DO INNOVATION BARRIERS DRIVE A FIRM TO ADOPT OPEN INNOVATION? INDONESIAN FIRMS' EXPERIENCES

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ABSTRACT

Although previous studies on innovation barriers have been conducted, in the context of Indonesian firms, the studies that link innovation barriers to open innovation practices that consist of external knowledge search breadth and depth do not exist. Hence, this study intends to narrow this gap by using innovation data derived from Indonesia Innovation Survey.

This study sheds the light on how Indonesian firms' source external knowledge widely and deeply as a response to different innovation barriers. Barriers to innovation can be grouped into market and institution, employee and organization attitudes, financial and risk, and knowledge and cooperation. Of the four innovation barriers groups, only barriers related to employee and organization attitudes are positively and significantly influence both external search breadth and depth. Smaller firms are more likely to use breadth of openness in their innovation than larger firms. Exporters tend to use depth of openness in innovation when they face innovation constraints. Lastly, the implication for both theoretical and practical from this study is discussed.

Keywords: Innovation Barriers, Open Innovation, Emerging Economy, Indonesia.

INTRODUCTION

Since the term Open Innovation (OI) was coined, it has gained a strong increase in scholarly attention. Although previous studies on OI have been conducted extensively, however, existing studies that link innovation barriers to OI in developing countries context are relatively scarce, with the exception studies performed by Fu et al. (2014) and Savitskaya et al. (2010). Fu et al. (2014) argue that the most important questions for firms in developing countries are why and when firms should implement OI practices. One of the reasons for firms in developing economies to adopt OI practices is that such practice is natural choice for firms in emerging countries to overcome constraints to innovation (Fu et al., 2014).

In the context of developed economy (i.e. Switzerland), using "*exploration-exploitation*" dichotomy as theoretical framework, Keupp & Gassmann (2009) studied how barriers to innovation influence the breadth and depth of OI. While, in an emerging country context, i.e. China, Fu et al. (2014) use "*push-pull*" framework to link innovation barriers to OI. This study aims to extend these studies by using Indonesia Innovation Survey (IIS) 2011 data that covers innovation activities performed by Indonesian manufacturing firms during 2009-2010. Following Laursen & Salter's (2006) study, OI practices in this study consist of the width sources of external information (breadth) and the depth sources of external information (depth) use for innovation.

In the case of Indonesian firms, currently, very few insight on OI studies that use data from innovation survey, with the exception a study that investigates the impact of OI on

innovation performance (Hartono & Kusumawardhani, 2018). Hence, empirical evidence on what innovation barriers faced by Indonesian firms and its linkage on OI practices remain unexplored. This study attempts to narrow this research gap. The research question that is addressed "*To what extent innovation barriers experienced by Indonesian manufacturing firms influence external knowledge search breadth and depth*?"

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Innovation Barriers: Indonesian Firms Context

According to Dahlander & Gann (2010), a starting point for the idea of firm openness is that "*a single organization cannot innovate in isolation*" and hence, firms should engage with different external partners to absorb knowledge and resources beyond the firm boundary to win competition (Chesbrough, 2006; Laursen & Salter, 2006). OI is defined as "*the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the market for external use of innovation*" (Chesbrough, 2006). Internal and external factors may drive firms to open up their innovation process. In this study, drivers of OI are linked to any internal and external factors that hamper firms' innovation activities. Following Fu et al. (2014), this study uses "*push-pull*" factor framework to explain internal and external barriers that motivate firms to adopt OI.

A variety of internal barriers may "*push*" firms to open up the innovation process. For example, internal barriers faced by Swiss firms consist of information-and capability-related barriers and risk-related barriers (Keupp & Gassmann, 2009). In the same vein, internal barriers of Chinese manufacturing firms are divided into financial- and risk-related barriers and knowledge- and skill-related barriers (Fu et al., 2014). While "*pull*" factors external to firms are also varies such as pressure and change from external environment; availability of skilled workers, knowledge, or venture capital; greater competition intensity (Chesbrough, 2006); technology intensity and fusion (Gassmann, 2006); knowledge transfer and leveraging of spillovers (Chesbrough et al., 2006; De Bondt, 1997), and partner advantages (Hagedoorn, 2002) that motivate firms to externalize their R&D activities beyond firm boundary.

