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Linking open innovation, innovation barriers, and performance of Indonesian firms

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Linking open innovation, innovation barriers, and performance of Indonesian firms

Purpose – This study examines open innovation, that consists a wide range of external knowledge search activities such external search breadth and depth, external R&D, cooperation, and acquisition activities, as a response to different innovation barriers faced by Indonesian firms.

Design/methodology/approach – Data derived from Indonesia innovation survey. Exploratory factor analysis is used to identify and combine innovation barriers variables. Ordered logistic estimation is used to measure the impact of innovation barriers on firm openness decision. Logistic regression is used to measure the impact of innovation barriers on firm openness indicators such as external R&D, cooperation, and acquisition as the variables are binary variables. Lastly, Tobit regression is used to measure the impact of firm openness decision on innovation performance.

Findings – The main findings indicate that different barriers to innovation lead to different firms' openness decisions and different decisions on openness have differentiated influence on innovation performance.

Originality/value – This study contributes to the innovation barrier literature by empirically testing whether experiencing barriers to innovation is associated with a broader external knowledge search activity. Previous studies tend to link innovation barriers with a narrow activity as indicated by external knowledge searching widely and deeply.

Keywords Open innovation, innovation barriers, innovation performance, Indonesian firms

1. Introduction

A firm's openness has become a prominent issue in both theory and practice over the last decades, especially, after the concept of open innovation (OI) was coined by (Chesbrough, 2003). Firms become more open and permeable to their external environment for several reasons. Many firms lack the adequate resources and capabilities to deal with market and technological uncertainty of innovation, the rising cost of internal R&D and risks, and shorter product life cycles, as consequently a large majority of firms can hardly address those challenges by relying solely on their own resources and capabilities (Chesbrough, 2006). In the context of developing countries, issues related to innovation barriers are more relevant as firms naturally face substantial barriers innovation related to institutional, resources, and capabilities (Fu *et al.*, 2014). Hence, firms in developing countries have been found not to perform R&D (Goñi and Maloney, 2014), unable to catch-up with developed countries (Gorodnichenko and Schnitzer, 2013), to pursue different innovation strategies (Gault, 2010), have underdeveloped absorptive capacity than their counterparts in developed countries (Bilgili *et al.*, 2016), and as a result, to engage with greater breadth and depth of external knowledge to overcome innovation barriers (Fu *et al.*, 2014).

Any factors that impede, delay or completely block innovation can be seen as innovation barriers (Mirow *et al.*, 2008). The terms barriers, hurdles, impediments and obstacles can be used interchangeably (Hueske and Guenther, 2015). It is argued that better understanding of innovation barriers can help firms to create the development of an environment that supports innovation (Hadjimanolis, 1999). The 3rd edition of Oslo Manual (OECD and EUROSTAT, 2005) that used by many developed countries (e.g. European countries) as guidelines for collecting and interpreting innovation data, divided any factors that hamper innovation activities into cost factors, knowledge factors, market factors, institutional factors, and other reasons for not innovating.

