarly, (Cai et al. 2020) propose that firms' participation in export can significantly increase the likelihood of technological innovation. In contrast, (Zhu et al. 2019) record an inverted U-shape relationship between export and technological innovation, indicating an increase in export lead to an increase in technological progress, but at a certain level, a further increase in export

reduces the technological innovation. Based on these empirical findings, the current study proposes:

H3: Export activity increases the firm-level technological progress

1.4 *Import intensity and technological progress*

Another external factor that is visibly affecting technological progress is the import of production materials. The technology channels through the high-quality material imported from more-advanced countries (Ciborowski & Skrodzka 2020). Yasar & Rejesus 2020 state that the international linkage through the import of intermediate inputs facilitates technology transfer from advanced economies to Indonesian manufacturing firms. A study on China's agricultural products Wen et al. 2020 notes a positive regional spillover from international linkage, import, and export. From these empirical findings, the current study hypothesis is

H4: Import intensity positively affects technological progress.

2 RESEARCH METHODS

The two-stage estimation is applied in examining the key determinants of technological progress in Indonesian food processing firms. In the first stage, the non-parametric Data Envelopment Analysis Malmquist Index (DEA-Malmquist) is employed to decompose total factor productivity growth into two distinctive components, namely technical efficiency change (EC) and technological progress (TP). In the second stage, technological progress is examined concerning its key determinants.

The DEA-Malmquist index is adopted from (Cappellesso et al. 2020) and can be written as

$$M(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)} \times \frac{d_0^{t+1}(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_t, y_t)}\right]^2$$

$$M(yt+1, xt+1, yt, xt) = EC \times TP \quad (1)$$

Where M is malmquist index; EC is efficiency change; TP is technological progress; y_t is output matrix NxM for every n-firm in the year t; x_t is input metrix NxK for every n-firm in the year t; d_0 is output oriented distance; t is time.

After the decomposition process, the scores of technological progress for each firms in each year are obtained together with the scores of technical efficiency change and the score of scale efficiency change. The obtained scores of technological progress are used as an endogenous variable in the General Method of Moment (GMM) of the dynamic panel data (DPD) analysis. The empirical model is adapted from (Suyanto & Sugiarti 2020) with some different exogenous variables and can be written as

$$TP_{it} = \beta_0 + \beta_1 Age_{it} + \beta_2 Size_{it} + \beta_3 Exportit + \beta 4 Import_{it} \quad (2)$$

Where TP_{it} is technological progress for the i-firm at time-t; Age_{it} is the age of i-firm at time-t; $Export_{it}$ is the dummy variable of export for i-firm at time-t, which has a value of 1 if the firm is exporting its product, 0 if otherwise; $Import_{it}$ is the percentage of material imported to total material used in production of i-firm at time-t; β_0, β_1, β_2, β_3 are parameters to be estimated.

The data used in this research is from 393 manufac-turing plants in Indonesia for the period 2010 and 2015, so that the total observation is 2,358. This balanced panel data is constructed using the six-step procedure as in (Suyanto et al. 2009), derived from the annual survey of large and medium manufacturing firms conducted by Indonesian Central Bureau of Statistics (BPS).

3 RESULTS AND DISCUSSIONS

The average scores of technological progress for Indonesian food processing firms is presented in Fig-ure 1. These scores are calculated using equation (1) for each firm in each year. The figure shows that the average scores of technological progress are fluctated along the observed period. There was a technological progress of 4 percent in 2010

and the advancement of technology increases in 2011 at 9 percent, which is the highest progress along the observed years. A slight decrease of technological improvement happened in 2012, by 2 percent. The small decreases in technological growth in 2012 probably due to the decline in the values of international trade because of the crisis in some European countries. From 2013 to 2015 the technology tends to be stable with a tiny progress of less than 1 percent in technology advancement. Overall for the periode 2010-2015, the average score of technological progress is 1.02, meaning that the technology advances by 2 percent.

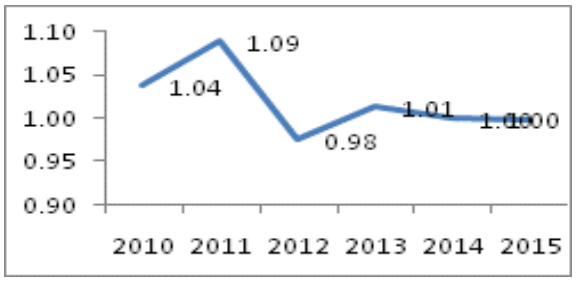

Figure 1: The Average Scores of Technological Progress ofIndonesian Food Processing Firms, 2010-2015

After the scores of technological progress are ob-tained for all firms under study, estimations for the key determinants of technological progress are per-formed using equation (2). The results of estimations are presented in Table 1. Estimations are performed under three methods of GMM, namely Arellano-Bover/Blunder-Bond method, Arellano-Bond meth-od, and linear method. The estimation results for the first method are given in the second column of Table 1, whereas the results for the second method are in the third column. The last column shows the results under the third method.