In the case of Indonesia, based on Indonesia Innovation Survey (IIS) 2011 data, a previous study has grouped innovation barriers into internal (i.e. *financial- and risk-related barriers*; *employee-and organization attitudes-related barriers*; and *knowledge-and cooperation-related barriers*) and external (i.e. *market-and institution-related barriers*) (Hartono, 2017). This study also employed similar groups of innovation barriers to measure the impact of innovation barriers on OI practices.

Innovation Barriers and OI Practices

Any factors that hamper, delay or block innovation are known as innovation barriers (Hueske & Guenther, 2015). Other scholars, Sandberg & Stenroos (2014) define an innovation barrier as "*an issue that either prevents or hampers innovative activities in the firm*". The majority of innovation barrier literature discusses the influence of financial constraints on innovation performance (Canepa & Stoneman, 2002:2007; Efthyvoulou & Vahter, 2013; Mohnen et al., 2008; Savignac, 2006) and the factors influencing perceptions of constraints (Baldwin & Lin, 2002; Galia & Legros, 2004; Iammarino et al., 2007). However, only a few existing studies that link innovation barriers to OI practices. Previous studies tend to link

externalization of R&D activities beyond the boundary of the firm to various firm-external factors such as partner advantages (Hagedoorn, 2002), spillovers (De Bondt, 1997), or environmental pressures (Belderbos et al., 2004).

Previous studies in the context of developed and emerging economies show that there are positive and significant associations between different constraints to innovation and OI. Using large-scale panel data of Swiss Innovation Survey, Keupp & Gassmann (2009) investigate how impediments to innovation influence the breadth and depth of OI. They grouped innovation barriers into information-and capabilities-related impediments and risk-related impediments. They found that both innovation barriers groups positively and significantly influence both the breadth and depth of OI. Using similar innovation survey data (i.e. Swiss Innovation Survey), Garriga et al. (2013) found that constraints related to firms' resources positively affect external search breadth and negatively affect external search depth.

In an emerging country context, using Chinese firm-level survey of the manufacturing sector, Fu et al. (2014) examine the determinants of OI as a response to the constraints and risks of innovation. They grouped constraints to innovation into finance/risk, knowledge/skills, and institute/market. Their study shows that Chinese firms that suffer from the three groups of innovation barriers are more likely to engage with OI in greater breadth and depth. However, the strength such response varies across ownership types, firm size, and technology intensity. Fu et al. (2014) argue that OI is a natural choice for firms in emerging countries that tend face substantial institutional, resources, and capability constraints in innovation than firms operating in developed economies. Based on the four innovation barrier groups from our previous study, hence, the following hypotheses are proposed:

Market and institution-related barriers deal with external environment of the firms. Previous studies also have classified innovation constraints related to external environment (Hadjimanolis, 1999; Madrid-Guijarro et al., 2009). However, the studies did not link innovation constraints to open innovation. A relevant study that links market and institution barriers with external search breadth and depth was conducted by Fu et al. (2014). The study shows that both market and institution positively affect the adoption of breadth and depth of OI of Chinese firms. While in the case of Indonesian firms, there is no insight in relation to such linkage. Hence the following exploratory hypotheses can be proposed:

H_{1a}: The firms that face greater level of market- and institution-related barriers, they are more likely to adopt the breadth of OI.

H_{1b}: The firms that face greater level of market- and institution-related barriers, they are more likely to adopt the depth of OI.

Financial and risk-related barriers are common constraints revealed by many innovation studies. These types of innovation barriers positively affect both the breadth and depth of OI (Fu et al., 2014; Keupp & Gassmann, 2009). Hence, this study proposed the following hypotheses:

H_{2a}: The firms that face greater level of financial- and risk-related barriers, they are more likely to adopt the breadth of OI.

H_{2b}: The firms that face greater level of financial- and risk-related barriers, they are more likely to adopt the depth of OI.

Employee-and organization attitudes-related barriers cover issues on staff and manager resistance to innovation and organizational rigidity. Although this type of barrier also emerged in previous studies (Hewitt-Dundas, 2006; Madrid-Guijarro et al., 2009; Zwick, 2002), however, there is no insight on the linkage between the barriers and OI practices. Hence, exploratory hypotheses can be formulated:

H_{3a}: The firms that face greater level of employee-and organization attitudes-related barriers, they are more likely to adopt the breadth of OI.

