# R&D, productivity, and exports: Plant-level evidence from Indonesia

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## ARTICLE INFO

## ABSTRACT

This study examines the relation between productivity and exports in Indonesian manufacturing firms by taking account the endogenous choice of R&D. We first examine the determinants of R&D activity and find that exporting activity contributes positively to plants' R&D activity, while multinational corporate do not have a higher R&D propensity. The simultaneous estimates on the interrelation of R&D, productivity, and export show that R&D has a positive impact on both productivity and exports, suggesting the importance of R&D to Indonesian economic growth. It suggests also a two-way causality between productivity and exports, implying the coexistence of self-selection and learning-by-exporting effects in Indonesian manufacturing sector.

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## 1. Introduction

The emphasis on export-oriented growth is a successful development strategy for developing economies in East Asia, (World Bank, 1993), because an export-oriented policy accompanies higher output growth and enables exporters to learn advanced foreign technologies. Indonesia, a Southeast Asia developing country, has undertaken a series of economic reforms to promote exports in the mid-1980s, contributing to rapid economic growth and industrialization in the following decade (Hill, 2000). However, critics have suggested that the high economic growth of Indonesia is investment-driven, accompanied with low total factor productivity (TFP) growth, and a small contribution of TFP to output growth (Page, 1994). Literatures linking productivity and exports argue that the bilateral causality relation between productivity and exports means that productive firms can enter foreign markets (self-selection hypothesis) and obtain productivity gain through learning by exporting. An export-oriented policy is a key factor for Indonesian economic growth. One important issue is whether greater access to best-practice technologies in international markets stimulates exporters to learn advanced knowledge, spilling over to the rest of the economy, leading to a higher productivity. This issue is relevant to long-term Indonesian growth.

The endogenous growth theories, e.g. Romer (1990), Grossman and Helpman (1991a, 1991b), and Aghion and Howitt (1992) emphasize the role of innovation in ensuring long-term economic growth. The mechanism by which this occurs is the contribution of R&D to productivity growth. Despite that R&D can lead to proprietary technologies and contribute to productivity, it is risky and time-consuming. A latecomer in East Asia, Indonesian manufacturing is composed of mainly resource- and labor-intensive industries, such as textile and wood, in which most firms do not undertake R&D. However, the Indonesian government has come to recognize the importance of innovations on economic growth since the mid-1990s. Members of the Association of Southeast Asian Nations (ASEAN) signed the Framework Agreement on Intellectual Property Cooperation in December 1995, which aims to enhance cooperation in reducing piracy in the area and to create ASEAN standards and practices consistent with international norms. Indonesia further enacted the TRIPs-consistent Patent, Trademark, and Copyright Laws in 1997,[1] experiencing rising preferences for IPRs. However, Indonesia is still some way off from the point in its development where R&D arguably matters, because the vast majority of manufacturing firms report nil R&D. Even if there is an extremely low share of firms engaging in R&D in Indonesia, why do they undertake R&D? This interesting question needs to be addressed.

More importantly, R&D may play a key role in the productivity – exports nexus. In the presence of sinking costs and uncertainty of

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[1] Indonesia adopted amendments to Copyright Law in 1987, implemented Trademark Law in 1993, and proposed an Action Plan to combat copyright piracy in 1996.

entering exports markets, only more productive firms can conquer the obstacles to enter such markets, suggesting the importance of R&D as determinants of exports (Wakelin, 1998). The endogenous decision of R&D and productivity could positively relate to export performance.[2] The potential productivity-enhancing effect brought on by learning by exporting, depends heavily on the absorptive ability of exporting firms. R&D improves innovation ability as well as learning from an external knowledge source, "the two faces of R&D" (Cohen and Levinthal 1989; Griffith et al., 2003). The importance of absorptive ability as a carrier of learning foreign technology has received serious attention in recent years. While entering the international market contributes to output growth, its potential TFP-enhancing effect is of greater concern, because productivity is one of the key factors as to whether Indonesia can transform from an investment-driven economy to a TFP-driven economy. Indonesian firms rarely undertake R&D, therefore the endogenous decision of undertaking R&D may positively contribute to both r productivity and exports if they enter foreign markets.

In light of the aforementioned concerns, this paper investigates the interrelations of R&D, productivity, and exports in Indonesia. Despite numerous studies linking innovation, productivity, and exports, this study attempts to contribute to empirical literature by providing the following distinct types of empirical evidence. First, we empirically examine the determinants of R&D in Indonesian manufacturing firms. While this exploration is not new to the literature, it is interesting to identify the determinants of R&D, enabling us to know why some firms undertake R&D in a less developed country. Second, this study examines the role of R&D in the productivity-exports nexus in the Indonesian manufacturing sector by considering the endogenous choice of firms' R&D investment. As formal R&D activity in Indonesian firms is less existent, our analyses highlight the potential importance of R&D in the productivity-exports nexus and lends implications for other export-oriented, less developed countries.

This paper proceeds as follows: first, we briefly introduce the Indonesian manufacturing sector, exports, and innovative activity. Section 3 summarizes the enormous amount of literature linking innovation, productivity, and exports. Section 4 describes the empirical specification and the data. Section 5 displays and discusses the data. The final section provides concluding remarks and policy implications.

## 2. Exports and R&D activity in Indonesia

### 2.1. Exports and R&D activity in Indonesia

Indonesia actively opened the economy to trade and investment in the early 1980s when its revenues from oil and other raw materials reduced sharply. The trade policy shifted from import substitution to removing biases against exporting by adopting various policy measures, aiming to encourage exports (Jacob and Meister, 2005). The government scaled down tariffs and non-tariff barriers, liberalized the exchange rate policy, frequently devalued currency to support export growth, and enacted new investment laws to attract foreign investments. Overall, these policies attracted many export-oriented FDI and exposed much of the industrial sectors to international competition. As a result, manufacturing outputs and exports upsurged from the mid-1980s to 2000 except during the 1997–1998 financial crises.

According to the statistics published by the Asian Development Bank (2000), the share of manufacturing outputs to GDP in Indonesia increased from approximately 12.16% in 1981 to 26.04% in 2000. Correspondingly, the number of plants increased about 34% from 16,536 in 1990 to 22,174 in 2000 (Sjöholm and Takii, 2008). Along with growth of the manufacturing sector, manufacturing industries became

more export-oriented. Table 1 summarizes Indonesian export statistics during 1991–2008, highlighting the important role of exports on the Indonesia economy.