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3 Although substantial number of studies on innovation barrier have been conducted, the studies
4
5 tend to focus on financial factors that hinder innovation activities (Altomonte *et al.*, 2016;
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7 Canepa and Stoneman, 2002, 2008; Crisóstomo *et al.*, 2011; Efthyvoulou and Vahter, 2016;
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9 Hall *et al.*, 2016; Löf and Nabavi, 2016; Mohnen, Palm, van der Loeff, *et al.*, 2008; Savignac,
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11 2008; Silva and Carreira, 2012; Ughetto, 2009) and perception of innovation barriers (Baldwin
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13 and Lin, 2002; D'Este *et al.*, 2008, 2012; Demirbas *et al.*, 2011; Frenkel, 2003; Galia *et al.*,
14
15 2012; Hölzl and Janger, 2013, 2014; Iammarino *et al.*, 2007; Segarra-Blasco *et al.*, 2008; Shiang
16
17 and Nagaraj, 2011; Tourigny and Le, 2004; Xie *et al.*, 2010). Issues related to financial
18
19 constraints include the importance between financial and non-financial constraints; comparison
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21 financial constraints across firms' size, sectors, technology intensity, export orientation as well
22
23 as the influence of financial constraints on not starting, being delayed or postponing projects.
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25 The issues studied in the perceived innovation barriers include the comparison between
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27 innovative and non-innovative firms; between users and non-users of technology; between
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29 small and large firms; and among firms in European countries.
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36 This study intends to directly link innovation barriers with firms' openness decision that
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38 has hitherto received little attention in the academic literature. In previous studies, which
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40 employed data from innovation survey (e.g. community innovation survey, also known as CIS),
41
42 innovation barriers tend to be linked with narrow firm's openness indicators and focuses
43
44 exclusively on the inbound perspective of open innovation, i.e. the external search for
45
46 information and cooperation to innovate internally. More precisely, those indicators encompass
47
48 external search breadth and depth based on Laursen and Salter's (2006) framework (Fu *et al.*,
49
50 2014; Garriga *et al.*, 2013; Keupp and Gassmann, 2009), cooperation activities (Antonioli *et*
51
52 *al.*, 2017), and breadth of cooperation activities with local and foreign partners (Drechsler and
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54 Natter, 2012). Hence, this paper intends to extend these studies by linking innovation barriers
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56 with a broader firm openness decision (beyond external search breadth and depth) using
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3 innovation data derived from a developing country i.e. Indonesia Innovation Survey 2014 (IIS
4
5 2014).

6
7 Firm openness decision can be based on different activities that are operationalised
8
9 differently by different authors (Barge-Gil, 2010). A broad definition of openness is proposed
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11 by Chesbrough (Chesbrough, 2003), it emphasises that valuable ideas emerge and can be
12
13 commercialised from inside and outside the firm. This is the most commonly used definition in
14
15 the literature (Dahlander and Gann, 2010). Other scholars identified three cores OI process such
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17 as the outside-in process, the inside-out process, and the coupled process (Gassmann and Enkel,
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19 2004). While others identified three strategic characteristics of OI such as opportunity-seeking
20
21 prospector, dual-oriented analyser, and market segment securing defender (Bader and Enkel,
22
23 2014). Openness studies using innovation surveys data tended to use inbound breadth and depth
24
25 framework developed by Laursen and Salter (2006). Based on a bibliographic analysis of
26
27 previous openness studies, the outside-in process can consist of firms' sourcing and acquiring
28
29 activities (Dahlander and Gann, 2010). Other scholars, Drechsler and Natter (2012) propose the
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31 degree of openness based on a firm's external domestic and foreign collaboration partners.
32
33 Other scholars use three ways for firms to be open such as information transfer from informal
34
35 the network, R&D collaboration, and technology acquisition (Kang and Kang, 2009). While,
36
37 Huang and Rice (2009) argue that openness can include acquisitions; the purchase of
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39 technology rights through licensing; the contracting out of internal R&D to external agents,
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41 other firms or research institutions; and the use of formal and informal inter-organizational
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43 networks. Hence, this study employs firm openness decision that differs from previous CIS-
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45 based innovation barrier studies, that encompass external search breadth and depth, external
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47 R&D, cooperation, and acquisition (machinery, equipment, and software). External R&D,
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49 cooperation, and acquisition activities imply that firms' partners share their resources and
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51 knowledge.
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3 This study intends to answer whether firms that face different barriers to innovation are more
4 likely to open up their innovation process, as can be reflected from external search breadth and
5 depth, external R&D, cooperation, and acquisition activities. Subsequently, this study intends
6 to measure the impact of firm openness decision on innovation performance. It is expected that
7 this research contributes to two key issues in the innovation literature. First, this study employs
8 a broader firm openness decision than previous CIS-based innovation barrier studies. Therefore,
9 this study looks whether a broader firm openness might be a viable strategy to cope with
10 different barriers to innovation. Second, this study examines the impact of a broader firm
11 openness decision on innovation performance, while previous CIS-based studies tended to
12 focus on the impact of external search breadth and depth on innovation performance.
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29 **2. Literature Review and Hypotheses Development**

