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Globalization and Innovation in Indonesia: Evidence from Micro-Data on Medium and Large Manufacturing Establishments

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Abstract: In this paper we examine the impact of globalization on innovation in the Indonesian manufacturing sector. The lack of innovation data in the manufacturing survey has necessitated the use of R&D expenditure as an input in the innovation production function. Globalization is represented by being exporters, FDI and effective rate of protection (EPR). The model is set up such as within the concept of R&D as conditional input demand function, allowing labor productivity to have impact on R&D. In this case we find that less productive firms are less likely to venture into R&D activities. In terms of globalization variables we find that being exporters is important determinant of R&D. Meanwhile the impact of FDI firms on domestic R&D is only on the incidence not on the intensity of R&D. It will require a critical mass of firms within a location or an agglomeration to have a meaningful impact. Also lower ERP would induce firms to spend more on R&D. So lowering protection or trade barriers will have positive impact on R&D.

Keywords: Indonesian manufacturing, Research and Development

JEL Classification: D21, O31, O12

1. Introduction

Globalization is a process whereby countries become more integrated via movements of goods, capital, labor and ideas (Bloom, 2002). From the economic policy standpoint, how globalization is transmitted into the domestic economy is manifested in many ways, but is usually focused in the realm of trade and investment liberalization. Decreasing trade barriers allows increasing exchange of goods and services between countries. This process is facilitated by advances in information and communication technology. In this setting new ideas are quickly brought to fruition, and new technologies are developed and superseded faster than at any other time in history. More important than any other time in the past, knowledge has now become an increasingly important determinant of the wealth of nations.

The importance of knowledge has revived attention on innovation systems and research institutions. The process of globalization has made innovation more important than before - even poor countries can no longer neglect the development of innovation systems. Innovation systems as creators, adaptors and disseminators of knowledge can be used as a vital tool for developing countries to benefit from globalization.

Firms now have to compete domestically and internationally. A fast changing business environment is a fact of life that has to be faced by corporations in the globalization. From the organizational standpoint it requires firms to adjust with changing market demand immediately, and for this they need to innovate.

The purpose of this study is to examine the impact of globalization on innovation at the firm level in the Indonesian large and medium manufacturing. This study, using the Indonesian micro data on large and medium size manufacturing establishment, attempts to provide contribution to resolve the debate whether globalization is innovation enhancing or innovation reducing. The key question is whether government policies to liberalize trade and investment regime will boost innovations. If that is the case, then the policy to open up the economy to global competition is desirable. It will allow developing countries or more specifically Indonesia to jump up the learning curve by bypassing the expensive process of invention. The government then after a series of trade and investment liberalization policies could focus on policies to facilitate firms to exploit the benefits of globalization.

The relationship between globalization and innovation is a complex one. Increasing imports and inward foreign direct investment (FDI) brought about by decreasing trade barriers would intensify competition in the domestic market and erode the domestic firms' profitability. This would force domestic firms to produce efficiently (Berthschek , 1995). One way of staying competitive in business one way is to increase innovation activity. So globalization and innovation may be positively related.

On the other hand, others have argued that the above relationship may be just the opposite (Braga and Wilmore, 1991). Because firms have to spend handsomely on R&D to create new product and new production processes while its return is highly uncertain, they tend to be very conservative on innovation - focusing only on the assimilation of imported technology to local conditions. Hence, the relationship between globalization and innovation may be negative.

Between these two opposing views some prefer to adopt the middle ground stance that globalization allows developing countries to jump up the learning curve without having to undergo the lengthy and expensive process of discovery, by accessing ideas and technologies developed elsewhere and putting them into practice after some modification (Bloom, 2002).

Although the term "globalization" is well understood, translating it into more 'operational' variables for an empirical exercise is another matter. First globalization can be considered as a regime change from a relatively highly regulated and protected economy to a more open and deregulated one. Any economic reform that involves trade and/or investment liberalization will suit into this definition. In this respect, the period of analysis will be divided into before and after liberalization to examine the impact of regime change on any defined outcomes, for example its impact on the number of innovations conducted by firms.

The second way is more microeconomic in nature (i.e. at the firm or industry level). As a result of the dismantling trade barriers, a firm has options to enter export markets, operating as FDI, licensing or some or all combinations of the above. This applies to all firms irrespective of their countries of origin (Bertschek, 1995). One implication is that export activities, the presence of FDI and/or licensing can be used to signify the extent of globalization at the firm, industry and national levels – depending on how disaggregated is the analysis. One example is to use the ratio of exported output at the firm level (Kuncoro, 2002). Meanwhile the presence of FDI firms is often used to capture the impact of globalization on firms (Kuncoro, 2007). Therefore globalization is treated as an exogenous factor – the possibility that firms learn through R&D to become more productive so that they can go global as in Damijan *et al*. (2010), Crespi *et al.* (2008) and MacGarvie (2006) is completely abstracted from.

For innovation the measurement is more straightforward. There are two aspects of innovations, namely product technology or product innovation and process technology or process innovation. Product innovation is a substantial improvement of a current product or development and manufacture of a new product. Kraemer and Dedrick (2000) for example used the number of new products introduced over the last three years to capture product innovation. Process innovation on the other hand involves substantially improved or new production process through the introduction of new process equipment or re-engineering of operational process. For example if a firm in a specific period of time do the following; to set up new production line, to put in new production system and to put in new computerized system to upgrade production facilities, then they can be categorized as undertaking process innovation. This also applies to the purchase of new capital equipment if it involves new production process or at least brings improvement in production process.

The concept of 'knowledge' production function allows us to estimate directly the determinants of innovation provided that the data are available. One important feature of innovation data is that they consist of integer number and zero counts. This necessitates the modification of distributional assumption when it comes to estimate innovation function. The simplest is the Poisson distribution (Crepon and Duguet, 1997)

In subsequent development, Andersen (1970) extends the basic model to allow estimation of fixed effects where the heterogeneity term u_i is no longer assumed to be independent of right hand side variables. So potentially one can allow individual or industry effect such as different operating skills, appropriate condition and technological opportunities in the innovation relationship.[1] The pioneering work applying the Poisson regression or count data model to the relationship between innovation and R&D was conducted by Hausman *et al.* (1984).

One important contribution of this study is methodological – how to deal with the situation when the innovation data are very rudimentary. Both types of innovation are simply not available in BPS (Indonesian Statistical Agency) large and medium manufacturing surveys. The only observed outcome from innovation activities is R&D expenditure in which all product and process innovations are lumped together. To overcome this problem instead using the knowledge production function directly, using economic theory one can derive R&D expenditure as a product of the cost minimization process where total cost of production which includes R&D expenditure is minimized subject to a certain level of targeted output. In other words by relying on the concept of innovation or the knowledge production function R&D expenditures are interpreted as preceding activities prior to actual innovations. The attempt to endogenize R&D decision is in line with Constantini and Melitz (2008) while export remains exogenous.

2. R&D Activities & Globalization in Indonesian Manufacturing

Before we proceed to the conceptual model guiding our empirical research, we examine the main data sets – the annual survey of large and medium manufacturing firms. The biggest problem is that the data do not contain the count of innovation, what is available R&D expenditure. Under this condition, one way to get around the problem is to model R&D expenditure as a conditional input-demand function representing innovation generating activity.

The manufacturing data sets mentioned above are available from 1980 to 2007. So potentially one can construct a long panel data to study the dynamic of R&D activities. Unfortunately R&D expenditure is only recorded intermittently for the years 1995, 1996, 1997, 1999, 2000 and 2006. There is no R&D data prior to 1995.[2] Although

[1] This effect can be either fixed or random.
[2] 1996 was eventually dropped from our regression sample due to the fact that it misses one crucial variable for our modeling set up, namely new investment in machinery.

potentially one can construct a balanced panel data set, the main hurdle is to link data sets before 2000 to that of 2006. We find that the firm identifiers are unreliable to link the same firms from different years. So at best one can use the data sets in a pooled fashion. Another problem is that R&D events are such rarities that from the total combined sample from 1995 to 2006 the overall percentage of firms doing R&D rarely exceeds 8 percent, which happened only in 1997 and 2006 (**Table 1**). On this consideration, a lot more can be learned from firms' decision to undertake R&D or not by using a pooled sample.