The signs of each variable are similar under the three methods of estimation, while the magnitudes and the levels of significance are different. The dis-cussion of the estimation results is based on the Arellano-Bover/Blundell-Bond since the Wald Chi-squared of this method is the highest.

The age of firm is positive and significant affecting technological progress, indicating that the older the firm the more advanced the technological progress. This might due to the learning process in the firms, as mention in endogenous growth theory (Režný & Bureš 2018). Older firms have more time to learn more advanced technology than younger firms, so that the former experiences a higher technological progress than the latter. This finding is in line with (Akinwale et al. 2018) that studies Nigerian firms and (Pellegrino & Piva 2020) that examines Italian firms.

Table 1: GMM Estimation Results of Key Factors Affecting Technology Progress of Food Processing Firms (Dependent Variable: Technological Progress)

Variable	Arellano-Bover/Blundell-Bond GMM	Arelano-Bond GMM	Linear GMM
Const.	0.0859*** (-19.71)	0.0615*** (-12.31)	0.2804*** (-8.56)
Age	0.0028*** (18.54)	0.0019***(12.09)	0.0118*** (11.73)
Size	0.0285 (0.20)	0.2083 (1.32)	0.5904 (0.51)
Export	0.0185*** (3.33)	0.0149***(2.69)	0.0571* (1.78)
Import	0.0013*** (3.87)	0.0008* (1.81)	0.0093*** (3.59)
Wald Chi-sqr	465.62	160.31	143.24
Prob. Chi-sqr	0.000	0.000	0.000
Number of firms	393	393	393
Number of Obs	2,358	2,358	2,358

Source: estimation results for Dynamic Panel Data (DPD) of 393 observed firms under General Method of Moment (GMM).
Note: *** indicates significance at 99%, ** indicates signifi-cance at 95%, and * indicates significance at 90%. The Z-statistics are in parentheses.

The size of firm is positive but insignificant affect-ing technological progress. The sign of the coefficient is similar with (Akinwale et al. 2018) and (Iza 2020) but the significance level is difference. The difference in the significance level between this current research and the previous studies might be due to the difference in measurement of the size of firm. In this current research, the size of firm is measured using the proportion of a

firm's labour to the total labour in the 5-digit ISIC sub-sector, hence the interpretation of the finding in this study related to the size of labour. In contrast, the size of firm in (Akinwale et al. 2018) and (Iza 2020) is measured using numbers of em-ployment in the firm. The difference in measurement of variable might cause the difference in significance level.

The result of Export variable shows that a firm that engages in exporting its product has a higher technological progress compared to the one that does not doing export. An exported firm has an average 0.0185 higher in score of technological progress than a non-exported firm. In addition, the coefficient of Export is significant at a 99% level. This finding is clearly sup-port the theoretical argument in (Deng et al. 2020) and in line with the empirical finding in (Cai et al. 2020). Although the measurement in this current study using a dummy variable of export, the results conform the finding in (Cai et al. 2020) that uses the value of export in measuring export variable.

A positive and significant coefficient is also ap-peared in Import variable. A firm that imports some amount of material for production has a higher tech-nological progress than a firm that does not has an imported material. This result confirms the theoretical argument in (Ciborowski & Skrodzka 2020) and is similar to empirical findings in (Yasar & Rejesus 2020) and (Wen et al. 2020).

The significance of Wald Chi-squared test justifies that the four independent variables are althougher significantly affecting technological progress. This result reassures the importance of the four factors in influencing firm-level technological progress.

4 CONCLUSION

This research investigates the effects of age, size, export and import on technological progress of Indo-nesian food processing firms. The total observed firms 393 for the period 2010-2015. The technologi-cal progress is decomposed out using the non-parametric DEA-Malmquist. The impacts of the four determinants on firm-level technological progress are estimated under three methods of DPD GMM, namely Arrelano-Bover/Blunder-Bond method, Arrelano-Bond method, and linear method. The findings show that either the age of firm, export and import has a positive significant effect on firm's technological progress, whereas the size of firm is positive but insignificant affecting technological progress. The results are robust under three models under three different methods. The implication of these findings are three-folds: (1) an older firm has a bigger capacity for high technological progress; (2) a firm needs to engage in exporting products for enhancing its technology; (3) a firm can import its material input for gaining technological transfer from overseas partners.

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