30 *2.1. Common barriers to innovation*

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32 The first common factor that hinders innovation activities that have been studied extensively is
33 the financial factor. Most research was conducted in developed countries empirical setting, for
34 examples, across European countries (Altomonte *et al.*, 2016; Canepa and Stoneman, 2002;
35 Efthyvoulou and Vahter, 2016; Hall *et al.*, 2016), in the UK (Canepa and Stoneman, 2008), in
36 Spain (González *et al.*, 2005), in Sweden (Lööf and Nabavi, 2016), in Netherland (Mohnen,
37 Palm, van der Loeff, *et al.*, 2008), in France (Savignac, 2008), in Portugal (Silva and Carreira,
38 2012), and in Italy (Ughetto, 2009). In contrast, there are a few studies that focus on financial
39 factors as barriers to innovation in developing countries, for instance a study conducted by
40 (Crisóstomo *et al.*, 2011).
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54 Based on data used in the financial barriers studies, it can be divided into CIS-based innovation
55 barriers studies (Canepa and Stoneman, 2002, 2008; Efthyvoulou and Vahter, 2016; Mohnen,
56 Palm, Van der Loeff, *et al.*, 2008; Savignac, 2006) and non-CIS-based innovation barrier
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3 studies (Altomonte *et al.*, 2016; Crisóstomo *et al.*, 2011; González *et al.*, 2005; Hall *et al.*, 2016;
4
5 Lööf and Nabavi, 2016; Savignac, 2008; Ughetto, 2009). CIS-based innovation barriers studies
6
7 provide a different insight on how financial factors affect innovation. Financial factors,
8
9 especially lack of the appropriate source of finance found to be the most important barrier than
10
11 other factors that affect innovation projects to be delayed, abandoned, or even not started
12
13 (Canepa and Stoneman, 2002; Mohnen *et al.*, 2008). Financial factors also severely impact
14
15 innovative activity, especially in high technology sectors and smaller firms (Canepa and
16
17 Stoneman, 2008). Furthermore, it affects the innovation performance in the production sector
18
19 stronger than in the service sector (Efthyvoulou and Vahter, 2016). Using data similar to French
20
21 CIS, Savignac (2006) reveals that innovative firms without financial constraints have a better
22
23 profile in economic performance, financing structure and risk than non-innovative firms. In
24
25 addition, firms having innovative projects that face financial constraints tend to reduce the
26
27 implementation of innovative investments (Savignac, 2006). Based on Portuguese CIS data,
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29 (Silva and Carreira, 2012) found that financial constraints hinder investment in R&D and
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31 innovation, but subsidy as part of public financial support did not help to overcome such
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33 constraints.
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40 Different impacts caused by financial factors on innovation activities also can be found
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42 in previous non-CIS studies. For instance, a mutual relationship exists among exporting,
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44 productivity, and financial constraint. For example, exporters and high productivity firms are
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46 less likely to be credit constrained and better access to credit is associated with firms with larger
47
48 productivity and a higher probability of exporting (Altomonte *et al.*, 2016). Altomonte *et al.*,
49
50 (2016) concluded that financial constraints have the indirect effect on innovation by reducing
51
52 incentives to innovate, rather than by reducing the ability to innovate. In the case of firms in
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54 an emerging country, the study shows that although recent institutional framework changes and
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56 market advances started since the 1990s, Brazilian firms face financial constraints when they
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3 implement innovation projects (Crisóstomo *et al.*, 2011). A positive impact of financial
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5 incentive in the form of subsidies on R&D activities also has been found. For example,
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7 subsidies stimulate R&D and some firms would stop performing R&D in the absence of
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9 subsidies (González *et al.*, 2005). In the case of exporters, high technology innovative firms
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11 tend to exploit internal cash resources if they face financial shock, while there is no relationship
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13 between financial factors and innovation in medium and low technology exporters (Löf and
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15 Nabavi, 2016).
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19 The second main strand of innovation barriers literature is related to the perception of
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21 innovation barriers. The literature is dominated by CIS-based studies in developed economies
22
23 context with the exception of Shiang and Nagaraj's (Shiang and Nagaraj, 2011) study. An
24
25 interesting finding from these studies is that barriers to innovation in innovation survey should
26
27 be considered as indicating how successfully a firm can overcome barriers (Baldwin and Lin,
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29 2002; Tourigny and Le, 2004). Clausen (Clausen, 2008) suggested that instead of obstacles
30
31 variables, the real obstacles are the obstacles perceived by the managers. Hence, innovative
32
33 firms are more inclined to perceive obstacles and as a result, the perception of obstacles would
34
35 be positively linked with the propensity to innovate. In relation to that, D'Este *et al.*, (2012)
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37 argue that we need to differentiate between deterring barriers to innovation that deter firms from
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39 engaging in innovation activities and revealed barriers that are experienced by firms as they are
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41 performing innovation activities.
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47 Another issue in the perception of innovation barriers discussion is what are the most
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49 important barriers commonly faced by firms. In this case, previous studies consolidate a list of
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51 obstacles from innovation survey into fewer groups of obstacles. The four sets of innovation
52
53 barriers that are identified and usually studied are cost factors, knowledge factors, market
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55 factors, and regulation factors (Galia *et al.*, 2012). Examples of innovation barriers groups from
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57 the previous studies are as follows. Baldwin and Lin (2002) grouped innovation barriers related
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3 to cost, institution, labour, organisation, and information. A slightly different group of obstacles
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5 also can be found in D'Este et al., (2012) study such as cost, knowledge, market, and regulation.
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7 Using principal component analysis (PCA), Galia and Legros (2004) distinguish groups of
8
9 obstacles faced by firms that postponed and abandoned innovative projects. In the former
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11 project, obstacles consist of three groups such as rigidities and information; risk, cost and source
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13 of finance; and customer response and skilled personnel. While, in the later project, obstacles
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15 can be grouped into organisational rigidities; risk and skilled personnel; and cost, finance,
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17 institution, and market. A fewer group of innovation barriers can be found in the study using
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19 Spanish CIS such as the cost of innovation, lack of knowledge, and market characteristics
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21 (Segarra-Blasco *et al.*, 2008).
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27 In the context of Indonesia, using data derived from IIS 2011, Hartono &
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29 Kusumawardhani (2019) explore the nature and importance of innovation constraints faced by
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31 manufacturing firms and its impact on innovation performance was examined. The study groups
32
33 innovation constraints into market and institution, employee and organisation attitude, finance
34
35 and risk, and knowledge and cooperation. Factors related to financial and risk are perceived to
36
37 be the most important constraints. The study shows that different innovation barriers influence
38
39 types of innovation and innovation performance differently. Since the IIS 2011 only surveyed
40
41 Indonesian manufacturing firms, insights on how non-manufacturing firms experiencing
42
43 innovation barriers do not exist. The IIS 2014 data used in this study covers seven industry
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45 sectors, including both manufacturing and services firms, extends that body of knowledge by
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47 providing insights covering a wider context.
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54 2.2. *Innovation barriers and firms' openness relationship*

