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The impact of R&D, competition, and market share on productivity of Indonesian chemical firms

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ABSTRACT: This study examines the impact of research and development (R&D), competition, and market share on the productivity of Indonesian chemical firms. There were 568 firms under this study for the period of 13 years so that the total observation was 7,384. The estimation of the firm-level data is conducted using three methods of panel data: random effect, fixed effect, and general method of moment. The results show that R&D is a significant factor increasing firms' productivity, the competition of firms in the chemical industry provides a positive and significant effect on productivity and the market share of a firm influences push-up the firm's productivity. These findings implicate the importance of R&D, competition, and market share in boosting firms' productivity in Indonesian chemical sector.

Keywords: firm's productivity, R&D, competition, market share, chemical sector.

1 INTRODUCTION

The rapid changing in the environment and the new industrial revolution 4.0 require a firm to increase its productivity in order to survive and prevent itself to be wiped out from the industry. Many efforts have been done by a firm in increasing its productivity, either through a conventional way such as increasing the inputs combination or through a more contemporary effort such as Research and Development (R&D), competition power, and market power. The classical production theory suggests an increase in labor hours or capital accumulation or volume of material. The new-classical theory includes R&D, competition, and market share in production analysis to capture the exponential factors that induce productivity. Romer (2019) highlights the importance of R&D in a growth model for creating innovation and invention, and hence increasing productivity. In addition, Demir & Duan (2018) extend the growth model by augmented the competition from FDI on productivity. The inclusion of market size on productivity growth is discussed by Chaney & Ossa (2013).

Researches on firms' productivity focus on input combination are numerous, whereas those focus on R&D and competition are sparse. Castellani et al. (2019) are among those points out the significant role of R&D in boosting productivity. Amin (2015) points out the pivotal role of competition in enhancing firms' productivity, while Ding & Niu (2019) add that market share should not be neglected when observing firms' productivity. This current research contributes to the productivity literature by including R&D, competition, and market share in the estimation of firm-level productivity in Indonesian chemical industry. The contribution is twofold. Firstly, it estimates simultaneously the R&D, competition, and market share on productivity using three-panel data methods, adapting the models of Castellani et al. (2019), Amin (2015), Ding & Niu (2019). Secondly, it focuses on a homogenous and capital-intensive sector of the chemical industry in Indonesia, which providing a robust estimation result and developing high R&D activities.

The development of hypotheses in this study streams from three groups of literature. The literature on R&D and productivity, the literature on

competition and productivity, and the literature on market power and productivity.

R&D is an important factor in triggering productivity improvement through new invention and innovation. In a study of Germany micro firms, Baumann & Kritikos (2016) find out that R&D intensity affects positively the productivity of firms. A similar finding is showed by Castellani et al. (2019) for the US and the EU firms. The same evidence is provided by Falk & Lemos (2019) instead of Castellani et al. (2019) using the data of Austria firms. The positive effect of R&D on the productivity of multinational firms is also noted by Castellani et al. (2019), whereas Khanna and Sharma (2018) instead of Castellani et al. (2019) highlight the large effect of R&D on productivity in Indian manufacturing. Based on these previous studies, the first hypothesis for this current study is: H1: R&D increases the productivity of firms.

Several studies have been conducted on the relationship between competition and productivity. The spectrum of the analysis tends to be varied among the studies. Amin (2015) focuses on the impact of competition degree on the output productivity of India's retail stores. In contrast, Olper et al. (2014) analyze the import competition effect on productivity growth of nine food industries in the EU. Abdoh (2019) scrutinizes the shock of productivity due to the similarity products (that reflecting the competition degree) among firms, whereas Basker et al. (2018) emphasize on the opportunity to survive in competition between high and low productivity firms using the data of the US grocery stores. From these existing studies, the current research develops the second hypothesis as follows: H2: competition provides a positive effect on firms' productivity.

The market share or the market size of a firm can determine its productivity. Ding & Niu (2019) utilize the Chinese manufacturing data to examine the impact of market size on productivity and find out a positive effect. Ranasinghe (2017) compares Canada and the US firms on the firm size and the productivity gaps, whereas Chaney & Ossa (2013) conclude that market size induces a deeper division of labor that leads to an increase in firm productivity. Therefore, these current studies put forward the third hypothesis as: H3: the market share of firm affects positively the firm productivity.