Indonesian exports increased steadily during the 1990s, except for decreases in the 1997–1998 economic crises. The amount of total exports increased more than 2.1 times – that is, from US$ 29,142 million in 1991 to US$ 62,124 million in 2000. Increasing exports show the positive impact of the open policy on Indonesian exports. While the Asian Financial Crisis shocked the Indonesia economy, its exports recovered gradually in the 2000s, increasing from US$ 56,320 million in 2001 to US$ 137,020 million in 2008. Correspondingly, the ratio of exports to GDP accounted for 20% - 30% in most years, except for a few years after the Asian Financial Crisis. The share of manufacturing exports to total exports also rose steadily from 50.14% in 1990 to 69.57% in 2000 (Ramstetter and Takii, 2006), suggesting that the Indonesian manufacturing sector has become more export-oriented inspired by the trade policy. This development suggests that the manufacturing sector plays an emerging important role in Indonesian exports. Despite an overwhelming share of Indonesian exports attributed to food, textile, and wood and furniture industries (Sjöholm and Takii, 2008), the exports of capital (technology)-intensive industries, e.g. electric and precision machinery, exhibited a substantial increase during the 1990s. The share of electric and precision machinery exports to manufacturing exports reached 29.79% in 2000 (Ramstetter and Takii, 2006).[3]

The innovative activity in Indonesia remained a meaningless activity for most firms in the 1990s. However, the Indonesian government has begun to recognize that R&D can play a key role in long-run growth. Since the mid-1990s, government policy has focused on utilizing mastering, and developing science and technology (S&T), and formulating industrial technology. TRIP enacted -consistent patent, trademark, and copyright laws in 1997 to strengthen the legal environment of IPRs. Public research institutions and universities carry out most R&D activities conducted in Indonesia, in term of budgets, accounting for about two-thirds of total R&D expenditures, whereas the private sector plays a minor role.

The right two columns of Table 1 demonstrate the share of R&D expenditure to GDP (R&D intensity) and patent applications by residents. The available information is quite limited. This ratio was only 0.16% in 1994 and decreased gradually. In 2000, the ratio of R&D to GDP was as low as 0.07% and then remained at a consistent level. Frankema and Lindblad (2006) indicated that the ratio of R&D expenditure to GDP in Indonesia was below 0.5% from 1968 to 1998. In sum, Indonesia devotes less effort on R&D then its Southeast counterparts, such as Thailand and Malaysia. In addition, researchers collected the earliest available S&T data of manufacturing industries in 1995.[4] The survey displayed that the total number of R&D manufacturing firms accounted for about 5%, but the ratio of R&D firms rose to 11.34% in 2000. This finding suggests that R&D activity was unpopular for firms within the manufacturing sector, while it increased over time.

Due to the limited and unreliable data on R&D expenditure, the current study looks at an innovative output for patents. The number of domestic patent applications has fluctuated and there is no apparent increasing trend before 1996, after which it increased sharply after 1997 with enactment of the TRIPs-consistent patent, trademark, and copyright laws. The number of patents applied by residents in 1996 doubled to seventy-nine cases in 1997. Since year 2000 and onward, this number has increased steadily from 212 in 2001 to 601 in 2008, suggesting that Indonesian firms and the public sector have begun to devote more efforts to innovations since 1997 and onward.

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[2] A large number of studies have also evidenced the contribution of R&D to productivity at the firm level using panel data. For a recent review on the relationship between innovation and productivity, please refer to Griffith et al. (2006).

[3] Anther capital-intensive industry, chemicals, accounted for about 15% of manufacturing exports during the 1990s.

[4] The survey was conducted under the cooperation between the Center for Analysis of Science and Technology Development - Indonesian Institute of Sciences and the Center Bureau of Statistics.

**Table 1**
Descriptive statistics of Indonesian exports, 1990–2000.

| Year | Exports (US $million ) | Share of exports to GDP (%) | R&D to GDP ratio (%) | Domestic patent applications |
|---|---|---|---|---|
| 1991 | 29,142 | 22.737 | n.a. | 34 |
| 1992 | 33,976 | 24.423 | n.a. | 61 |
| 1993 | 36,823 | 23.305 | 0.16 | 30 |
| 1994 | 40,053 | 22.643 | n.a. | 29 |
| 1995 | 45,418 | 22.469 | n.a. | 61 |
| 1996 | 49,815 | 21.909 | 0.11 | 40 |
| 1997 | 53,444 | 24.771 | n.a. | 79 |
| 1998 | 48,848 | 51.787 | 0.10 | 93 |
| 1999 | 48,665 | 34.760 | 0.07 | 152 |
| 2000 | 62,124 | 37.646 | 0.05 | 151 |
| 2001 | 56,320 | 35.102 | | 212 |
| 2002 | 57,189 | 29.229 | | 391 |
| 2003 | 61,058 | 26.007 | | 364 |
| 2004 | 71,585 | 27.872 | 0.05 | 404 |
| 2005 | 85,660 | 29.965 | 0.07 | 398 |
| 2006 | 100,799 | 27.649 | n.a. | 530 |
| 2007 | 114,101 | 26.416 | n.a. | 493 |
| 2008 | 137,020 | 26.828 | n.a. | 601 |

Source: Statistics of Indonesia and Directorate General of Intellectual Property Rights, Indonesia.

## 3. Literature review

A large body of literature has linked innovation, productivity, and exports over the past decade. To focus on distinct studies relevant to this study, we confine our discussion to two strands of literature. The first strand relates to the causality relation between productivity and exports. The second strand is limited but growing, and incorporates the three dimensions of innovation, productivity, and exports simultaneously, to examine their inter-relation.

### 3.1. Productivity and exports

Why are exporters more productive than non-exporters? The first possibility is that only productive firms can survive in a highly competitive export market. If fixed costs of selling in a foreign market are higher than that in the domestic market, then only high productivity firms will find it profitable to enter international markets, better known as the self-selection hypothesis (Roberts and Tybout, 1997). Competition and exposure to a superior foreign market can, on the other hand, speed up technological acquisition and lead to promoting technological capability. Therefore, exporters are more likely to acquire foreign orders and have higher rates of productivity growth than those selling in the domestic market, known as the learning-by-exporting hypothesis (Clerides et al., 1998).