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56 In the context of a developing country, Fu et al., (2014) use push and pull framework to group
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58 barriers innovation into institutional, financial, and knowledge/skill and subsequently link the
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3 barriers with breadth and depth of OI performed by Chinese manufacturing firms. They found
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5 that the three groups of obstacles are significantly associated with the firms' breadth and depth
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7 of openness in innovation. This suggests that the Chinese firms facing to a higher extent three
8
9 groups of barriers, are more likely to engage with OI in greater breadth and depth to mitigate
10
11 the barriers. Furthermore, the firms' openness varies across different firms' ownership, size,
12
13 and technology intensity. Lastly, Fu et al., (2014) suggest that future studies that link innovation
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15 barriers and firm openness should beyond inbound or outside-in process as the indicator of firm
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17 openness.
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22 Using the exploration-exploitation framework, Keupp and Gassmann (Keupp and
23
24 Gassmann, 2009) examine the impact of information- and capability-related constraints and
25
26 risk-related constraints on firms' openness based on Swiss CIS data. They found that the two
27
28 types of constraints positively and significantly influence breadth and depth of OI. This suggests
29
30 that firms face greater the two constraints are more likely to use external knowledge broader
31
32 and deeper. Using similar CIS, i.e. Swiss CIS, Garriga et al., (2013) linking constraints on
33
34 resources to firms' openness i.e. breadth and depth of OI. It turned out that such constraints
35
36 have a different direction of impact on the firms' openness. The constraints positively influence
37
38 breadth of OI, by contrast, the constraints have a negative impact on depth of OI. This indicates
39
40 that the firms are more likely to engage in wider external knowledge search and are less likely
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42 to engage in deeper external knowledge search to overcome constraints related to firms'
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44 resources.
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50 Using French CIS, Antonioli et al., (2017) conducted a recent study the impact of
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52 obstacles related to cost, market, and knowledge on the firms' probability to cooperate with any
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54 partners and specific partners such as firms and research organisation. The study shows that
55
56 financial constraint is a robust and significant driver of cooperation, both in general and across
57
58 different partners. Firms experiencing financial constraints tend to cooperate with research
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3 organisations. Furthermore, interaction among the three barriers to innovation and its impact
4 on cooperation activities are also tested. One of the most consistent findings is that combination
5 between cost and knowledge barriers significantly decrease the propensity to engage in
6 cooperation activities. Based on the German CIS, scarce firm resources that consist of financial
7 and knowledge gaps are also linked to the degree of firms' openness in innovation that is
8 measured by the breadth of firms' involvement in cooperation activities with local and foreign
9 partners (Drechsler and Natter, 2012). The finding shows that scarce financial resources drive
10 firms to increase their openness.
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21 Based on the previous studies review, the following hypothesis related to the impact of
22 innovation barriers on a broader firm openness can be drawn:
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26 *H1 Firms experiencing greater innovation barriers are more likely to adopt greater openness*
27 *of innovation that can be reflected from external search breadth and depth, external*
28 *R&D, cooperation, and acquisition activities.*
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36 2.3. *The impact of firms' openness on innovation performance*