2 RESEARCH METHODS

The method of analysis in this study is panel data analysis. There are three methods were used, namely random effect (RE), fixed effect (FE), and general method of moment (GMM). The first two methods are the standard panel data analysis, whereas the third is a dynamic method that including time-lags in the analysis.

RE method estimates a model by dividing error-term into two components, the one that under control (u_i) and the rest is white-noise error (v_i) (Wooldridge, 2016). FE method estimates a model by adding the fixed effect within variables (or dummy variables for a constant) (Baltagi 2013). GMM method is a dynamic panel data analysis using autoregressive (Wang et al. 2018).

The empirical model for this study is written as:

$$\mathrm{Y}_{\mathrm{it}} = \beta_0 + \beta_1 RD_{it} + \beta_2 COMP_{it} + \beta_3 MS_{it} + \varepsilon_{it} \qquad (1)$$

where Y is output productivity that is calculated from the natural logarithmic of total value of firm output, RD is research and development that has a value of 1 if the firm conducts an R&D activity and 0 if the firm does not commit on R&D activities, COMP is a competition measure of a firm that is calculated from the inverted Herfindahl-Hirschman Index (HHI), MS is a measure for the market share of a firm that is calculated from the output of firm-i to the total output in the four-digit ISIC, *i* indicates firm-*i*, *t* indicates year-*t*, and ε represents error-term.

The data source is an annual survey of large and medium enterprises from the Indonesian Central Bureau of Statistics (BPS). The survey was conducted on all Indonesian manufacturing; with numbers of establishments vary from 8,000 to 16,000 depending on the year of survey. This paper used only data of chemical firms with ISIC codes 353 and 354 and the period of observation is from 1988 to 2000. The reason to choose this period is the availability of R&D information. The final balanced dataset has undergone a cleaning process following Suyanto et al. (2014) instead of Ding & Niu (2019). The number of establishments in the final dataset is 568 establishments (or total observation 7,384).

3 RESULTS AND DISCUSSIONS

The estimation results of model in equation (1) are presented in Table 1. The results for RE method are in the second column of Table 1, whereas the results for FE method are in the third column. The last column of Table 1 presents the results for GMM method. In general, the significance of the statistical tests provides the same conclusion for the effect of each variable RD, COMP, or MS on firms' productivity under the three methods. Although the magnitude of each coefficient of variables are differed under the three methods, the significance results lead to the same conclusion of the impact of each independent variables (either RD, or COMP, or MS) on produc-

tivity. These findings also suggest that the observed data are robust under the three different methods.

Table 1. Estimation Results for the Impact of R&D, Competition, and Market Share on Indonesia Chemical Firms' Productivity.

Variables	Random Effect	Fixed Effect	General Method of Moment
Constant	6.1809***	6.1833***	2.5946***
	[210.57]	[562.64]	[32.68]
	(0.000)	(0.000)	(0.000)
RD	0.1204***	0.1069***	0.1037***
	[11.06]	[9.81]	[7.92]
	(0.000)	(0.000)	(0.000)
COMP	0.0016***	0.0016***	0.0009***
	[11.55]	[11.98]	[7.60]
	(0.000)	(0.000)	(0.000)
MS	0.0116***	0.0011***	0.0103***
	[34.38]	[31.80]	[23.50]
	(0.000)	(0.000)	(0.000)

Note: RD is research and development, COMP represents competition, MS is market share. Numbers in squared parantheses [ ] are partial significance statistic-values, i.e. Z-value for the random effect and the general method of moment models and t-value for fixed effect model. Numbers in round parathesis ( ) are the probability values.

As the significance results are the same for each variable under the three different methods, one can use either of the results to interpret the economic meaning of each coefficient of variables. Interpreting from the estimation results of RE methods, the coefficient of RD 0.1204 that significant at the 1% level suggests that the average productivity score of RD firms are 0.1204 higher compared to the average productivity score of non-RD firms. The coefficient of COMP that significant at the 1% level and has a magnitude 0.0016 is interpreted as an average increase of 1 percent of competitive index leads to the average 0.0016 percent increase in output productivity. Similarly, the coefficient of MS with a value of 0.0116 and significant under the 1% level suggests the average 1 percent increase in market share will increase the productivity of firms by an average 0.0016

4 CONCLUSION

This research investigates the effect of Research and Development (R&D), competition, and market share on output productivity of Indonesian chemical firms. The findings are R&D increases firm productivity, competition generates a positive impact on the firms' productivity, and market share pushes up the productivity of firms.

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