Previous studies have differentiated between self-selection and learning-by- exporting effects using firm-level data and found that these two alternative hypotheses are not mutually exclusive. The standard empirical methodology calculates the unconditional productivity differential or export premium on productivity. Most studies find that exporters are more productive than non-exporters; productive firms select into the exports market but exporting does not necessarily improve productivity. Studies often present evidence in favor of the self-selection hypothesis, while evidence regarding the learning-by-exporting hypothesis is somewhat more mixed.[5]

Does the well-developed productivity-exports nexus for developed or developing countries apply to Indonesia. Sjöholm (1999) used Indonesian manufacturing firm level data in 1980 and 1991 to analyze the foreign network impact on productivity. Empirical results

show that firms participating in export markets have high productivity growth, supporting the learning-by-exporting effect. Sjöholm (2003) and Sjöholm and Takii (2008) examined export propensities among Indonesian manufacturing firms and found that exporting requires high productivity, considering the large entry cost of exporting, suggesting that the Indonesian case supports the self-selection hypothesis. Using a panel dataset of Indonesian manufacturing establishments from 1990 to 1996, Blalock and Gertler (2004) examined whether Indonesian firms become more productive by learning through exporting. They found strong evidence that firms experience a jump in productivity of about 3%-5% following the initiation of exporting, suggesting the importance of learning-by-exporting. Amiti and Konings (2007) proposed an alternative channel of productivity gain through lowering tariffs. They argued that lower output tariffs increase productivity by inducing tougher import competition, whereas cheaper imported inputs raise productivity via learning, variety, and quality effects. Using Indonesian manufacturing census data from 1991 to 2001, their results show that a 10 percentage point fall in input tariffs leads to a productivity gain of 12% for firms that import their inputs.

While the above studies have examined the productivity-export nexus, they examine this relation by looking at one-direction rather than causality directions, and never discuss the possible key role played by R&D.

### 3.2. Innovation, productivity, and exports

Research has frequently examined innovation-productivity and the innovation-export nexus using firm-level data in the literature. Many studies, e.g. Hall and Mairesse (1995), Crepon et al. (1998), Griffith et al. (2003), and Griffith et al. (2006), demonstrated that R&D is an important factor for promoting firms' productivity. On the other hand, studies linking R&D and exports, such as Wakelin (1998) and Barrios et al. (2003) claimed that R&D has positive impact on export propensity. Some studies examining the relationship between exporting and innovation suggest that exporters have higher innovation propensities, e.g. Braga and Willmore (1991), Lee (2004), and Aw et al. (2007). However, this line of research does not clearly indicate a causality relation between R&D and exports.

Previous literature does not typically include R&D, exports, and productivity into a unified analytical framework. Melitz (2003) modeled innovation in the exports-productivity nexus by assuming that the innovation process takes the form of a random productivity drawn from an exogenous distribution. In the model, firms with productivity levels exceeding an endogenously determined threshold enter export markets. Baldwin and Gu (2004) included a more explicit treatment of innovation within the exports-productivity nexus. The empirical evidence shows that Canadian exporting firms are innovative via greater use of advanced technologies and staff training to promote their productivity. Aw et al. (2007) adopted Heckman's sample selection model to deal with the endogenous problem of firms' exit decisions and productivity evolution. The key finding is that Taiwanese firms engaging in R&D and exports experience larger productivity increases than firms that only export. Aw et al. (2008) again examined the role of R&D in the relation between exports and productivity. Using the firm-level data of the Taiwanese electronics industry, they found that firms investing larger R&D increase their productivity, which induces them to enter export markets, lending strong support to the self-selection hypothesis.

## 4. Empirical specification and data descriptions

The above literature review shows few empirical studies linking R&D to the productivity-export nexus. They adopt diverse methodologies, because of the different research questions addressed and the data constraints. R&D activity should play a key role in the exports-productivity

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[5] There are some comprehensive and excellent surveys on firm-level evidence, e.g. Yasar et al. (2006) and Wagner (2007). Greenaway and Kneller (2007) provided new theories of firm heterogeneity, exporting, and productivity and extensive micro-econometric evidence.

nexus to promote firms' productivity and enable them to conquer the cost of entering export markets. R&D serves as a firm's absorptive ability, enabling exporters to learn advanced technologies. While devoting to R&D is a common firm behavior in developed countries, it is unpopular across Indonesia because a vast majority of firms are highly labor-intensive, suggesting that R&D is less meaningful for their productions. However, why do some firms undertake R&D in Indonesia, and does this investment positively contribute to productivity and exports? This question is the main concern of this study.

To model the endogenous decision of R&D in the exports-productivity nexus, this work proposes an analytical framework depicted in Fig. 1. Because of a lacking theoretical model to clarify the causality relation between R&D and exports, this study assumes exports to be an exogenous determinant of R&D (Fig. 1a) or there is a bilateral relationship between exports and R&D (Fig. 1b).

The current research examines the determinants of R&D investment in the Indonesian manufacturing sector. Using the predicted R&D value as the instrumental variable, we examine the role of R&D in the exports-productivity nexus. Since there is no confirmative argument to support the causality relation between R&D and exports (shown as the dotted lines in Fig. 1), this work employs various econometric techniques in the second-step estimation.

### 4.1. Empirical specification

Referring to existing studies on examining the determinants of R&D, we include three categories of determinants in the following R&D equation for Indonesian firms, including: firm level controls, international linkage, and industry-level characteristics.

$$RD_{it} = \alpha_0 + \alpha_1 \ln SIZE_{it} + \alpha_2 SKILL_{it} + \alpha_3 \ln KL_{it} + \alpha_4 GR_{it} + \alpha_5 EXPR_{it}$$
$$+ \alpha_6 MNC_{it} + \alpha_7 CR_{it} + \alpha_8 SCI_{it} + \alpha_9 YDUM + \varepsilon_{it} \quad (1)$$

This study adopts two measures of R&D activities: one is a dummy variable that equals one if a firm reports a positive R&D expenditure and the other is R&D intensity measured by the ratio of R&D expenditure to sales. The subscripts $i$ and $t$ denote firm $i$ for year $t$.

Four firm characteristics are controlled, including: firm size (SIZE), skill intensity (SKILL), capital intensity (KL), and firm growth (GR). Firm size is measured by the number of employees and is often thought to affect a firm's propensity to innovate. While the considerable body of literature on the relationship between firm size and innovation reaches inconclusive results, evidence in developing economies finds a positive relation (Ramstetter and Yang, 2009). Skill intensity and Capital intensity are measured by the ratio of white-collar employees to total employees and the fixed capital per employee, respectively,[6] two alternative determinants which might positively correlate with R&D. Firm growth is included as the proxy variable of internal financing as well as potential market, expected to positively relate to R&D.

International linkage variables contain export intensity (EXPR) and foreign share (MNC). Most studies examining the relationship between exporting and innovation suggest that exporters have higher innovation propensities, e.g. Braga and Willmore (1991), Lee (2008), and Aw et al. (2007). Evidence that affiliates of foreign multinational enterprise (MNC), in whole owned, or joint venture, is weaker or mixed in developing host countries. For example, a positive relation is found in India (Lall, 1983), an insignificant relation is found in Malaysia (Lee, 2004), and a negative relation is found in China (Lundin et al. 2007). FDI inflow to Indonesia might be because of regional advantages, such as resource endowment, cheaper labor, and government policies. Multinational enterprises may reallocate production lines to Indonesia, utilizing Indonesian resource endowment and cheaper labor and retain R&D activity in parent firms. Thus, their Indonesian affiliates may pay nearly no attention to R&D activity.