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38 Studies on the relationship between innovation barriers and firms' openness tend to treat
39 innovation barriers as determinants of OI and do not link firm openness to innovation
40 performance (Drechsler and Natter, 2012; Fu *et al.*, 2014; Keupp and Gassmann, 2009).
41 Laursen and Salter (2006), pioneering a study to examine the impact of firm openness, as
42 indicated by external search breadth and depth, on innovation performance using a large scale
43 data derived from UK innovation survey. The study found that breadth and depth positively
44 affect innovation performance, however, over searching on external knowledge tend to
45 diminish the return of innovation performance. Following Laursen and Salter (2006), a number
46 of CIS-based OI studies have been conducted, however, the studies tend to be conducted in
47 developed economies context. Evidence from OI studies in developing economies are rather
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3 scarce and research methods used limited to qualitative because data collection is rather
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5 complicated (Podmetina *et al.*, 2014).
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8 Studies on firm openness and innovation performance relationship in both developing and
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10 developed economies tend to support Laursen and Salter's (2006) work. An OI study using data
11
12 from IIS 2011 found that firm openness, that is measured by external search breadth and depth,
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14 positively influence innovation performance of Indonesian manufacturing firms (Hartono and
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16 Kusumawardhani, 2018). However, decreasing returns in over searching on external search
17
18 breadth and depth also can be found among Indonesian manufacturing firms. A survey on how
19
20 the innovative performance is affected by the breadth, depth, and orientation of firms' external
21
22 search strategies among Chinese firms has been conducted (Chen *et al.*, 2011). The study found
23
24 that the greater breadth and depth improve innovation performance, however, decreasing
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26 returns of innovation performance are not always present and are contingent on the innovation
27
28 modes. Another study based on Indian firms shows that 'inbound open innovation is crucial in
29
30 helping firms to catch-up and move toward the technological frontier' (Kafouros and Forsans,
31
32 2012, p. 362). CIS-based OI studies using various innovation surveys in different developed
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34 countries (Ahn *et al.*, 2014; Battisti *et al.*, 2015; Ebersberger *et al.*, 2012; Laursen *et al.*, 2007;
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36 Salge *et al.*, 2012) also reveal a significant and positive relationship between firms' openness
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38 and innovation performance.
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45 Hence, the following hypothesis related to firms' openness and innovation performance
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47 (measured by share of product innovation new to the markets and to the firms) relationship can
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49 be proposed:
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53 *H2 Firm openness as indicated by external search breadth and depth, external R&D,*
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55 *cooperation, and acquisition are positively affecting sales' proportion of product*
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57 *innovation new to the market and to the firms.*
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3. Research Methodology