H_{3b}: The firms that face greater level of employee-and organization attitudes-related barriers, they are more likely to adopt the depth of OI.

The last group of barriers is related to knowledge and cooperation such as lack of: qualified personnel, information on technology and market, and cooperation activities. This type of barriers is relevant to firms' resources. Previous studies that link this barriers to OI practices reveal positive and significant relationship (Fu et al., 2014; Garriga et al., 2013; Keupp & Gassmann, 2009). Hence, the following hypotheses are proposed:

H_{4a}: The firms that face greater level of knowledge- and cooperation-related barriers, they are more likely to adopt the breadth of OI.

H_{4b}: The firms that face greater level of knowledge- and cooperation-related barriers, they are more likely to adopt the depth of OI.

METHODOLOGY

Data

Data used in this study is derived from the IIS 2011 that covers 2009-2010. The surveyed firms are classified based on the International Standard Industrial Classification (ISIC) Rev. 3.1. Multi-stage random sampling was used to collect data from 1,500 firms and a total of 1,375 questions were successfully collected. Of the returned questionnaires, 1,179 were usable. Face to face interviews with R&D or production managers were conducted to collect the data. In terms of firms' size, the IIS 2011 surveyed only medium (20-99 employees) and large (more than 99 employees) Indonesian manufacturing firms. The IIS 2011 used the Oslo Manual (OECD & EUROSTAT, 2005) as the guideline for collecting and interpreting innovation data and adjustments were made to facilitate innovation activities in Indonesia that may differ from those in developed economies. Indonesia has three waves of innovation survey i.e. 2008, 2011, and 2014. The IIS 2008 and 2011 cover manufacture firms only, while 2014 covers both manufacture and service firms. Although the IIS 2011 did not capture the current survey of innovation, it covers the broadest Indonesian manufacturing firms than other waves of innovation survey. Hence this study employed the IIS 2011. Since innovation survey was discontinued, lack of current innovation survey data is the greatest challenge for Indonesian scholars to disseminate innovation survey-based innovation studies.

Variables and Its Measurement

Dependent variables consist of breadth and depth. External sources of knowledge use for innovation are presented in Table 3. Measurement of breadth and depth follows Laursen &

Salter's (2006) study. Breadth is constructed based on 9 external sources of knowledge used for innovation present in the IIS 2011 dataset, such as: (1) suppliers of equipment, materials, components or software (SUPPLIERS); (2) clients or customers (CUSTOMERS); (3) competitors or other enterprises (COMPETITORS); (4) consultants, commercial laboratories or private R&D institutes (CONSULTANTS); (5) universities or other higher education institutions (UNIVERSITIES); (6) government or public research institutes (GOV_RD); (7) professionals and industry associations (ASSOCIATIONS); (8) conferences, trade fairs, exhibitions (EVENTS); and (9) scientific journals and trade/technical publications (SCIENCE_PUB) (Table 1).

The breadth is defined as the total number of sources used and ranges from 0 when no external information is used, to 9 when all external information is used. Firstly, each of the 9 sources are coded as a binary variable, 0 being no use and 1 being use of the given knowledge source. Then, the 9 sources are simply added up so that each firm gets a 0 when no external knowledge sources are used, while the firm gets the value of 9, when all external knowledge sources are used. A high degree of internal consistency resulted from breadth construct (Cronbach's alpha coefficient=0.93).

In the case of depth measurement, firstly, each of the 9 sources are coded with 1 when the firm uses the source to a high degree and 0 in the case of not used, low, or medium use of the given source. Then, the 9 sources are added up so that each firm gets the value of 9 when all knowledge sources are used to a high degree, while each firm gets 0 when no knowledge sources are used to a high degree. A reasonably good internal consistency resulted from this construct (Cronbach's alpha coefficient=0.65).

Given that the dependent variables are conditioned on values between 0 and 9, both variables are both left and right-censored, hence, the use of Ordinary Least Squares (OLS) estimates will be biased. Empirical measurement in this study used Tobit regression to assess the impact of innovation barriers on open innovation. However, this study reports both Tobit and robust OLS regressions as a robust check.