CR4 is the four-firm concentration ratio that denotes the degree of market competition and is calculated based on 3-digit industries. The Schumpeterian hypothesis predicts a more concentrated industry normally accompanied with more R&D activity, an argument widely supported in existing firm-level studies.[7] SCI is dummy variable equaling one if a firms belongs to scientific industries and this industry-specific feature is included to control for the differences in technological opportunities. Finally, we include a year dummy to capture the influence of macroeconomic condition.

When measuring R&D activity by a binary variable, the Probit model is employed to estimate Eq. (1). Alternatively, we adopt the Tobit model technique to estimate Eq. (1) as the dependent variable, measured by R&D intensity.

In the second step, we specify two simultaneous equations for exports and productivity as follows, referring to Sjöholm (2003).

$$\ln LP_{it} = \beta_0 + \beta_1 RD^*_{it} + \beta_2 \ln KL_{it} + \beta_3 DIMP_{it} + \beta_4 MNC_{it}$$
$$+ \beta_5 EXPR_{1_{it}} + \beta_6 Time\ Dummy + u_{it} \quad (2)$$

$$EXPR_{it} = \gamma_0 + \gamma_1 RD^*_{it} + \gamma_2 \ln KL_{it} + \gamma_3 DIMP_{it} + \gamma_4 MNC_{it}$$
$$+ \gamma_5 DEXP_{it} + \gamma_6 \ln LP_{1_{it}} + \gamma_7 Time\ Dummy + v_{it} \quad (3)$$

In Eqs. (2) and (3), the dependent variables are labor productivity (LP) and export intensity, respectively. Labor productivity is measured by the million Rupiah per employee. To deal with the endogenous problem of R&D choice on affecting productivity and exports, the variable of R&D intensity in Eqs. (2) and (3) ($RD_{it}^*$) is the instrumental variable calculated from the Tobit estimates. As depicted in Fig. 1, R&D input is the key determinant of productivity, expected to have a significantly positive impact on productivity. R&D is often used as a proxy for technology and is helpful for firms of developing countries to compete in the global market, including Indonesia (Van
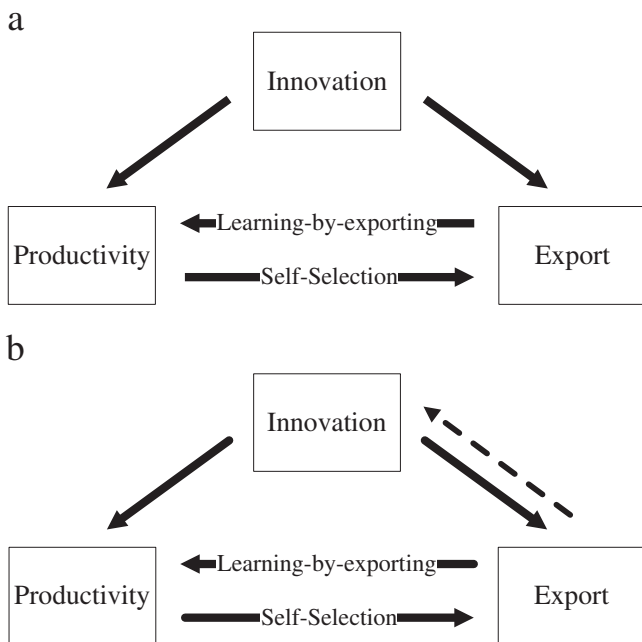
a



b

Fig. 1. The interaction between innovation, productivity and export.

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[6] Due to too much missing data in the estimated value of fixed capital, this study follows the method by Battese et al. (2004), using the value of operating costs as capital. The value of operating costs is composed of expenditures on electricity, fuel, lubricants, maintenance, repairs of capital goods, and building and machinery rental.

[7] For a comprehensive review on the R&D-concentration nexus, please see Aghion et al. (2005).

Dijk, 2002). Capital intensity (*KL*) may play another important firm feature on influencing productivity and exports for Indonesian firms. Firms with higher capital intensities are expected to reveal a higher productivity due to the saving on labor utilization. However, whether and how capital intensity affects export behavior is uncertain. Wakelin (1998) argued that capital intensity can enhance export success because it embodies past innovations, while the opposite is possibly true for developing countries where capital is scarce, such as Indonesia (Van Dijk, 2002). Specifically, Indonesian exports concentrate on labor-intensive products, implying that a possible negative relationship between capital intensity and exports. *DIMP* is a binary variable that equals one if a firm has positive imports of intermediate inputs, considered an important learning channel for Indonesian firms to promote productivity and enhance exports (Sjöholm, 1999; Sjöholm and Takii, 2006; Sjöholm and Takii, 2008). Amiti and Konings (2007) argued that the trade reform in terms of lowering import tariff, has contributed to Indonesian firms' productivity, because cheaper imported inputs can raise productivity via learning, variety, and quality effects.

Again, *MNC* denotes the foreign share of firms. Multinational corporations are expected to have higher productivity than their local counterparts do in developing countries, because MNCs possess superior technologies and management knowledge. MNCs enjoy certain benefits not available to local firms, such as access to superior production technology and management know-how and possessing sophisticated (international) marketing networks (Ramstetter, 1999), and are expected to export more, *ceteris paribus*. In Eq. (3), *DEXP* denotes the share of exports to a district's gross output. According to Sjöholm (2003), the regional agglomeration of exports is a distinct feature in Indonesia that affects firms' export behavior.

To test the hypotheses of self-selection and learning-by-exporting, most studies adopt the simple Granger-causality test to examine the impact of lagged productivity and export on current export and productivity. The impact of the one-year lag variable is particularly significant if enacting self-selection and learning-by-exporting effect (Wagner, 2007). As our dataset contains a short time span of three years, preventing us from including the lag structure of export and productivity, this study includes the one-year lagged variable of export intensity in the productivity Eq. (2). A significantly positive estimated coefficient of the lagged export variable implies that past exporting experience has positive impact on firms' current productivity, supporting the learning-by-exporting hypothesis. Correspondingly, the lagged one-year productivity variable is included in the exporting equation to test the self-selection hypothesis. A significantly positive coefficient attached to the lagged productivity variable suggests that firms with higher productivity tend to export more, *ceteris paribus*.