Table 1: R&D versus no R&D

Year	No R&D (%)	R&D (%)	Number of firms
1995	92.4	7.4	21530
1996	92.8	7.2	22969
1997	91.7	8.3	22355
1999	94.7	5.3	20445
2000	93.9	6.1	21762
2006	91.2	8.8	29421

Source: calculated from the Annual Manufacturing Surveys

Our observation on data sets will also help in determining the direction of the modeling. In particular we want to know the main motivation behind carrying out R&D. It is known that at the present stage of technology maturity, R&D has not been an important factor in affecting the competitiveness (Kuncoro, 2002). Even if R&D activities do exist, mostly they take the form of process innovation. Process innovation involves substantially improved or new production process through the introduction of new process equipment or re-engineering of operational process. There are three situations where process innovation may take place: setting up a new production line, putting in a new production system and installing new computer or information technology components to upgrade production facilities (Kraemer and Dedrick, 2000).

The purchase of new capital equipment can be categorized as process innovation if it involves a new production process or at least brings improvement in production process. So a common occurrence is R&D activities taking place after new machinery is installed. To examine this, we tabulate new machinery investment and the incidence of R&D. The results are presented in **Table 2**.

Table 2: Firms Investing in New Machinery and R&D

Year	No New Machinery Investment		New Investment in Machinery	
	% Firms doing R&D	Number of Firms	% Firms doing R&D	Number of Firms
1995	5.4	18246 (84.7%)	19.6	3284 (15.3%)
1997	6.5	19401 (86.6%)	20.3	2954 (13.4%)
1999	3.5	17347 (85.2%)	15.1	3007 (14.8%)
2000	4.5	18622 (85.8%)	15.3	3100 (14.2%)
2006	5.6	25342 (86.1%)	10.4	4079 (13.9%)

Source: Calculated from the Annual Manufacturing Surveys.

For all years under observation firms making new investments in machinery have higher likelihood of conducting R&D. In 1995 for example only 5.4 percent firms with no new machinery investment carried out R&D. The corresponding figure for firm with new machinery investment is almost four times higher. For both investing and non-investing firms, the Asian economic crises have obviously had significant impact on R&D activities. For investing firms the propensity to do R&D declined ever since and it has yet recovered in 2006. On the contrary it reached its lowest figure of 10.4 percent in that year. The figures for non investing firms are virtually flat – suggesting that there is no relationship between R&D and machinery investment.[3] The decision to invest in new machinery is not an easy one. Since the investment cost is sunk a careful consideration must be made by a firm taking account business uncertainty and future profits, in effect it makes investment in machinery more volatile. Whatever the trend of the likelihood of engaging R&D, **Table 2** suggests that there is a relationship between new investment in machinery and R&D.

As mentioned above, we hypothesize that an increase in competition from arising globalization may induce firms to do more R&D. For this we replicate the above simple analysis to two variables representing globalization, namely going into export market and the presence of FDI firms (**Table 3** and **Table 4**).

[3] If there is no relationship between new machinery investment and R&D – the existence of R&D must be driven by something else like packaging, sales and so on.

Table 3: FDI Firms and R&D

Year	Non FDI Firms		FDI Firms	
	% Firms doing R&D	Total Number of non FDI Firms	% Firms doing R&D	Total Number of FDI Firms
1995	7.1	20657 (95.9%)	18.6	873 (4.1%)
1996	6.7	21988 (95.7%)	18.7	980 (4.3%)
1997	6.7	21254 (95.1%)	20.9	1101 (4.9%)
1999	7.7	18926 (93.0%)	10.6	1428 (7.0%)
2000	4.8	20028 (92.0%)	13.1	1734 (8.0%)
2006	8.7	27252 (92.8%)	10.1	2169 (7.2%)

Source: Calculated from the Annual Manufacturing Surveys.

FDI firms are almost three times more likely to engage in R&D. In 1995 the percentage of FDI firms recording R&D is 18.6 percent in contrast to 7.1 percent for non FDI. The percentage of FDI firms carrying out R&D reaches its peak in 1997 just a year before the Asian Crisis. As a mimic to observed pattern in the new machinery investment before the likelihood of FDI firms engaging in R&D dropped after the Asian crisis almost by half (**Table 3**). Interestingly the figures for non FDI firms show a drop only in 2000 – the number is virtually stable for all other years. One plausible explanation is that since R&D is tied to new machinery investment, the number is less volatile for those that are less likely to make such investment namely non FDI firms.

Table 4 shows how exporting is related to R&D activities. Manufacturing is dominated by non-exporters, which account for about 80 percent of total firms. Exporting firms are clearly more likely to do R&D. But as in the previous analysis, the likelihood to carry out R&D diminishes after the crisis and by 2006 it has still to recover. To summarize there are three factors that may drive firms to engage in R&D: making new machinery investment, being FDI enterprises and being exporters, all of which may be interrelated. To disentangle this we have to wait for a formal econometric analysis.

Table 4: Exporting Firms and R&D

Year	Non Exporters		Exporters	
	% Firms doing R&D	Total Number of non-exporters	% Firms doing R&D	Total Number of Exporters
1995	6.1	17907 (83.2%)	15.1	3623 (13.0%)
1996	5.5	18614 (81.0%)	14.6	4354 (19.0%)
1997	7.3	19298 (86.3%)	14.8	3057 (13.7%)
1999	3.9	17553 (86.2%)	13.6	2801 (13.8%)
2000	4.3	18187 (83.6%)	13.0	3575 (16.4%)
2006	8.5	24422 (82.3%)	10.4	5199 (17.7%)

Source: Calculated from the Annual Manufacturing Surveys.

The above analysis yields the likelihood of firms to commit R&D but not the propensity or intensity of doing so. To measure the propensity we use the ratio of R&D expenditures to the values of total inputs, in percentage terms. The results are shown in **Table 5**. All figures are quite small. None of them is higher than 1.5 percent. Interestingly for all variables supposedly represent globalization namely; export orientation and FDI, the results show that firms facing globalization do not necessarily posses higher propensity to engage in RD. Globalization may increase the likelihood or the incidence of R&D but it does not necessarily mean at high level.[4] Higher levels of R&D, regardless of denominator used may indicate sophistication so these small values suggest that, if any, R&D activities may involve only non-sophisticated activities. Another interesting observation is the observed turn around in 2006 where in the categories of export orientation and FDI versus non FDI, all respective firms have a higher propensity to engage in R&D compared to their non-exporter and/or non-FDI counterparts, though all are at lower percentage. The Asian crises have lowered propensity for R&D in all categories. The same pattern can also be observed for firms with new machinery investment versus those without it.