Table 1
EXTERNAL SOURCES OF KNOWLEDGE

External sources of knowledge	Description (0=not used, 4=highly used)
SUPPLIERS (0/4)	Suppliers of equipment, materials, components or software.
CUSTOMERS (0/4)	Clients or customers.
COMPETITORS (0/4)	Competitors/other enterprises in firm sector.
CONSULTANTS (0/4)	Consultants, commercial laboratories or private R&D institutes.
UNIVERSITIES (0/4)	Universities/other higher education institutions.
RES_INSTITUTES (0/4)	The government/public research institutes.
EVENTS (0/4)	Conferences, trade fairs, and exhibitions.
PUBLICATIONS (0/4)	Scientific journals and trade/technical publications.
ASSOCIATIONS (0/4)	Professional and industry associations.

Source: Indonesia Innovation Survey (2011).

Table 2
INNOVATION BARRIERS

Barriers abbreviations	Description (0=not important, 4=very important)
INFUND	Lack of funds within your enterprise or group
EXFUND	Lack of finance from sources outside your enterprise
COST	Innovation costs too high

RISK	Excessive perceived economic risks
STAFF_RESIST	Staff resistance (being not open) towards change
MGR_RESIST	Manager resistance (being not open) towards change
ORG_RIGID	Organizational rigidities within the enterprise
PERSONNEL	Lack of qualified personnel
TECH_INFO	Lack of information on technology
MKT_INFO	Lack of information on markets
COOPERATION	Lack of ability to find cooperation partners for innovation
LABOUR	Inability to allocate labour in innovation activities because production has higher priority
MARKET_DOM	Market dominated by foreign established enterprises
UNCER_DEMAND	Uncertain demand for innovative goods/services
CUSTOM_ACCEPT	Lack of customers' acceptance
INFRASTRUCTURE	Lack of sufficient infrastructure to support innovation activities
IND_STANDARD	Lack of industry standard
GOVREG	Lack of government regulation

Source: Indonesia Innovation Survey (2011).

Independent variables consist of four groups of innovation barriers resulted from Factor Analysis (FA). FA is used in order to identify and combine innovation barrier variables in "*a weighted fashion to form components which account for the maximum amount of variability in the variables' scores*" (Cooksey, 2007). The four groups of innovation barriers resulted from FA are presented in table 3. It displays the results of varimax rotated FA of the 18 innovation barrier variables (Table 2). Factor loadings above 0.3 were used for factor grouping. The Bartlett test of sphericity: 12000, significance=0.000. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.917, which is well above the acceptable range of greater than 0.50 (Hair et al., 2014). The scale reliability value for each factor (coefficient alpha) is 0.924. The barriers used in FA are grouped into four categories: market and institution; financing and risk; employee and organization attitude; and knowledge and cooperation.

Table 3
COMPONENT LOADINGS FOR INNOVATION BARRIERS

VARIABLES	INBAR1	INBAR2	INBAR3	INBAR4
INFUND	-0.067	**0.476**	0.015	0.099
EXFUND	-0.065	**0.476**	0.005	0.087
COST	0.033	**0.502**	0.002	-0.066
RISK	0.090	**0.487**	-0.045	-0.118
STAFF_RESIST	-0.040	0.051	**0.519**	-0.004
MANAGER_RESIST	0.009	-0.002	**0.564**	-0.054
ORGRIGID	0.039	-0.072	**0.520**	0.017
PERSONNEL	-0.073	0.019	0.251	**0.336**
TECH_INFO	-0.052	0.030	-0.035	**0.557**
MARKET_INFO	0.048	-0.086	-0.020	**0.543**
COOPERATION	0.048	0.141	-0.073	**0.366**
LABOUR	0.129	0.015	0.163	0.223
MARKET_DOMINATION	**0.400**	-0.021	-0.067	0.014
UNCER_DEMAND	**0.394**	-0.013	-0.063	0.084
CUSTOMER_ACCEPT	**0.413**	-0.107	-0.108	0.150
INFRASTRUCTURE	**0.334**	0.067	0.023	0.023
STANDARD	**0.413**	0.058	0.102	-0.111
GOVREG	**0.427**	0.040	0.111	-0.132
Eigenvalue	7.866	1.632	1.226	1.063
Cronbach's alpha				0.924

Kaiser-Meyer-Olkin	0.917
Percentage of total variance explained	65.50

Source: Prepared by the authors.