Previous studies on testing the self-selection or learning-by-exporting effect in Indonesia mainly estimate only one equation. Thus, this study adopts GMM to deal with the endogeneity problem between productivity and export, e.g. Sjöholm and Takii (2008). Not only productivity and export are mutual related, but also other unobserved factors may affect both variables simultaneously. To estimate the system of Eqs. (2) and (3) by considering the possible endogeneity of the R&D decision, this study adopts the technique of three least squares (3SLS). We first estimate Eq. (1) to obtain the predicted value of R&D (RD*) as the instrumental variable and include it as an explanatory variable in Eqs. (2) and (3), aiming to correct for the correction between R&D and error terms. In the next step estimation of system of Eqs. (2) and (3), we adopt the technique of seeming unrelated regression estimation (SURE) to control for causal relations. As shown in Eqs. (2) and (3), exports enter the productivity equation and productivity enters the exporting equation in the one-year lagged form, suggesting that we cannot detect their causality directly. The SURE approach assumes that the equations are related through the correlation in errors and this joint estimation yields estimators that are least asymptotically more efficient than those obtained by an equation-by-equation OLS (Zellner, 1962).

## 4.2. Data source and descriptions

The data used in this study is the Indonesian industrial survey conducted by the Indonesian Central Bureau of Statistics (Biro Pusat Statistik, BPS). This survey covers only medium-sized and large plants with twenty or more workers and the coverage rates of these surveys have varied over time.[8] For the R&D analysis, this paper used the industrial censuses of 1998–2000, describing data of 21,423, 22,070, and 22,174. After removing firms with missing data or unrealistic figures and dealing with the need of including a one-year variable lag, our final sample consisted of 38,637 observations during 1999–2000.[9] Table 2 displays the variable definitions and summary statistics.

Before turning to the econometric analysis, we first look at the distributions of R&D, exports, and labor productivity across industries in Indonesia. Table 3 shows that R&D intensity is quite low in Indonesian manufacturing industries, reaching only an average of 0.092% during 1999–2000. The magnitude of R&D intensity ranges from 0.017% (tobacco products and recycling industry) to 0.327% (radio, television and communication equipment and apparatus). On the other hand, the average export intensity is about 9.848%. While the average export intensity was not high for the Indonesian manufacturing sector, it ranged widely across industries. The two highest export-intensive industries are the furniture industry and the wood product industry, with export intensities of 31.942% and 28.631%. This finding reflects a strong forest resource in Indonesia, enabling it to export mainly wood products and wood furniture. Correspondingly, few industries, such as office, accounting and computing, machinery, and recycling industries, have an export intensity of lower than 1%. Labor productivity ranges widely across industries. Employees of the basic metals industry experience the highest labor productivity of 291.200 million rupiahs per capita, more than eighteen times larger than that (18.341 million rupiahs per capita) of the recycling industry.

## 5. Empirical results and discussions

### 5.1. Determinants of R&D in Indonesian manufacturing plants

Table 4 shows a series of estimates on the determinants of R&D activity in Indonesian manufacturing firms. This research obtains the estimates in columns (1) to (3) by the Probit model, and obtains the results in columns (4) to (6) using the Tobit model. Since R&D activity remains rare across Indonesian firms, we adopt both estimating strategies to examine the determinants of R&D activity in Indonesia. This process enables us to obtain robust estimates on the determinants by checking whether the estimated influence of various determinants varies between two estimations. Among various specifications, all results are similar in important respects, indicating that the determinants of different measures of R&D activity are quite consistent.

All results suggest that both R&D propensity and intensity positively correlate with firm size. This result is consistent with most findings for developing countries, that large firms have noteworthy advantages in undertaking R&D, supporting the Schumpeter hypothesis that larger firms are more likely to undertake R&D activity than small ones. Relative to labor-intensive firms, skill-intensive and/or capital-intensive firms exhibit a higher R&D propensity and R&D intensity in Indonesia, consistent with findings in China (Lundin et al.,

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[8] For problems regarding coverage and variables contained in this survey, please see Takii and Ramstetter's (2005) discussion.

[9] It is inappropriate to examine the interrelation between R&D, export, and productivity in Indonesia using data over 1998–2000, because the Asian Financial Crisis seriously affected the Indonesian economy, suggesting that the 1998–2000 is an unusual period. As the export-productivity nexus has been widely examined in the existing literature and most studies support self-selection and learning-by-exporting effects, this relation can be widely examined using data of various countries and times. Therefore, the econometric results obtained in this study are useful to examine the productivity-export nexus.

**Table 2**
Variable definitions and summary statistics.

| Variable | Definition | Mean | Std. dev. |
|---|---|---|---|
| LP | Labor productivity: million rupiahs per capita | 63.349 | 463.717 |
| SIZE | Plant size: number of total workers | 201.503 | 702.992 |
| KL | Capital intensity: the ratio of output (million rupiahs) to employees | 1.418 | 10.542 |
| SKILL | Skill intensity: the ratio of white-collar employees to total employees (%) | 15.578 | 15.008 |
| GR | Growth rate of Firm's production values (%) | 49.051 | 937.068 |
| EXPR | Export intensity: the ratio of exports to output (%) | 12.141 | 30.461 |
| RDR | R&D intensity: the ratio of R&D expenditure to output (%) | 0.067 | 0.707 |
| MNC | Foreign ownership: percentage of foreign capital owned (%) | 6.017 | 21.663 |
| DIMP | Dummy variable for raw material imported | 0.198 | 0.398 |
| DEXP | Share of district's export to gross output (%) | 18.464 | 15.780 |
| CR4 | The four-firm concentration ratio within a 4-digit industry (%) | 36.181 | 22.029 |

Note: The statistics are calculated by year 1999 and 2000; while the statistics of lag terms are calculated by year 1998 and 1999. All dollar figures are deflated using the 1998 CPI as the base year. The deflator for 1999 and 2000 is 1.208 and 1.253, respectively.

2007) and India (Lall, 1983). This finding is economically intuitive because skill-intensive and/or capital-intensive firms are more aggressive to engage in R&D activity to develop new products and manufacturing processes. Results regarding the relationship of R&D activity and firm growth were less consistent, however. The Porbit estimates suggest that the relationship to plant growth was significantly positive in all estimates. In contrast, the estimated coefficient of firm growth was positive but not statistically significant in all Tobit estimates. Because we treated the firm growth variable as the proxy of market size or internal financing source, our results suggest that firms with a larger market or sufficient internal financing source have a higher propensity to engage in R&D. However, their R&D intensity is not significantly higher.