3.1. Data

Data were drawn from the IIS 2014 and multi-stage random sampling is used and a total of usable 927 questionnaires were successfully collected. The surveyed firms are classified based on the International Standard Industrial Classification (ISIC) Rev. 3.1. The IIS 2014 used the Oslo Manual (OECD and EUROSTAT, 2005) as the guideline for collecting and interpreting innovation data. For the analysis purpose, the sample comprises only innovative firms, that is firms producing any product, process, organisational and marketing innovation and expend non-zero or positive innovation activities expenditure during 2011 – 2013 period. From the IIS 2014 dataset of 927 Indonesian firms, a sample of 535 innovative manufacturing and services firms was finally retained.

A firm size indicator is based on the number of employee i.e. small (5-19 employees), medium (20-99 employees) and large (more than 100 employees) firms. Of 535 firms, small firms outnumbered the proportion (55.33%), then followed by medium (32.52%) and large (12.15%) firms. In terms of firm ownership, the proportion of national firms is highly dominated, i.e. around 91%. While the rest of them accounted for small proportion i.e. multi-national firms (2.80%) and joint venture (5.79%).

3.2. Variable definition and measurement

Innovation barriers. The IIS 2014 contains 18 Likert-scale items used to question firms regarding the extent to which a specific barrier had significant negative consequences on innovation activities. The items are rated from 0 (no negative consequence) to 4 (strong negative consequence). Table 1 displays the innovation barrier variables used in this study.

Table 1 Innovation barriers and its definition

Abbreviations	Definition
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: The IIS 2014

Firm openness. This study employs BREADTH, DEPTH, external R&D, cooperation, and acquisition (e.g. acquisition of machinery, equipment, and software) as the firm openness indicators. Construct of BREADTH and DEPTH follows Laursen and Salter (2006) study based on 9 external sources of knowledge used for innovation present in the IIS 2014 dataset, such as suppliers of equipment, materials, components or software (SUPPLIERS); clients or customers (CUSTOMERS); competitors or other enterprises (COMPETITORS); consultants, commercial laboratories or private R&D institutes (CONSULTANTS); universities or other higher education institutions (UNIVERSITIES); government or public research institutes (GOV_RD); professionals and industry associations (ASSOCIATIONS); conferences, trade fairs, exhibitions (EVENTS); and scientific journals and trade/technical publications (SCIENCE_PUB).