Notes: INBAR 1: Barriers related to market and institutions; INBAR 2: Barriers related to financial and risk INBAR 3: Barriers related employee and organization attitude; INBAR 4: Barriers related to knowledge and cooperation; *p<0.10; **p<0.05; ***p<0.01.

Factor 1 is **market and institution barriers** that consist of six items including market domination by foreign established enterprises; uncertain demand for innovative goods and services; lack of customer acceptance; lack of sufficient infrastructure to support innovation activities; lack of industry standards from government; and lack of regulation from government. This group of innovation barriers is associated with the external environment of firms. Based on factor analysis, previous studies have also classified constraints related to the external environment (Hadjimanolis, 1999; Madrid-Guijarro et al., 2009).

Factor 2 consists of **financial and risk barriers**, including lack of internal and external funding, the high cost of innovation and perception of excessive economic risk. Obstacles related to financing are some of the most common barriers faced by firms, as shown in previous studies (Canepa & Stoneman, 2007; Efthyvoulou & Vahter, 2013; Mohnen et al., 2008).

Factor 3 consists of innovation barriers related to **employee and organization attitudes** that include staff and manager resistance to innovation and organizational rigidity. This type of barrier also has been discussed in previous studies (Hewitt-Dundas, 2006; Madrid-Guijarro et al., 2009; Zwick, 2002). Factor 4 is associated with **knowledge and cooperation** and consists of the lack of qualified personnel; lack of information on technology and market; and a lack of cooperation activities. Lastly, firms' characteristics that consist of firm size, firm age, exporters, and technology intensity also were used as control variables.

RESULTS

Descriptive

Table 4 reports the descriptive statistics of the major variables and the correlation coefficients among them, respectively. Table 3 shows that on average breadth are higher than depth, 4.21 and 1.12 respectively. It means that each firm on average use 4 to 5 different external sources of knowledge for innovation and use 1 to 2 external sources of knowledge intensively. The range for the innovation barrier variable scores is from 0 (not important) to 4 (very important). On average, the score for barriers related to financing and risk, including COST, RISK and INFUND, scored nearly 3, which are among the top three mean scores compared to other types of barriers. This finding confirms previous studies that reveal financial constraints are more important than other constraints. For example, barriers related to financial are more important than other internal and external barriers on innovation projects not starting, being delayed or postponed among firms in European countries (Canepa & Stoneman, 2007).

The top barriers related to financial factors in this study are also similar to previous studies in developing countries context. For instance, Cypriot owners/managers perceive that lack of financing of innovation as the top barriers hamper small firms in Cyprus (Hadjimanolis, 1999). Based on the Malaysia National Survey of Innovation, Lee & Lee (2006) and Shiang & Nagaraj (2011) find that Malaysian manufacturing firms perceive that financing is more important factor than other factors that hampering innovation activities. In contrast, the mean

scores for obstacles related to organizational rigidities, ORG_RIGID, and managers' resistance to change, MGR_RESIST, are the lowest at 1.789 and 1.732, respectively.

Considering firm resources, the mean of firm size as indicated by number of employees is approximately 175 people. Of surveyed firms, mature firms that have been in business for more than 20 years dominate in the IIS 2011. Exporters, on average, export approximately 10% of their products. In terms of technology intensity, there is a big difference between the means for low- and high-technology firms, with values of 0.735 versus 0.009, respectively.

Empirical Results

Table 5 displays results from the estimation of Tobit and robust OLS models of breadth and depth, respectively. The table shows that direction and significance of the four innovation barriers in the Tobit and OLS models are broadly consistent. Table 5 shows that only constraints related to employee and organization attitudes are positively and significantly influence firms' breadth of openness in innovation. In contrast, knowledge and cooperation barriers negatively and significantly impact breadth. These findings suggest that when the firms face employee and organization attitudes barriers in the innovation process, they are more likely use the greater or wider number of external knowledge (breadth). By contrast, the firms will perform different direction when they suffer from knowledge and cooperation barriers. While, the last two of barriers have no significant association with breadth. Hence, it may be summarized that only *H3a* that is supported and this differ compared to the previous similar studies in the context of Swiss firms (Keupp & Gassmann, 2009) and Chinese firms (Fu et al., 2014).