As for the influences of international linkages, all estimates revealed a significantly positive relationship between export intensity and R&D, suggesting that exporters have higher innovation propensities or a greater probability of becoming innovators than non-exporters. The widely adopted strategy of export-led growth in Southeast Asian countries also facilitates exporters to devote more efforts on R&D due to tough competitive pressure in global markets, such as Malaysia (Lee, 2008)

**Table 3**
The distribution of R&D, exports, and labor productivity across industries in Indonesia.

| ISIC | Industry | Number of observations | R&D intensity (%) | Export intensity (%) | Labor productivity, million rupiahs per capita |
|---|---|---|---|---|---|
| 31 | Food | 10,232 | 0.039 (0.366) | 6.510 (23.083) | 65.665 (215.509) |
| 32 | Textile | 7,444 | 0.053 (0.729) | 13.951 (32.087) | 48.312 (803.386) |
| 33 | Wood | 3,090 | 0.054 (0.346) | 28.631 (41.842) | 39.214 (97.503) |
| 34 | Paper | 1,662 | 0.080 (0.639) | 3.100 (15.589) | 51.849 (100.152) |
| 35 | Chemical | 4,572 | 0.135 (0.975) | 9.511 (26.444) | 116.966 (405.641) |
| 36 | Non-metal products | 3,621 | 0.036 (0.302) | 2.867 (14.211) | 16.714 (43.191) |
| 37 | Metal products | 377 | 0.100 (0.829) | 11.390 (28.353) | 291.200 (1200.210) |
| 38 | Fabricated metal products | 2,058 | 0.071 (0.564) | 5.935 (20.758) | 88.780 (772.710) |
| 39 | Other manufacturing | 5,581 | 0.102 (1.143) | 24.126 (40.734) | 57.507 (270.516) |

Note: Figures in parentheses are standard errors.

**Table 4**
Determinants of R&D activity in Indonesia manufacturing firms.

| | Probit model | | | Tobit model | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Constant | −2.630*** | −2.629*** | −2.651*** | −6.141*** | −6.128*** | −6.211*** |
| | (0.045) | (0.045) | (0.045) | (0.128) | (0.128) | (0.128) |
| lnSIZE | 0.255*** | 0.283*** | 0.290*** | 0.528*** | 0.584*** | 0.602*** |
| | (0.008) | (0.008) | (0.007) | (0.019) | (0.019) | (0.018) |
| SKILL | 0.008*** | 0.007*** | 0.007*** | 0.019*** | 0.017*** | 0.017*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| lnKL | 0.123*** | 0.124*** | 0.122*** | 0.234*** | 0.239*** | 0.238*** |
| | (0.006) | (0.006) | (0.006) | (0.014) | (0.014) | (0.014) |
| GR | 1.32e−05* | 1.60e−05* | 1.56e−05** | 1.98e−05 | 2.37e−05 | 2.29e−05 |
| | (6.98e−06) | (7.11e−06) | (7.08e−06) | (1.57e−05) | (1.58e−05) | (1.59e−05) |
| EXPR | 0.005*** | | | 0.010*** | | |
| | (0.0003) | | | (0.001) | | |
| EXPR_1 | | 0.004*** | | | 0.007*** | |
| | | (0.0004) | | | (0.001) | |
| MNC | 0.0002 | 0.0009** | 0.001** | −0.0001 | 0.001 | 0.002** |
| | (0.0003) | (0.0004) | (0.0004) | (0.0008) | (0.001) | (0.001) |
| CR4 | 0.001*** | 0.0002 | −0.0003 | 0.003** | 0.0015 | 0.0003 |
| | (0.0004) | (0.0004) | (0.0004) | (0.001) | (0.001) | (0.001) |
| SCI | 0.114** | 0.122*** | 0.127*** | 0.344*** | 0.358*** | 0.369*** |
| | (0.020) | (0.020) | (0.020) | (0.047) | (0.047) | (0.047) |
| T-Dummy | 0.091*** | 0.039** | 0.104** | 0.160*** | 0.062 | 0.185*** |
| | (0.019) | (0.020) | (0.019) | (0.045) | (0.047) | (0.044) |
| Sigma | | | | 2.392*** | 2.382*** | 2.398*** |
| | | | | (0.029) | (0.029) | (0.029) |
| # of obs. | 35,766 | 35,335 | 35,766 | 35,766 | 35,766 | 35,766 |

Figures in the parentheses are standard deviations. ***, **, and * denote coefficients are significant at 1%, 5%, and 10% statistical levels, respectively.

and Thailand (Intarakumnerd et al., 2002). One point worth noting is that, as depicted in Fig. 1b, R&D and exports may be simultaneously causal. Therefore, including the fitted value RD* obtained from Eq. (1) to estimate Eq. (3) may cause biased estimates. To remedy this problem, this study adopts two alternative strategies that one is using lagged one-year export intensity (EXPR_1) and the other is excluding the export variable. As shown in columns (2) and (5), the variable of EXPR_1 is associated with a significant positive coefficient, confirming the R&D enhancing effect brought about by competition in the international market.

Do affiliates of foreign MNCs in Indonesia have a higher propensity to engage in R&D activity? Observation from the estimated coefficient on the MNC variable, it reveals inconsistent results in various estimates. Three out of six estimates are positive and significant at the 5% statistical level, whereas the other three estimates do not exhibit a significant relation between R&D activity and foreign ownership. It suggests that affiliates of foreign MNCs in Indonesia tend to be more innovative, but this difference is not very significant. It is because FDI in Indonesia may focus on acquiring natural resources and utilizing cheap labor. Overall, this finding is similar to findings in India (Lall, 1983) and Malaysia (Lee, 2004)

Results regarding the influence of industrial competition on firm-level R&D are mixed in the estimates. As highlighted in the review conducted by Aghion et al. (2005), most empirical findings of this literature support the Schumpeterian hypothesis that there is a positive relationship between concentration and innovation. This positive relationship between concentration and R&D is only found witnessed in columns (1) and (4), while other estimates do not find a distinct and significant relation between industrial concentration and firm-level R&D. The results suggest that the Schumpeterian hypothesis regarding the concentration-innovation nexus is not strongly supported in Indonesian manufacturing industries. Moreover, scientific industry firms have a higher R&D propensity and intensity than their non-scientific counterparts because the technological opportunity is likely more fertile in scientific industries.

## 5.2. The productivity-export nexus

Next, this study examines the productivity-export nexus in Indonesian manufacturing firms by considering the endogenous choice of R&D investment. To deal with the endogenous causal relationship between R&D and export intensity in Eq. (3), we adopt the fitted value RD* obtained in columns (5) and (6) of Table 4 and then estimate the system of Eqs. (2) and (3) using seeming unrelated regression estimation (SURE). Table 5 displays the empirical results. Estimates of R&D variables shown in models (a) and (b) are predicted value obtained from models (5) and (6) and Table 4.