Table 5: Percentage of R&D Expenditures to the Value of Total Inputs

Category	Year		
	1995	2000	2006
Non Exporter	1.05	1.29	0..44
Exporters	0.88	0.87	0.70
No investment in new machinery	1.05	1.23	0.46
With investment in new machinery	0.90	0.92	0.65
No FDI firms	1.02	1.05	0.47
FDI firms	0.72	1.47	0.70
All firms	0.99	1.12	0.49

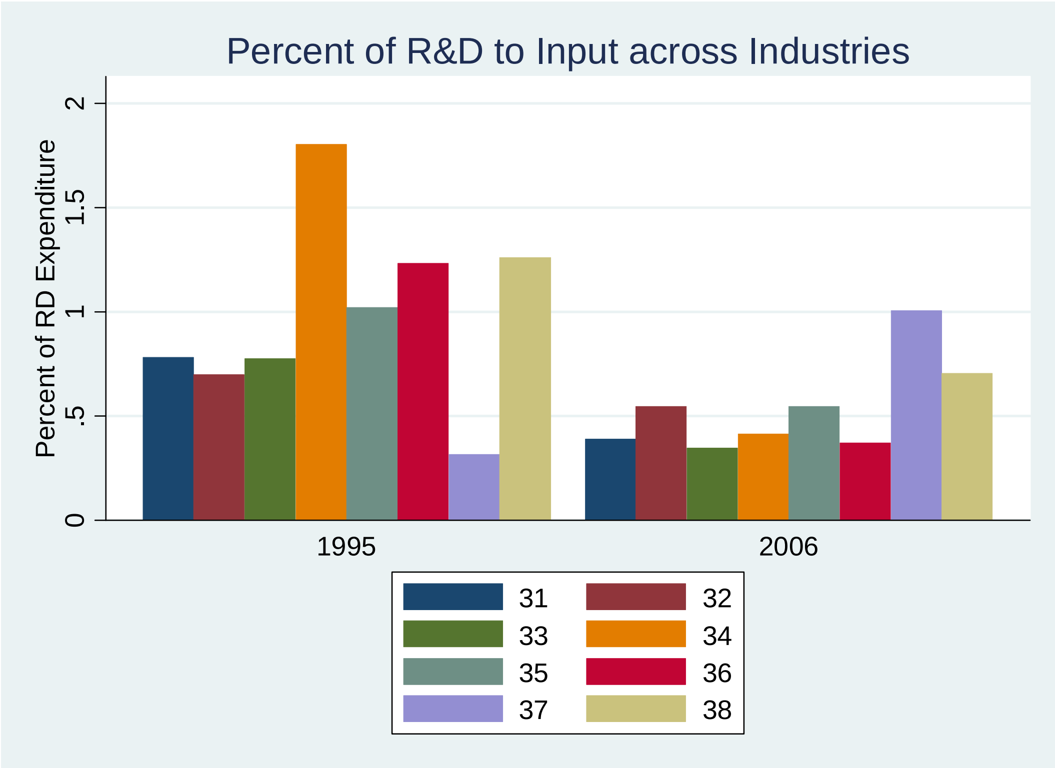
Source: Calculated from the Annual Manufacturing Surveys

<u>R&D Intensity across Manufacturing Branches</u>

The intensity to perform R&D certainly will differ from one industry to another. To provide more detailed pictures across manufacturing we replicate the above observation across two digits ISIC across manufacturing (**Figure 1**).

[4] In our terminology the likelihood to engage in R&D irrespective of how much firms spend on it, while their propensity is the percentage of R&D expenditure to the value if inputs which indicates 'level'.

Figure 1: Percent of R&D to Input across Industries



Overall, the propensity to pursue R&D declined after the Asian crisis. Taking out the outlier from paper (ISIC 34), both basic metal (ISIC 37) and machinery (ISIC 38) have the highest R&D propensity. Still, the figures are low, for example in 2006 none of them exceeds 1 percent. One plausible explanation is that R&D is a risky adventure and the Asian crisis made firms more cautious. The other explanation links the R&D decision to that of new machinery investment since most R&D is done in preparation of installing new machinery/technology. With the same logic, since investing in new machinery in the face of a sluggish economy in the aftermath of the Asian crisis is a risky venture, R&D will also be affected.

Figure 2: Percent of R&D to Input across Industries

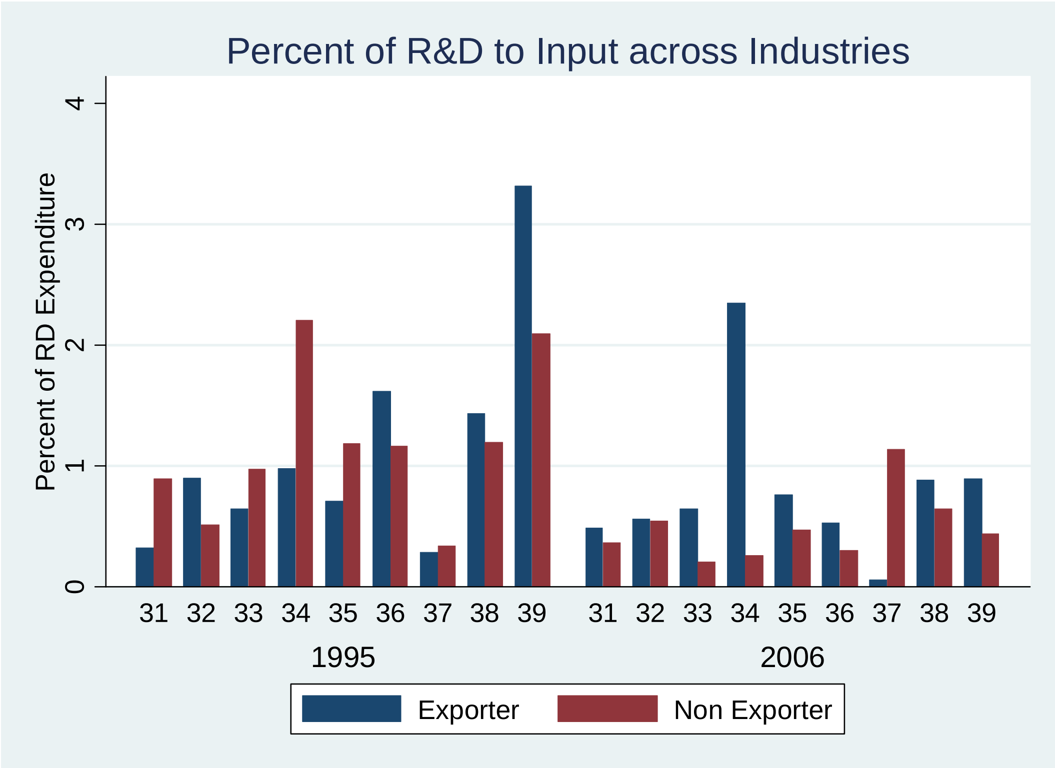
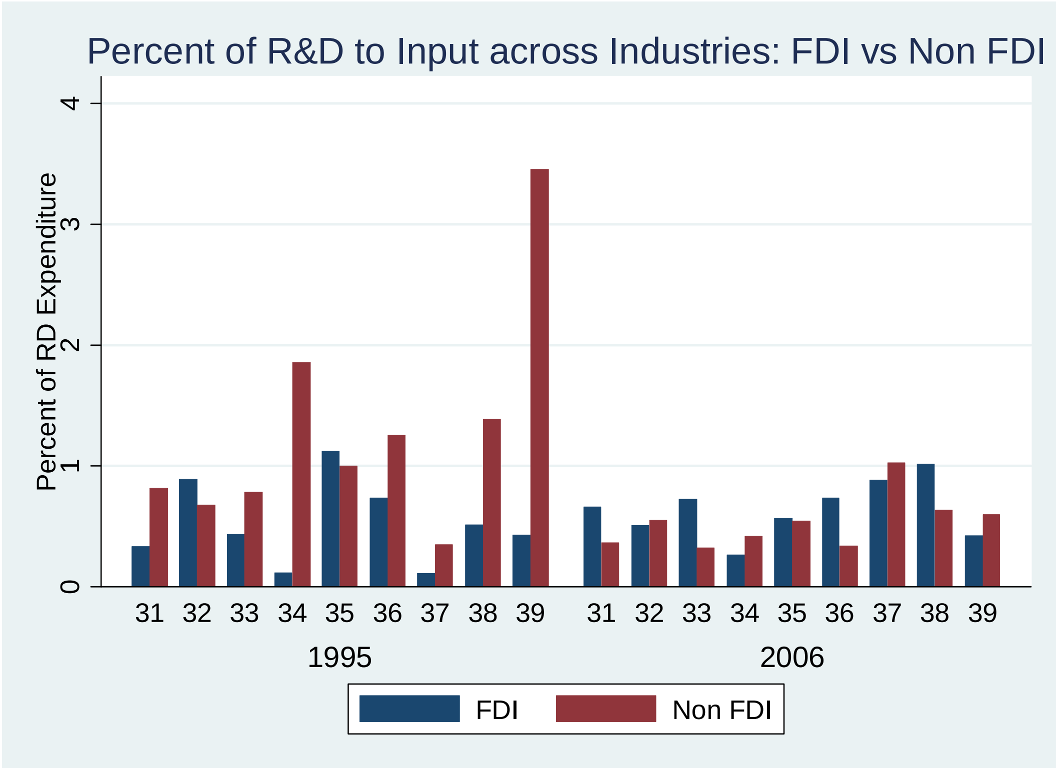