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. Each of the 9 sources is coded as a binary variable, 0 being no use and 1 being the use of the given knowledge source. Then,

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3 the 9 sources are simply added up so that each firm gets a 0 when no external knowledge sources
4 are used, while the firm gets the value of 9 when all external knowledge sources are used.
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8 In the case of DEPTH measurement, firstly, each of the 9 sources is coded with 1 when
9 the firm uses the source to a high degree and 0 in the case of not used, low, or medium use of
10 the given source. Then, the 9 sources are added up so that each firm gets the value of 9 when
11 all knowledge sources are used to a high degree, while each firm gets 0 when no knowledge
12 sources are used to a high degree. Each BREADTH and DEPTH then classified into the
13 following ordinal variables: 1 (1-3) means low; 2 (4-5) means medium; 3 (6-9) means high.
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21 *Innovation performance.* Sales' proportion of product innovation new to the market
22 (NEW2MARKET) and new to the firms (NEW2FIRMS) are used in this study as the indicator
23 of innovative performance.
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28 *Control variables.* In this study, the following common control variables in OI literature
29 is included such as absorptive capacity (AC), firm size, firm ownership, and firm sectors.
30 Absorptive capacity. To date, there is no consensus on the measurement of the AC construct.
31 Instead of using a single indicator of AC variable that is commonly used in previous innovation
32 barriers studies, for instance R&D intensity (Keupp and Gassmann, 2009) and internal and
33 external R&D (Fu *et al.*, 2014), this study modified an integrated AC used in the previous
34 studies (Escribano *et al.*, 2009; Kostopoulos *et al.*, 2011). In this study, the integrated AC
35 consists of (1) the firm total innovation activities expenditures, (2) proportion of employees
36 with bachelor's degrees, (3) proportion of employees work in R&D department, and (4) a
37 dummy that equals to 1 if a firm had provided training. In terms of innovation activities
38 expenditures, this study classifies into 1 for very small, 2 for small, 3 for medium, and 4 for a
39 high amount of budget.
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56 *Firm size.* Based on IIS 2014, there are three different firms' size i.e. small, medium, and
57 large firms. This study measures firm size based on the number of employees. Subsequently, a
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3 discrete variable that equals to 1 for small firms, 2 for medium firms, and 3 for large firms was
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5 created. Firm Ownerships. The ownership is also divided into three i.e. national (coded 1),
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7 multinational (coded 2), and joint venture (coded 3). Lastly, firm sectors, it consists of seven
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9 sectors such as mining and quarrying (ISIC 10-14); manufacturing (ISIC 15-37); electricity,
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11 gas & water supply (ISIC 40-43); construction (ISIC 45); trading, hotel & restaurants (ISIC 50-
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13 55); transport, storage & communication (ISIC 60-64); and financial intermediation (ISIC 65-
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22 *3.3. Statistical analysis procedures*

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24 The following are statistical procedures used in this study. Exploratory factor analysis is used
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26 to identify and combine innovation barriers variables. Ordered logistic estimation is used to
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28 measure the impact of innovation barriers on firm openness decision i.e. BREADTH and
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30 DEPTH as the two dependent variables are ordinal variables. Logistic regression is used to
31
32 measure the impact of innovation barriers on firm openness indicators such as external R&D,
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34 cooperation, and acquisition as the variables are binary variables. Tobit regression is used to
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36 measure the impact of firm openness decision on innovation performance that consists of sales'
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38 proportion of product innovation new to the market and to the firms.
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45 **4. Data analysis and results**

46 *4.1. Descriptive statistics*

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48 Table 2 reports the descriptive statistics results. On average, the innovative firms produce a
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50 higher proportion of product innovation new to the firms (NEW2FIRMS) than product
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52 innovation new to the market (NEW2MARKET), 32.13% versus 19.91%, respectively.
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54 Surprisingly, there is no big gap between the mean of innovation barriers. The average of
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56 barriers related to high cost and risk of innovation is slightly higher than the rest of innovation
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barriers i.e. around 2.60. In terms of firms' openness, on average, Indonesian firms use between 5 and 6 sources of external knowledge in innovation activities. While the firms source external knowledge intensively from 1 to 2 external knowledge providers. Acquisition activities of machinery, equipment and software, on average, have a greater proportion (i.e. around 70%) than external R&D and cooperation that accounted for lower than 30%. Table 3 displays correlation outputs among the studied variables. In general, there is no correlation coefficient that may indicate multicollinearity among the variables.