We first look at the productivity equation estimates shown in the upper panel of Table 5. Does R&D also have significant impact on enhancing productivity in Indonesia? Both estimates show that the coefficient of the R&D variable is positive and significant at the 1% statistical level, suggesting that R&D expenditure does have a positive impact on labor productivity. This provides evidence that firms undertaking more R&D have resulted in higher labor productivity in Indonesia. The estimated magnitude of R&D elasticity hover about 0.42, suggesting that a 1% increase in R&D investment can raise a firm's labor productivity to 0.42% on average. While Indonesian manufacturing firms engage less intensively in R&D and mainly produce labor-intensive products, the impact of R&D capital on labor productivity seems considerable.[10] This finding implies that R&D can play a crucial role in influencing economic development and raising the technology level for the Indonesian economy.[11]

The influences of other factors on labor productivity are as expected and are consistent with findings in previous studies for Indonesian manufacturing plants. Capital intensity exhibits a significantly positive impact on labor productivity, suggesting that plants with higher capital intensities have better performance on labor productivity. Benefited from the learning effect, firms with imported intermediate inputs experience higher labor productivity than their counterparts without importing intermediate goods. This result is consistent with findings in Sjöholm (1999), and Sjöholm and Takii (2004, 2008). The estimated coefficient on the MNC variable is significantly positive at the 1% level in both estimates, indicating that multinational corporations have higher labor productivity than their local counterparts in Indonesia. This is because MNCs possess superior technologies and management knowledge than local firms in developing countries.

Does international competition enhance productivity for exporting firms in Indonesia, as argued in theoretical literature? In various estimates, the variable of on one-year lagged exporting intensity is associated with a significantly positive coefficient, supporting the learning-by-exporting hypothesis that exporting experience can help to promote productivity for Indonesian manufacturing firms.[12] The estimated coefficient suggests that, other variables remaining at the mean value, exporters experience a higher labor productivity of nearly 1.2% than non-exporters. While Indonesian exports concentrate on natural resource-related and labor-intensive products, such as wood products and textiles, the competition effect brought on by exporting to foreign markets seems to promote their labor productivity. Although the results seem to highlight the causal relationship of exports spurring productivity, the short time span utilized in this study provides limited evidence.

Correspondingly, the lower panel of Table 5 demonstrates the estimates of the exporting equation. The estimated coefficient of R&D intensity is significantly positive at the 1% level, supporting the finding

**Table 5**
The estimates of productivity-export nexus in Indonesian manufacturing firms.

|  | (a) | (b) |
| --- | --- | --- |
| *Productivity equation* | | |
| Constant | 4.543*** | 4.535*** |
|  | (0.029) | (0.028) |
| RD* | 0.422*** | 0.414*** |
|  | (0.008) | (0.008) |
| lnKL | 0.241*** | 0.245*** |
|  | (0.004) | (0.004) |
| IMP-D | 0.340*** | 0.340*** |
|  | (0.016) | (0.016) |
| MNC | 0.006*** | 0.006*** |
|  | (0.0003) | (0.0003) |
| EXPR_1 | 0.002*** | 0.001*** |
|  | (0.0003) | (0.0003) |
| T-Dummy | 0.026** | −0.023* |
|  | (0.012) | (0.012) |
| | | |
| *Export equation* | | |
| Constant | 42.713*** | 33.368*** |
|  | (0.767) | (0.803) |
| RD* | 13.194*** | 10.297*** |
|  | (0.197) | (0.207) |
| lnKL | −3.977*** | −3.038*** |
|  | (0.111) | (0.114) |
| DIMP | −4.826*** | −2.947*** |
|  | (0.420) | (0.432) |
| MNC | 0.174*** | 0.197*** |
|  | (0.007) | (0.008) |
| DEXP | 0.305*** | 0.314*** |
|  | (0.010) | (0.010) |
| lnLP_1 | 0.0007** | 0.0006* |
|  | (0.0003) | (0.0003) |
| T-Dummy | −3.242*** | −3.491*** |
|  | (0.317) | (0.326) |
| # of obs. | 35,335 | 35,335 |

Note: Figures in parentheses are standard errors. ***, ** and * represent significance at the 1%, 5% and 10% statistical level, respectively.

by Van Dijk (2002) that R&D expenditure positively affects exporting activity in most Indonesian manufacturing industries. The endogenous decision to undertake R&D is helpful to raise technological capability and promote firms' competitiveness in the international market for Indonesian manufacturing firms.

The variable capturing capital intensity (lnKL) is unexpected, found to associate with a significantly negative coefficient in all estimates. Although capital intensity may enhance export success for firms in some developed countries (Wakelin, 1998), exporting labor-intensive products seems relatively advantageous compared to capital-intensive products for Indonesian manufacturing firms. This finding is consistent with findings in Van Dijk (2002). The coefficient for the import dummy is surprisingly significantly negative, contrasting to previous findings of significantly positive (Sjöholm, 1999) or insignificant (Sjöholm and Takii, 2008). Due to the difference in the measure of export variable, our result cannot compare directly with that in previous studies. Our estimates suggest that plants utilizing imported intermediate goods to produce final goods have lower export intensities than other plants in the Indonesian manufacturing sector. This is partially because Indonesian exports concentrate mainly on natural resource industries, such as the wood industry. All estimations display that foreign ownership is significantly positive on influencing exporting behavior, supporting the important relation between foreign networks and exports in Indonesian plants (Sjöholm and Takii, 2008). Sjöholm (2003) pointed out that the regional agglomeration of export is a distinct feature in Indonesia, which affects firms' export behavior. The current study supports this argument because the variable of *DEXP* is found to associate with a significantly positive coefficient in all estimates.

Does the fixed cost of selling in a foreign market enable only more productive firms to enter the international market? Does the positive relation between productivity and exports attribute to the self-

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[10] See Mairesse and Sassenou (1991) for a survey on the estimation of R&D contribution to output in developed countries.

[11] Technology transfer from abroad is also another important mean for promoting productivity for less developed countries, such as Indonesia.

[12] Labor productivity is not really a true measure of TFP, but after purging its correlation with capital stocks, it embodies the concept of TFP. It may also have the advantage of lowering bias due to the difficulty of getting capital price. This is particularly relevant to Indonesian firms with incomplete capital data.

selection of productive firms to export? The export coefficient has a significantly positive association in all estimates, supporting the self-selection hypothesis. This finding suggests that plants with high productivity export more intensively in Indonesia.

Researchers widely recognize the export-oriented policy as a key factor contributing to economic growth in Southeast Asian countries. The question of whether it is adequate for a government to devote most of its resources to promote exports depends on the causality direction between exporting and productivity. The aforementioned analyses evidence the coexistence of self-selection and learning-by-exporting effects in Indonesian manufacturing industries. This issue of how to promote exports is particularly important for a less developed country like Indonesia.

### 5.3. Robustness analysis

As depicted in Fig. 1b, besides the causality between exports and productivity, exports and R&D are possibly interrelated. Some studies have claimed the need of unified frameworks to examine the interrelation across R&D, exports, and productivity, e.g. Melitz (2003), Baldwin and Gu (2004), and Aw et al. (2007, 2008). This suggestion implies biased estimates on the productivity-export nexus by treating the R&D decision as an exogenous choice.