Figure 2 divides the sample into the exporter and non-exporter categories. The decrease of R&D propensity is also observed when comparing 1995 to 2006, but the decrease for exporters is less than non-exporters. In 1995 non-exporters in food (ISIC 31), woods (ISIC 33), paper (ISIC 34), chemicals (ISIC 35) and basic metal (ISIC 39) recorded higher R&D propensities. But the situation is reversed after the crisis. It appears that in the face of increasing uncertainty, exporters facing competition abroad have to maintain a minimum level or intensity of R&D expenditures which happens to be higher than non-exporting firms, otherwise they would lose businesses. One exception is heavily capital-intensive basic metal (ISIC 37) of which steel industry is included. Even when the overall figures are declining between 1995 and 2006, non-exporters have always higher R%D propensity.

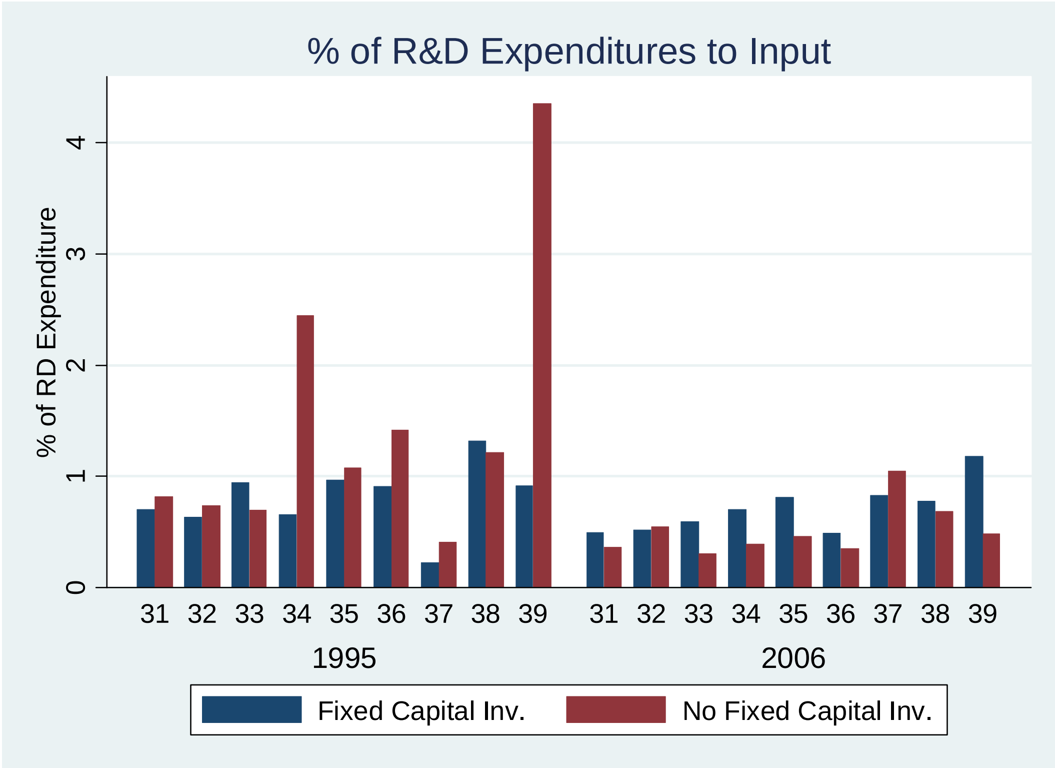
Figure 3: Percent of R&D to Input across Industries: FDI vs Non FDI



When comparing FDI versus non-FDI, there is no apparent consistent discernible pattern (**Figure 3**). For example in 1995 for food (ISIC 31), woods (ISIC 33), paper (ISIC 34), non-metallic (ISIC 36) and machinery (ISIC 38), the R&D propensity is higher for non-FDI firms. This completely reverses in 2006. For the rest the pattern is just the opposite. So the idea that being an FDI firm is a strong driver behind R&D is not as convincing as the case of being exporters. But for this the final conclusion may have to wait for a formal econometric test. In any case this pattern is useful in shaping our conceptual model.

Next we turn to investment in machinery as a prime driver for R&D activities (**Figure 4**). In 1995 the pattern is less clear, but in 2006 with basic metal (ISIC 37) as a clear exception, in almost all other industries, machinery-investing firms tend to have a higher R&D propensity. So in addition to a higher likelihood to engage in R&D (**Table 2**), the level of R&D expenditure is also relatively higher, which indicates a strong case for new machinery investment as a primary reason behind R&D.

Figure 4: Percent of R&D Expenditure to Input



<u>Effective Rate of Protection</u>

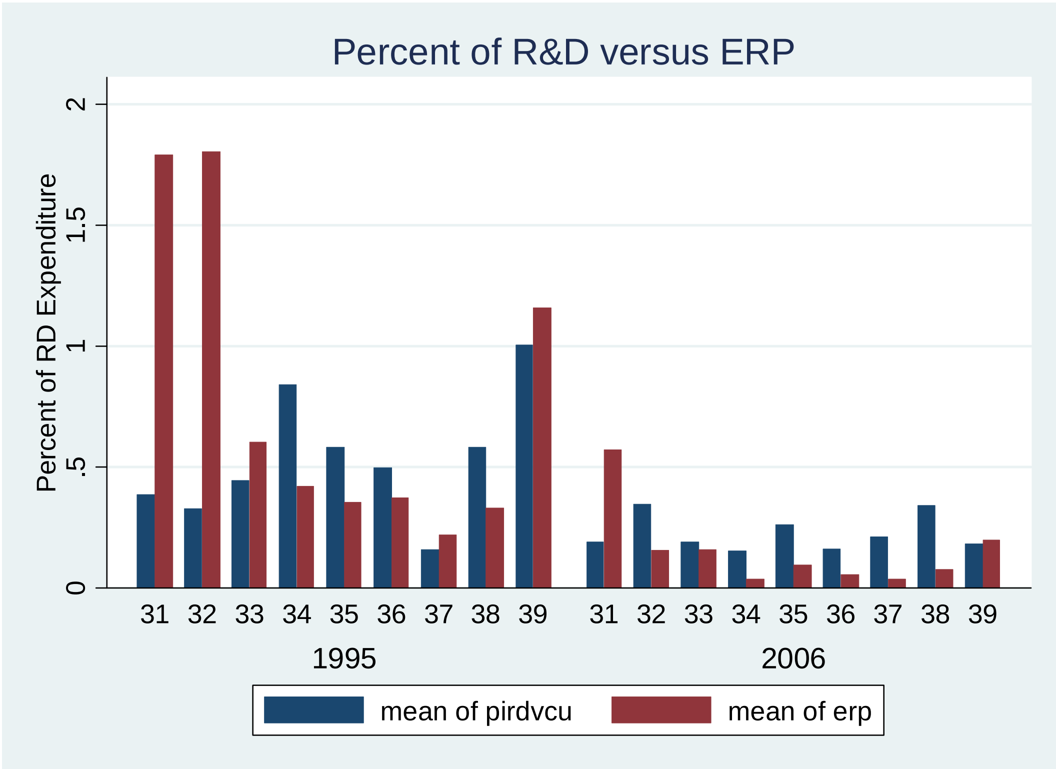
One way for a government to shield certain sectors from global competition is through tariff protection. This barrier will alter industry's relative profitability by creating an artificial price wedge. How the protection will affect R&D is at best ambiguous. If the market is contestable then the extra profit can reinvested in R&D to boost firms' competitiveness in anticipation of the day when the protection is eventually lifted. On the other hand, high artificial profits could also reduce pressure for firms to carry out R&D. Both forces are present in a protected environment but which one is stronger is a matter of empirical analysis.