In terms of control variables, firm size seems to have a negative impact on a firm's breadth of openness. It means that smaller firms tend to have a greater degree of openness in terms of the breadth of tapping into external knowledge sources. A possible reason behind this phenomenon is that smaller firms tend to lack capabilities and resources than larger firms, therefore OI adoption seems the right choice. This finding has opposite direction compared to the similar previous studies (Fu et al., 2014; Keupp & Gassmann, 2009). Of firm technology intensity classification, only medium to low technology firms tend to have a negative impact on breadth.

In terms of the depth to OI, Table 5 shows that two different group of barriers, i.e. market and institutions; and employee and organizations attitudes, positively and significantly influence the depth of OI. Hence, only *H1b* and *H3b* are supported. This suggests that when the firms face the two barriers, they are more likely use external knowledge intensively (depth). While the rest groups of barriers have no significant impact on depth. Of control variables, only exporters that have the propensity to tap knowledge from external sources intensively (depth). A speculative explanation regarding this issue is being an exporter may need intensive external knowledge to compete in an international market. These findings also differ compared to the previous similar studies (Fu et al., 2014; Keupp & Gassmann, 2009).

CONCLUSIONS AND STUDY IMPLICATION

Theoretical Implication

This study aims to investigate the impact of innovation barriers on Indonesian manufacturing firms' openness. The breadth and depth are indicators of the firms' openness on external knowledge. In the context of Indonesian firms, to the best our knowledge, there is no

existing study that focuses on such issue. Hence, it is expected that this study sheds the light on how Indonesian manufacturing firms' openness response to internal and external innovation barriers. This study contributes to the enrichment of innovation management literature, more specifically in the linkage between innovation barriers and open innovation adoption in the context of developing countries. In the context of Indonesian manufacturing firms, this study provides a different insight on such linkage to the previous similar studies that have been conducted in Switzerland and China.

Table 4
DECSRIPTIVE STATISTICS

Variables	Obs.	Mean	SD	Min.	Max.
OPEN INNOVATION					
BREADTH	1196	4.21	3.49	0	9
DEPTH	1179	1.12	1.45	0	8
INNOVATION BARRIERS					
INFUND	1179	2.85	1.38	0	4
EXFUND	1179	2.66	1.51	0	4
COST	1179	2.94	1.31	0	4
RISK	1179	2.88	1.31	0	4
STAFF_RESIST	1179	2.00	1.44	0	4
MGR_RESIST	1179	1.73	1.39	0	4
ORG_RIGID	1179	1.79	1.40	0	4
PERSONNEL	1179	2.42	1.40	0	4
TECH_INFO	1179	2.50	1.36	0	4
MKT_INFO	1179	2.34	1.34	0	4
COOPERATION	1179	2.60	1.41	0	4
LABOUR	1179	2.34	1.43	0	4
MARKET_DOM	1179	2.64	1.39	0	4
UNCER_DEMAND	1179	2.56	1.36	0	4
CUSTOM_ACCEPT	1179	2.25	1.35	0	4
INFRASTRUCTURE	1179	2.39	1.44	0	4
IND_STANDARD	1179	2.29	1.46	0	4
GOVREG	1179	2.25	1.48	0	4
FIRMS' RESOURCES					
SIZE	1179	174.61	1318.08	20	32977
AGE	1179	21.08	12.70	0	84
EXPORTERS	1179	9.73	25.11	0	100
LOW-TECH	1179	0.73	0.44	0	1
MEDLOW-TECH	1179	0.17	0.38	0	1
MEDHIGH-TECH	1179	0.08	0.27	0	1
HIGH-TECH	1179	0.01	0.10	0	1

Source: Prepared by the authors.