To obtain robust results on the interrelation between R&D, productivity, and exports, we further adopted the technique of unrelated regression estimation (SURE) to estimate the system of Eqs. (1)-(3). Table 6 shows the empirical results.

Compared with estimates shown in Tables 4 and 5, the estimates are similar, but some determinants show a quite different influence in each equation. The estimation of the R&D equation shows that plants with a large size, higher skill and capital intensity have a higher propensity to undertake R&D, while the influence of growth rate

**Table 6**
SURE estimates of interrelation of R&D, productivity, and export.

| | (1) | | (2) | |
|---|---|---|---|---|
| | Coefficient | S.E | Coefficient | S.E |
| *RD equation* | | | | |
| Constant | −0.144*** | (0.018) | −0.148*** | (0.018) |
| lnSIZE | 0.039*** | (0.003) | 0.040*** | (0.003) |
| SKILL | 0.001*** | (0.0003) | 0.001*** | (0.0003) |
| lnKL | 0.008*** | (0.002) | 0.009*** | (0.002) |
| GR | 4.55e−07 | (3.91e−06) | 2.03e−07 | (3.91e−06) |
| EXPR_1 | 0.0006*** | (0.0002) | | |
| MNC | −9.62e−05 | (1.78e−04) | −3.53e−05 | (1.77e−04) |
| CR4 | 0.0004** | (0.0002) | 3.46e−04** | (1.69e−04) |
| SCI | 0.048*** | (0.008) | 0.048*** | (0.008) |
| T-Dummy | −0.001 | (0.008) | 0.005 | (0.007) |
| | | | | |
| *Productivity equation* | | | | |
| Constant | 3.163*** | (0.010) | 3.163*** | (0.010) |
| RD | −0.007 | (0.008) | −0.006 | (0.009) |
| lnKL | 0.375*** | (0.004) | 0.376*** | (0.004) |
| DIMP | 0.618*** | (0.016) | 0.619*** | (0.016) |
| MNC | 0.009*** | (0.0003) | 0.009*** | (0.0003) |
| EXPR_1 | 0.002*** | (0.0003) | 0.002*** | (0.0003) |
| T-Dummy | 0.039*** | (0.012) | 0.039*** | (0.012) |
| | | | | |
| *Export equation* | | | | |
| Constant | −0.787* | (0.429) | −0.775* | (0.430) |
| RD | 2.178*** | (0.225) | 1.991*** | (0.225) |
| lnKL | 0.192** | (0.097) | 0.194** | (0.097) |
| DIMP | 3.780*** | (0.424) | 3.790*** | (0.424) |
| MNC | 0.275*** | (0.008) | 0.275*** | (0.008) |
| DEXP | 0.309*** | (0.010) | 0.309*** | (0.010) |
| lnLP_1 | 5.85e−4* | (3.33e−04) | 5.86e−04* | (3.33e−04) |
| T-Dummy | −1.598*** | (0.335) | −1.598*** | (0.335) |
| # of obs. | 35,335 | | 35,335 | |

Note: ***, ** and * represent significance at the 1%, 5% and 10% statistical level, respectively.

turns to be insignificant. As for the impacts of international linkages, exports exhibit a significantly positive impact on plants' R&D intensity, consistent with findings in Malaysia (Lee, 2004), and Taiwan (Aw et al., 2007). The estimates on foreign ownership are consistent to have lower R&D intensities than their local counterparts, but not statistically significant. Plants located in more concentrated or scientific industries, experience higher R&D intensity, *ceteris paribus*.

The middle and lower panels display the estimates for productivity and exporting equations. Focusing on the relationship between productivity and export, the estimated coefficients of the one-year lagged variable on export intensity (EXPR_1) and labor productivity (lnLP_1) are again significantly positive at a conventional statistical level in all estimates. In attempting to sort out the causality direction, the plant-level data analyses show that self-selection and learning-by-exporting effects exist contemporaneously for Indonesian manufacturing plants. This reflects that efficient plants select to enter the export market, while the exporting experience also results in a higher productivity for Indonesian manufacturing plants.

## 6. Concluding remarks

Previous empirical studies have shown a strong, widespread correlation between exporting and productivity, while fewer studies investigate the role of innovation on the productivity-export nexus. Endogenous growth theories claim that innovation is a major driving force of economic growth, and studies have emphasized export-oriented growth as a successful development strategy for East Asian countries. Recovering from the shock of the Asian Financial Crisis in 1997, Indonesia, the developing Southeast country, has undertaken a series of economic reforms to promote exports and has begun to recognize the importance of R&D. However, studies have not adequately investigated the determinants of R&D and the role R&D plays in the productivity – export nexus for Indonesian manufacturing firms.

This paper utilizes Indonesian industrial surveys from1998-2000 to examine the determinants of R&D and the interrelations of R&D, productivity, and exports. Various estimates on determinants of R&D find that plants with large scale, higher skill, and capital intensity devote more efforts to innovative activity in terms of R&D intensity. As for the influences of international linkages on R&D, exporting activity expectedly has a positive impact on plants' R&D activity through competition and learning effects. Multinational corporate do not strongly evidence higher R&D propensity than their local counterparts in Indonesia because MNCs may focus on utilizing natural resources and cheap labor rather than R&D in Indonesia. Market concentration positively relates to plants' R&D, supporting the Schumpeterian hypothesis that there is a positive relation between concentration ratio and R&D intensity.

After considering the endogeneity of R&D decision, the estimation of interrelations of R&D, productivity, and exports shows that R&D contributes positively to productivity and exports. Importantly, productivity has a significantly positive impact on exporting and vice versa, lending a supportive view of the coexistence of the self-selection and learning-by-exporting hypotheses. This study finds that multinational corporations are more productive and exporting-intensive than local firms in the Indonesian manufacturing sector.

This study inspires two policy implications. First, it is important for the Indonesian government to understand the determinants of firms' R&D propensity, while innovative activity is currently not prevalent among Indonesian manufacturing firms. Given the importance of R&D on sustainable growth and the contribution to productivity and export, the government should enact some policy measures to encourage firms to devote more efforts on R&D, especially for transforming industrial structure in the future. However, the external technological sources of technology imports or technology licensing are perhaps the more efficient way to promote productivity for Indonesian firms, because acquiring technologies from advanced countries can meet the technological

need directly and are less risky than R&D. Second, this study supports the learning-by-exporting effect that exporting experience is helpful to enhance firms' productivity. Since exporting is an important development strategy for Indonesia and can contribute to promoting productivity, how to promote and help firms compete in the global market is worth serious consideration by the Indonesian government.

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