To measure this we use the concept of the effective rate of protection (ERP) as in Amiti and Konings (2005).

(1) $$erp_{it}^{k} = \frac{(tariff_t^{k} - \alpha_{it}^{k} inputtariff_t^{k})}{(1-\alpha_{it}^{k})}$$

Where α_{it}^{k} is the ratio of inputs to outputs for firm i in industry k at time t. A lower output tariff would decrease the protection enjoyed by industry k, while a lower input tariff would increase the protection received by industry k. To examine the possible relationship between the R&D intensity and ERP, we compare the percent of R&D expenditures in total inputs to ERP in figure 5.

Figure 5: Percent of R&D versus ERP



The overall pattern suggests that the percentage of R&D expenditure declined after the Asian crisis. But one thing is obvious that higher ERP is associated with a lower propensity conducting R&D. So dismantling of protection barrier has positive impact on firms to do R&D to stay competitive. If R&D is tied to new machinery investment then it is more likely directed to upgrade technology to boost competitiveness in the face of increasing competition from abroad.

Information Spillover

Spatial centralization of resources and spatial concentration of manufacturing in a few largest metropolitan areas has been a feature of the modern economy. Centralization of industrial location at least in the early stages, may bring benefits to firms (Hansen, 1990). One important benefit of such agglomeration is that firms conducting R&D can learn from each other, to create a synergy that collectively boosts their average productivity. In this regard there are two types of 'positive' externalities. First is localization; in this respect firms doing R&D learn from their own industry, which in the dynamic form, is often called Marshall-Arrow-Romer (MAR) externalities. Alternatively, firms learn from all firms in a city, where the diversity of local industries enhances the local information environment. This type of externalities is called urbanization or in the dynamic context is termed Jacobs' externalities (Jacobs, 1969).

In the Indonesian context, one important question is which type of externalities is actually stronger for R&D. If externalities are in the form of localization, smaller city are more likely to be the place of R&D activities specializing in just one industry or a closely connected industries. On the other hand if the externalities happen to be urbanization in nature, to thrive R&D activities needs to find a location in a diverse and large urban environment. R&D activities are therefore more likely to be found in large urban areas. Another related question is whether externalities are mainly static or dynamic. If it turns out that externalities are dynamic – this would imply that R&D past activities affect the present productivity, because overtime a particular location would accumulate a large body of knowledge. The implication for R&D is that firms committing resources to do R&D would become more 'static' – tied to a particular industrial agglomeration – and less willing to move to cities where historically R&D has never existed, and thus have no built-up stock of knowledge.

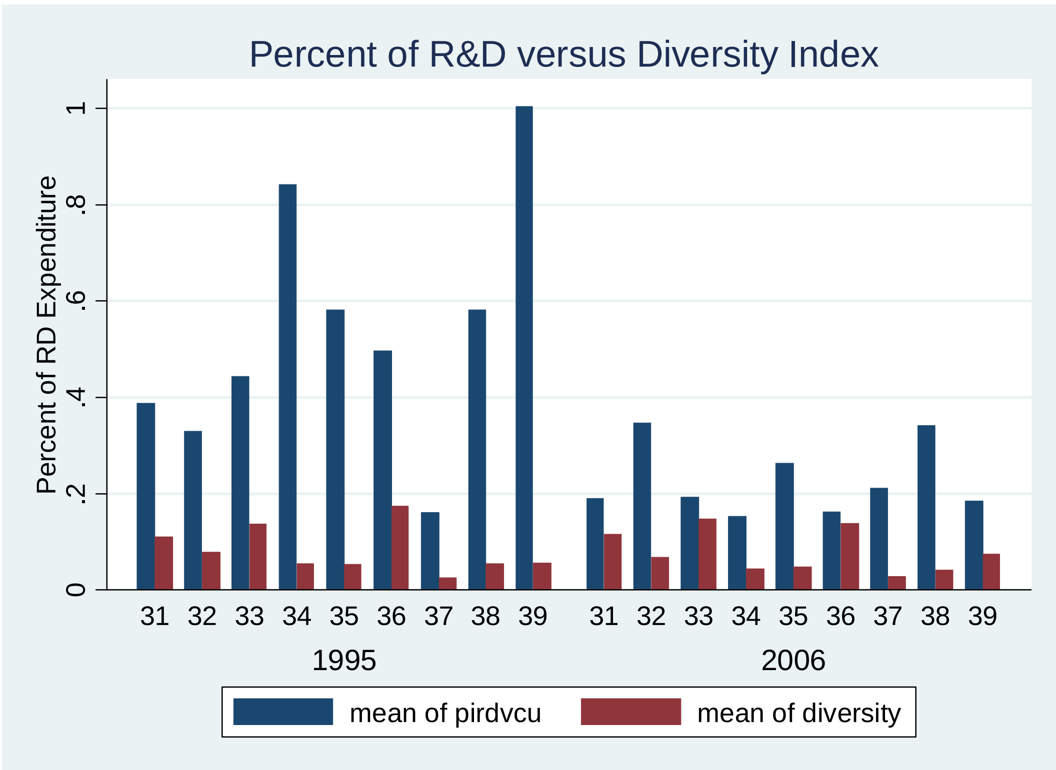
Localization/MAR externalities will be measured by total employment in the own industry in the respective districts. This measure is meant to capture interaction among firms within a district. Urbanization externalities are measured by a diversity index. For district i for example, the index of diversity is

$$(2) \qquad g_i^s = \sum_{j=1}^{J} \left[\frac{E_{ij}(t)}{E_i(t)} - \frac{E_j(t)}{E(t)} \right]^2$$

$E(t)$ is total national manufacturing employment and $E_j(t)$ is total national employment in industry j. Meanwhile, E_i and E_{ij} are the corresponding local magnitudes. The measure of urbanization economies $g^s_i(t)$ has a minimum value of zero, where in a district, each industry's share of local manufacturing employment is exactly the same as its national share, so the district is completely unspecialized because its industrial composition is merely a copy of the nation. At the other end, the maximum value of $g^s_i(t)$ will approach two for a district completely specialized in one industry, while at the same time national employment is concentrated in another industry. The higher is $g^s_i(t)$ the lower is the diversity, thus a district becomes more specialized.

To examine the location pattern of R&D activity we compare the percent of R&D expenditure to the index of diversity given in (2) across industry. For easy comparison we choose the year 1995 and 2006. The result is shown in **Figure 6**.

Figure 6: Percent of R&D versus Diversity Index



Although the pattern is somewhat less clear in 1995, the general relationship is that an industry with a higher R&D percentage tends to locate in a location with a lower diversity index or less specialized location, usually in bigger urban areas with bigger more diversified economies. Since previously it has been asserted that most R&D are directed toward preparation for new machinery investment (**Figure 4),** this type of R&D

may require only general information (capital goods markets, delivery times, general specifications, after sales service and so on) from its industrial surrounding.

3. The Model

The conceptual model is developed in accordance of what was observed in the background analysis that most R&D is presumably geared toward preparation for incoming new machinery and equipment. It is also tailored to accommodate the fact that the Indonesian manufacturing survey is at the establishment or plant level. A firm before pursuing a risky R&D project will examine its long-run profits or cost implications. From the economic theory we know that the existence of a duality between profit and cost optimization would allow us to derive demand for factors of production of which R&D is a crucial input.[5]

After an investment decision to improve machinery and equipment is made, the necessary R&D activities are determined. For this, we rely on the concept of the knowledge production function where R&D expenditure is related positively to innovations (Crepon and Duguet, 1997) and the learning by doing model (Romer, 1996) where innovations are learned from and are separable from the ongoing (constant return) production process.