Table 5
TOBIT AND OLS REGRESSION

	TOBIT AND OLS REGRESSION (BREADTH)		TOBIT AND OLS REGRESSION (DEPTH)	
	Tobit regression	Robust OLS regression	Tobit regression	Robust OLS regression
Market & institution	.083 (.088)	.113 (.068)	.174*** (.057)	.101*** (.031)
Financial & risk	-.113 (.088)	-.102 (.069)	.025 (.057)	.011 (.031)
Employee & org. attitudes	.729*** (.087)	.634*** (.071)	.245*** (.056)	.144*** (.028)
Knowledge & cooperation	-.292*** (.100)	-.254*** (.079)	-.090 (.064)	-.025 (.035)
SIZE	-.0002* (.0001)	-.0001** (.00004)	-.0001 (.0001)	-.00002 (.00001)
AGE	.007 (.009)	.004 (.008)	.002 (.006)	.003 (.004)
EXPORT	.007 (.005)	.007 (.004)	.006** (.003)	.003* (.002)
LOWTECH	-	-	-	-
MEDIUM-LOW TECH	-.606** (.308)	-.443* (.259)	-.110 (.194)	-.138 (.099)
MEDIUM-HIGH TECH	.428 (.420)	.415 (.348)	.195 (.267)	.082 (.139)
HIGH-TECH	.035 (1.192)	.098 (.992)	1.001 (.724)	.553 (.455)
Number of obs.	1179	1179	1179	1179
LR $chi^2(10)$	92.98		69.74	
Prob.>chi^2	.000		.000	
Pseudo R^2	.016		.019	
Log likelihood	-2922.31		-1812.60	
Left-censored obs.	197		549	
Right-censored obs.	982		630	
F(10, 1168)		12.00		8.38
Prob.>F		.000		.000
R-squared		.082		.094

Source: Prepared by the authors.
Notes: *p<0.10; **p<0.05; ***p<0.01; Standard errors are in parentheses.

An important or key finding from this study is that not all internal and external innovation barriers were responded by the adoption of OI practices. Surprisingly, only internal barriers to innovation (i.e. employee and organization attitudes towards innovation) that have positive links to both a firm's breadth and depth of openness. This group of barriers consists of three issues such as staff resistance to innovation, manager resistance to innovation, and organizational rigidity to innovation. The finding suggests that when Indonesian manufacturing firms face this type of barrier they are more likely to response by taping external knowledge widely (breadth) and deeply (depth). While the firms will response by tapping external knowledge more intense (depth) if they face market and institution barriers. Barriers related to financial and risk have no positive association with OI may be because to overcome such barriers, the firms will link to external financial institutions such bank and venture capital, that is more appropriate than adopt OI.

In terms of firm size, this study also reveals different findings compared to the previous studies i.e. the smaller the firms, the greater the firms to adopt breadth of OI. This may suggest that small firms, that normally experience higher level of constraints than their larger counterparts, prefer to go out to use broader knowledge from external sources.

Practical Implication

An important practical implication that may need to be addressed is the firms' managers' awareness to adopt more OI approach to overcome both internal and external barriers. Previous studies show that the most challenges to OI stem from firm-internal weakness such as knowledge- and skill-related barriers (Chesbrough & Crowther, 2006; Fu et al., 2014; van de Vrande et al., 2009) and barriers related to cost and risk (Fu et al., 2014; Keupp & Gassmann, 2009). Hence, such innovation barriers should not be underestimated. As OI paradigm suggests that innovation activities cannot be performed in isolation, hence to minimize any constraints and risk in innovation, OI approach is strongly recommended, especially for firms operating in developing economies that may suffer innovation barriers greater than firms in developed economies.

LIMITATION OF THE STUDY

Lastly, limitation of the study needs to be acknowledged to open possible opportunities for further studies. First, this study is cross-sectional in nature; hence insight on the dynamics of the linkage between innovation barriers and OI is missing. Further studies may address this issue by using innovation data panel. Second, the IIS 2011 data used in this study only covers innovation activities of Indonesian manufacturing firms. Hence, there is an opportunity to investigate this issue based on a comparison between manufacturing and service firms. Third, OI indicators employed in this study only focus on breadth and depth, hence, a broader indicator of OI that represent inbound, outbound, and coupled of OI (Gassmann & Enkel, 2004) are recommended to be studied in future studies.

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