First we assume that there is a relationship between innovation (n) and R&D activities (R) in the following knowledge production function

(3) $n = n(R)$, where dn/dR>0 or a positive relationship exists between *n* and *R*.

Output, *Y*, is assumed to follow a general function

(4) $Y = Y(K, L, n)$

where *K* is capital stock, *L* is labor and *n* are the number innovation. Substituting (3) into (4) we have

(5) $Y = Y(K, L, R)$

[5] The conceptual model has undergone major revision in order to accommodate the suggestion that plant productivity should have an impact on R&D activities. Also the decision to carry out R&D has been restructured to account for concern that the choice model is not different from the location choice. Now the choice for R&D is treated more explicitly.

R&D is separable from the ongoing (constant return) production process. R&D is modeled as a shift factor in the production function. If a firm chooses to carry out R&D then it will add to its stock of knowledge *B*. By assuming a constant return to scale technology for *K* and *L* in the production function, the appropriate form of this setup is given by

(6) $Y = B^{\theta} K^{\alpha} L^{1-\alpha} R^{\theta D}$

With this specification the excess (super normal) profit function is defined by

(7) $\Pi = P.Y - \pi^{*}$

where π^{*} is reservation profit which is assumed to be affected by factors that are considered when choosing R&D projects such as the nature of the local agglomeration including its industrial diversity (g) and own industry employment (e) which capture technological information spillover as well as ERP) as a general measure of average profitability.[6] This also includes firm characteristics. R&D projects are risky undertakings, to account for different degree of risk aversion among different types of firm, firm characteristics such as being an exporter (ex) and/or an FDI are also included.[7]

In (7) an increase in π^{*} would reduce Π so $\Pi_{\pi^{*}} < 0$ which would lower the incentive to engage in R&D. Meanwhile the reservation profit is given by

(8) $\pi^{*} = \pi^{*}(g, e, ERP, ex, fdi)$

The relationship between π^{*} and ERP cannot be determined *a priori*, an artificial increase in profitability because of higher protection may make firms 'too lazy' to pursue R&D. In another case a foresighted firm may reinvest these profits in R&D in anticipation that tariff barrier will come down in the future, so $\Pi_{ERP} \gtreqless 0$. The relationship between the reservation profit and the nature of agglomeration (g and e) is also ambiguous. It is up to the empirical exercise to determine the direction of these relationships. Due to their outward orientation, exporters and FDI firms are presumably

[6] So essentially excess profit is before labor, capital and material costs.

[7] This will allow us to incorporate firm characteristics in the choice carrying out R&D project or not to represent different degree of risk aversion.

less risk-averse and thus have lower reservation profits compared to non-FDI and non-exporters, so $\pi^*_{ex} < 0$ and $\pi^*_{fdi} < 0$.

In equation (6) D is a dichotomous variable with the value of one if the excess or super normal profit Π from undertaking an R&D project is greater or equal to zero or Π≥0 and having the value of zero otherwise or if Π<0.[8] If a firm chooses to undertake an R&D project then the production process will follow

(9) $Y = K^{\alpha} L^{1-\alpha} (BR)^{\theta}$.

In (9) the impact of B and R on Y is given by the parameter θ, which is not constrained so as to allow for decreasing, constant or increasing return of knowledge and R&D in the production. If a firm opts not to purse R&D because of profitability or cost concerns then the production will follow

(10) $Y = B^{\theta} K^{\alpha} L^{1-\alpha}$

which means a firm will use only the existing stock of knowledge. The per capita or intensive form of (9) is given by

(11) $y = \frac{Y}{L} = \left(\frac{K}{L}\right)^{\alpha} (BR)^{\theta} = k^{\alpha} (BR)^{\theta}$

where y is output per unit of labor Y/L and k=(K/L) is capital-labor ratio. .

A firm will choose a level of R&D, R, as to optimize the capital and labor costs plus R&D expenditure $C = rK + wL + R$, with the excess normal profit Π≥0 as a constraint, where r is price of capital and, w is wage rate. The conditional input demand function for R&D is then given by

(12) $R = R(r^*, \frac{Y}{L}, \pi^*(g, e, ERP, ex, fdi))$

If a firm chooses to realize (12) by committing resources to perform R&D this is because the excess normal profit requirement Π≥0 is met. Or alternatively it will not spend on R&D if it is unprofitable or too costly or if Π<0. In this case there will be no R&D activities or R = 0. In (12) r^* is price capital normalized by wages w. In this specification, y or Y/L can be interpreted as labor productivity so one can assess its

[8] Compared to the earlier version, the choices are much simplified. Rather than having to choose one among many alternatives we now have a yes or no decision.

impact on R&D activities R, that is to say, whether firms with higher labor productivity would have higher R&D intensity.

There is no specific 'price' for R to allow some flexibility of whether R&D is tied to capital or labor. The property of strict concavity of (5) is sufficient to establish that the negative relationship between r^*=r/w and R in equation (9) does exist. Empirically, this is a testable hypothesis which can be confronted with estimation results from the data sets.[9] Also the same property establishes positive relationship between R&D and output per labor.

In (12) the impacts of being exporters and being an FDI firm on performing R&D activities are given respectively by

$$(13) \qquad \frac{\partial R}{\partial ex} = \Pi_{\pi^*} \pi^*_{ex} > 0$$

and

$$(14) \qquad \frac{\partial R}{\partial fdi} = \Pi_{\pi^*} \pi^*_{fdi} > 0$$

So being less risk-averse, exporters and FDI firms are more likely to engage in R&D. The signs of other variables in (12) cannot be judged *a priori* – these will be determined by the empirical models.

Instead of innovations per se we now have R&D expenditure as the crucial input in the innovation process in the form of a conditional input-demand function.[10] The reservation profit π^* incorporates globalization variables and other firm-industry characteristics which will enable us to assess the impact of those variables on R&D and indirectly on innovations employing their presumed correspondence suggested above. The estimating version of equation (12) is therefore

$$(15) \qquad R_{it} = \delta_0 + \delta_1 (\frac{r}{w})_{it} + \delta_2 (\frac{Y}{L})_{it} + \delta_3 I_{it} + \Delta G_{it} + \Omega F_{it} + u_{it}$$

Where I is a dummy variable relating to whether a firm is investing in new machinery/equipment or not, G and F are vectors of globalization and location-industry level variables respectively. Variables representing G are being an exporter, being an

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[9] Interest rate r is calculated by dividing the amount of interest payment to total assets, while wages are constructed by dividing the total payroll for production workers with the total number of production workers.

[10] Instead of observing the count of innovations, we look at innovation-generating activity, namely R&D.

FDI versus non-FDI and ERP.[11] The vector F includes the diversity index g and own-industry employment. Equation (15) can be estimated directly, lumping together all variables affecting the decision to undertake R&D as well as the decision determining R&D intensity. But if one wants to mimic a dichotomous choice i.e. to undertake R&D or not depending on whether $\Pi \geq 0$ or $\Pi < 0$, the Heckman procedure can also be used.

4. Empirical Results

The estimation results of equation (15) are shown in **Table 6**. In the first two columns are the ordinary least squares method (OLS) applied to pooled data of the years 1995, 1997, 1999, 2000 and 2006. The difference between the first column and the second is that in the latter all variables supposedly affecting the reservation profit π^* are included and also the ratio of interest rate to wages is replaced with a dummy ind whether a firm committing new machinery investment or not as a direct test indicating whether R&D activities are tied to machinery investment. Finally the last two columns present the results of the two stage least squares – instrumental variables (2SLS-IV) estimation. All standard errors are clustered in a respective district. By construction output per labor in equation (11) is endogenous, thus output per labor in (12) and (15) is also exogenous. For the instrument we use the district average of firms' output.

Overall output per labor or labor productivity is positive and significant at least at the 10 percent level so labor productivity is an important determinant in R&D activities. In the model 1 of the OLS specification the coefficient of the ratio of interest rates to wages is negative and significant at the 5 percent level.[12] So there is an indication that R&D is tied to the acquisition of capital goods. If the relative price of capital goes up then it will have a negative impact not only on capital but also on R&D expenditures.

In model 1 the globalization variable is ERP is significant at the 5 percent level though the coefficient is small. The sign is negative which implies that lowering

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[11] The exporter dummy is equal to one if a firm exports at least 2 percent its total output and zero otherwise. The FDI dummy is defined as equal to one if the share of foreign equity is at least 10 percent.

[12] We experiment with the Tobit procedure but it is very weak statistically because not many firms are carrying out R&D.

protection would induce firms to increase R&D expenditure. The coefficients of other globalization variables FDI and exporter dummies are positive, confirming the prediction given by (13) and (14), and also significant albeit at different levels of which the later is stronger statistically.

Turning to model 2 of the OLS specification, the most significant variable is the new investment dummy – signifying that the most important factor behind R&D in Indonesia is new investment in machinery and equipment. The exporter dummy retains its significant but the FDI dummy is now insignificant. So being exporters have stronger drive to carry out R&D compared to FDI firms.

Table 6: Determinants of R&D Expenditure: 1995-2006

Covariates	OLS		2SLS	
	Model I	**Model II**	**Model I**	**Model II**
Output per labor	0.027	0.018	0.384	0.174
	*[1.76]	**[2.25]	*[1.67]	*[1.70]
Ratio interest rate to wages	-1.11		-0.376	
	**[-2.38]		[-1.06]	
FDI Dummy	0.037	0.015	-0.032	-0.018
	*[1..63]	[1.10]	[-0.58]	[-0.57]
Exporter Dummy	0.036	0.025	0.018	0.020
	**[2.80]	**[2.93]	**[2.67]	**[3.31]
Effective Rate of Protection	-0.00001	-0.00003	-0.00001	-0.00004
	**[-2.99]	[-1.25]	[-0.83]	[-1.21]
New Investment in Machinery		0.043		0.036
		**[3.34]		**[3.71]
Local Manufacturing Diversity		-0.017		-0.012
(5 years Lag)		**[-2.47]		**[-1.99]
Manufacturing Employment		0.000		0.000
(5 years lag)		[-0.13]		[-0.95]
Industrial Dummies	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
F-value	**3.29	**10.26		
Wald Chi-Square			**55.09	**73.14
Number of Observation	73706	73706	73706	73706

Notes: Figures in parentheses are-test.
* *:* Significant at the 10 percent level.
***:* Significant at the 5 percent level.

The ERP variable presents both in the model 1 and model 2 as to reflect the situation that it may not only represent long-run (reservation) profits but also affecting day to day operation especially when it comes to determine the level of R&D. It turns out that ERP is not significant in model 2. Its effect may be swept away by the presence of the new investment dummy of which most machinery is imported from abroad. This suggests that from all globalization variables in the model, the exporter dummy is the most robust. It survives different specifications as well as different estimation procedures.

The diversity index is negative and significant at the 5 percent level. R&D activities are higher in less specialized agglomerations usually in big urban areas – confirming the notion that most R&D activities require more general market information rather than industry-specific knowledge. The lag of own industry employment is not significant, suggesting that specialization of R&D activities in smaller cities is not a common phenomenon. Since the diversity index is also in the lagged form, these externalities are dynamic, so it is not easy to relocate the present R&D activities to non urban locations where historically they do not exist.

In the 2SLS-IV specification, output per labor is statistically weaker but still significant - reflecting the problem of finding good instruments with high predictive power but orthogonal to the error terms. One interesting finding is that the coefficient of labor productivity is now larger. The productivity effect on R&D is larger after the endogenous output per labor is taken care of.

The ratio of interest rates to wages is insignificant now although the sign remains negative as before. The exporter dummy is still significant (model 1 of 2SLS-IV) with a little smaller coefficient. ERP is not significant now, confirming that as a globalization variable ERP, like the FDI dummy is not as statistically robust as exporter dummy.

<u>Selectivity of R&D Activities</u>

In the Heckman procedure we estimate equation (11) explicitly acknowledging the decision that has to be made by a firm concerning R&D – whether to undertake R&D or not (incidence of R&D) and, if so, how much it is willing to spend on it (R&D intensity). The results are presented in **Table 7**.

Table 7: Selectivity of R&D Activity: 1995-2006 (Heckman Procedure)

Covariates	Model 1		Model 2	
	Continuous	Selection	Continuous	Selection
Output per labor	0.792	0.014	0.799	0.020
	**[2.05]	*[1.74]	**[1.97]	**[2.49]
Ratio interest rate to wages	-34.85		-25.81	
	[-1.28]		[-1.14]	
FDI Dummy	0.008	0.105	0.010	0.088
	[0.05]	*[1.74]	[0.07]	**[2.14]
Exporter Dummy	0.096	0.431	0.057	0.465
	[1.43]	**[11.97]	[1.35]	**[14.10]
Effective Rate of Protection		-0.0002	]	-0.0002
		**[-2.21]		*[-1.74]
New Investment in Machinery		0.650		0.633
		**[18.64]		**[19.86]
Local Manufacturing Diversity		-0.403		-0.337
(5 years Lag)		**[-2.40]		**[-2.27]
Manufacturing Employment		0.000		0.00001
(5 years lag)		[0.83]		**[3.00]
Industrial Dummies			Yes	Yes
Time Dummies			Yes	Yes
Mill-ratio	-0.073		-0.067	
	**[-5.86]		**[-6.33]	
Wald Chi-Square	**9.93		**57.68	
Number of Observation	107138		107138	

Notes: Figures in parentheses are-test.
* *:* Significant at the 10 percent level.
***:* Significant at the 5 percent level.

In the selection (incidence of R&D) equation we include variables that affect reservation profits π^* such as a new machinery investment dummy, a diversity index, own industry employment, and EPR, along with the usual FDI and exporter dummies and output per labor. In the continuous equation the usual conditional input demand function is used where output per labor and the ratio of interest rate to wages are the main variables along with other control variables such as FDI and exporter dummies.

The inverse of Mill's ratio is strongly significant in both models, which implies that performing R&D is not a random event. There is self-selection for firms devoting resources to R&D. The difference between model 1 and model 2 is that in the former it does not have industry and time dummies. But so far the models are robust to the inclusion or exclusion of industry and time fixed effects.

Fulfilling the requirement for the conditional input-demand function set up, output per labor is significant in the continuous equation in both models. The ratio of interest rate to wages, however, is not significant though the sign conforms with the theory (negative). Neither of the exporter and the FDI dummies in the continuous equation is significant, suggesting that once an R&D decision is made R&D intensity in the day to day operation is not influenced by firm types. This is akin to short-run versus long run investment. Since R&D is tied to sunk-capital so once it is made it will bring the consequence of R&D spending before and presumably even after installation of the machinery.

In the selection equation, the ratio of interest rate to wages is replaced by a dummy of new machinery investment. The coefficient of output per labor is strongly significant in both models. So firms with higher labor productivity have higher probability to perform R&D.

Unlike in the continuous equation where they do not affect the level of R&D expenditures, the likelihood of firms undertaking R&D is now strongly influenced by whether or not they are FDI firms or exporters or not. The other globalization variable, ERP, is negatively related to the probability of carrying out R&D, though statistically it is somewhat weaker than the exporter dummy.

The lag of the diversity index is statistically very strong and has a negative sign. This suggests that R&D activities are more likely to be found in less specialized agglomerations. The result for the lag of own industry employment is mixed. It is insignificant in model 1 where the dummy for new machinery investment does not appear. In model 2 it is significantly positive. Certainly there is some degree of co-linearity between these two but it still within a tolerable limit.

The most significant variable so far is the dummy for new machinery investment which signifies the most important motive behind commitment to R&D as asserted in the background analysis.

Spillover of the FDI Presence on Domestic Firms' R&D

It is asserted in the background analysis that the presence of FDI firms may have little impact on R&D. In this section we pursue this issue a little further by explicitly constructing a variable to capture FDI spillover. We experiment with two alternative indicators.[13] The first is the number of FDI firms in a particular location. In the second experiment, a diversity index is constructed exclusively for FDI firms, and added to the model in place of the number of FDI firms in a district. One after another, these variables are then put as a covariate in the regression of the conditional input demand function for R&D where the sample is exclusively restricted to non FDI firms. The results of the application of the Heckman procedure for this sample of domestic firms are shown in **Table 8**.

Table 8. Impact of the Presence of FDI Firms on Domestic Firms R&D (Heckman)

Covariates	Model 1		Model 2	
	Continuous	Selection	Continuous	Selection
Output	0.002 **[1.94]	0.0001 **[3.27]	0.002 **[1.94]	0.0001 **[3.05]
Ratio interest rate to wages	-19.18 [-1.00]		-17.22 [-0.95]	
Exporter Dummy	-0.021 [-0.37]	0.495 **[13.95]	-0.022 [-0.40]	0.490 **[13.83]
Effective Rate of Protection		-0.0002 **[-0.62]		-0.0002 [-0.37]
New Investment in Machinery		0.637 **[18.96]		0.634 **[19.15]
The number of FDI firms in a district	-0.001 [-1.03]	0.001 [1.40]		
Local diversity index of FDI firms				0.088 **[2.67]
Industrial Dummies	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
Mill-ratio	-0.063 **[-2.59]		-0.060 **[-2.41]	
Wald Chi-Square	**66.96		**69.16	
Number of Observation	104347		104347	

Notes: Figures in parentheses are-test.
* : significant at the 10 percent level.
**: significant at the 5 percent level.

Overall, the results are weaker than the full sample but they are still plausible statistically. The results for the crucial variables validating the equation as a conditional input-demand function, output per labor and the ratio of interest rates to wages are mixed. The coefficient of output per labor is positive and significant at the 5 percent

[13] We actually experiment with two other variables namely the share of value added of FDI firms and the share of FDI firms' workers in a particular district but both results are weak statistically.

level. The ratio of interest rates to wages has the right negative sign but it is insignificant. Obviously removing FDI firms from the sample weakens its statistical power.

None of the variables representing the presence of FDI firms matters in the continuous equation. In the selection equation only the diversity index of FDI firms is significant with a positive coefficient. The higher the FDI diversity index, the more specialized a location is with FDI firms from one particular industry. Only then will FDI firms have impact on R&D. However, this impact is limited to the incidence of R&D, but does not affect the intensity of the activities. The significance of this variable suggests that there is a critical mass of FDI firms in a location or in an agglomeration below which the impact of FDI firms, at least on the incidence of R&D at domestic firms is very small.

In this case the avenue through which FDI firms impact domestic firms' R&D could be through the force of competition or workers' movement in a locality or both. The limited impact of FDI firms on domestic firms' R&D can be explained by the circumstance that most of the FDI firms' R&D may have been performed in their home countries. Machinery and equipment may also have been standardized throughout their plants around the world, so not much specific information about capital goods technology can be exploited by domestic firms to produce a significant technological improvement.

Impact of R&D on Labor Productivity

The setting up of the model suggests that the causal relationship between R&D and labor productivity is bi-directional. R&D is modeled as a conditional input demand function from a constant-return production process which is estimated empirically. The results confirm that where output per labor affects R&D positively. So firms with higher labor productivity have higher R&D intensity. But by a construction, the intensive form of the production function in (9) also makes the direction of relationship to reverse. For this purpose we estimate (9) empirically. The results are presented in Table 9.

Table 9: Determinants of (log) Output per Labor Unit: 1995-2006

Covariates	OLS		2SLS	
	Model I	Model II	Model I	Model II
Log of Capital per Labor Unit	0.233	0.185	0.227	0.174
	**[18.09]	**[14.07]	**[17.54]	*[1.70]
Log of R & D Expenditure	1.971	1.401	6.211	4.375
	**[10.97]	**[10.42]	**[2.13]	*[1.95]
FDI Dummy		1.010		0.937
		**[14.91]		**[11.65]
Exporter Dummy		0.603		0.567
		**[13.53]		**[11.00]
Industrial Dummies	No	Yes	No	Yes
Time Dummies	No	Yes	No	Yes
Prob>F or Prob>Chi-Squared	**0.000	**0.000	**0.000	**0.000
R-Squared	0.227	0.349	0.177	0.325
Number of Observation	75109	75109	75109	75109

Notes: Figures in parentheses are-test.
* : Significant at the 10 percent level.
**: Significant at the 5 percent level.

In the first two columns the model is estimated with and without controlling for firm characteristics, industry and time dummies, ignoring the potential endogeneity of R&D. In the last two columns the 2SLS procedure is applied to account for this problem. For the instrument the district average of R&D expenditure is used. The coefficient of (log) R&D is always positive and significant. The coefficient of (log) R&D is positive, larger and always significant, though a little weak statistically when 2SLS specification is controlled for firm characteristics and industry-time dummies, which implies that R&D activities drive firms to become more productive. Therefore, the relationship between R&D and labor productivity is indeed bi-directional. The coefficient of (log) capital labor ratio suggests that the output elasticity with respect to capital is around 0.20.

5. Conclusion and Policy Relevance

In this paper we examine the impact of globalization on innovation in Indonesian manufacturing. One important contribution of this study is its method in dealing with the situation when the innovation data are very rudimentary. The lack of innovation data in the manufacturing survey has necessitated the use of R&D expenditure as an input in the innovation production function. Globalization is represented by being exporters, being FDI firms and the effective rate of protection (EPR). One caveat in this study is that globalization is treated as exogenous factor. The situation where firms can learns through R&D to become more productive so that they can enter the global export market is completely abstracted from and it is left for future research.

The model is set up such that within the concept of a conditional input demand function where it allows labor productivity to have impact on R&D. In this case we find that less productive firms are less likely to venture on R&D activities. The reverse causality is also true; namely firms with higher R&D intensity tend to be more productive.

In terms of globalization variables we find that being exporters is an important determinant of R&D. However, the impact of FDI firms on domestic R&D is only on the incidence but not on the intensity of R&D. It requires a critical mass of firms within a location or an agglomeration to have a meaningful impact. But the main motivation to engage in R&D is in preparation for the installation of new machinery and equipment. Through this avenue the impact of globalization may come indirectly from the desire of firms to remain competitive, by upgrading their machinery and equipment.

Also a lower ERP would induce firms to spend more on R&D. So lowering protection or trade barriers and maintaining openness will have positive impact on R&D. Despite the fact that trade barriers are trending downward many hurdles remain which continue to inhibit the flows of trade and investment. Two most important problems are the corruption and inefficiency of national customs and ports. The "national single window policy" and the establishment of Corruption Eradication Committee (KPK) would reduce corruption and bureaucratic inefficiency. But improving ports' efficiency would require substantial investment which cannot be done by the private sector alone.

With regard to information spillover R&D activities are more likely to be found in less specialized industrial or economic agglomerations presumably in larger and diverse urban areas but not in smaller cities. This is consistent with the earlier finding that the primary motivation for R&D in Indonesia is for adaptation, accommodation and perhaps some modification of new machinery and equipment to meet operational conditions in Indonesia, so the type of information needed is general and is not a specific to consumer needs. One policy implication from this is to maximize the gains from the current configuration of industrial agglomeration and minimizing the negative externalities by improving the connectivity between agglomerations.

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