Table 2 Descriptive statistics

VARIABLES	OBS	MEAN	SD	MIN.	MAX.
<i>Innovation performance</i>					
NEW2MARKET (%)	535	19.912	27.060	0	100
NEW2FIRMS (%)	535	32.125	32.931	0	100
<i>Innovation barriers</i>					
INFUND	535	2.550	1.102	0	4
EXFUND	535	2.273	1.114	0	4
HIGH-COST	535	2.695	1.049	0	4
HIGH-RISK	535	2.660	1.020	0	4
STAFF-RESIST	535	2.265	1.046	0	4
MGR-RESIST	535	2.099	1.074	0	4
ORG-RIGID	535	2.142	1.075	0	4
PERSONNEL	535	2.409	1.077	0	4
TECH-INFO	535	2.348	1.058	0	4
MKT-INFO	535	2.333	1.046	0	4
COOPERATION	535	2.398	1.086	0	4
LABOUR	535	2.176	0.994	0	4
MARKET-DOM	535	2.507	1.084	0	4
UNCER-DEMAND	535	2.394	1.015	0	4
CUSTOM-ACCEPT	535	2.265	1.011	0	4
INFRASTRUCTURE	535	2.391	1.084	0	4
IND-STANDARD	535	2.314	1.099	0	4
GOVREG	535	2.144	0.870	0	3
<i>Firm openness</i>					
BREADTH	535	5.222	2.612	0	9
DEPTH	535	1.533	1.483	0	8
EXTERNAL_RD	535	0.170	0.376	0	1
COOPERATION	535	0.273	0.446	0	1
ACQUISITION	535	0.708	0.455	0	1
<i>External sources of information</i>					
SUPPLIERS	535	2.725	1.124	1	4
CUSTOMERS	535	3.318	0.868	1	4

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3		COMPETITORS	535	2.779	1.040	1	4									
4		CONSULTANT	535	1.852	1.009	1	4									
5		UNIVERSITIES	535	1.527	0.827	1	4									
6		PUBLIC_RD	535	1.439	0.749	1	4									
7		EVENTS	535	2.021	1.069	1	4									
8		PUBLICATION	535	1.763	0.963	1	4									
9		ASSOCIATION	535	1.968	1.053	1	4									
10		<i>Absorptive capacity</i>														
11		INNOVATION_EXPEND.	535	1.817	1.053	1	4									
12		BACHELOR_STAFF (%)	535	20.056	26.685	0	100									
13		R&D_STAFF (%)	535	5.363	12.654	0	100									
14		TRAINING	535	0.634	0.482	0	1									
15		<i>Firms characteristics</i>														
16		Firm Size	535	1.568	0.699	1	3									
17		Ownership: <i>National</i>	535	0.914	0.281	0	1									
18		Ownership: <i>Multi-national</i>	535	0.028	0.165	0	1									
19		Ownership: <i>Joint-venture</i>	535	0.058	0.234	0	1									
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Table 3 Correlation outputs

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.NEW2MARKET	1.0														
2.NEW2FIRMS	-.12	1.0													
3.STAFF & ORG.	.01	.04	1.0												
4.INSTITUTION	.06	.00	.03	1.0											
5.FINANCE & RISK	-.06	-.10	.06	.13	1.0										
6.KNOWLEDGE	-.02	-.02	.17	.06	.13	1.0									
7.MARKET	.00	.03	.06	.09	.09	.11	1.0								
8.BREADTH	.12	.00	.15	.31	-.04	.02	.05	1.0							
9.DEPTH	.14	.01	.20	.18	.08	.10	.07	.38	1.0						
10.EXT-RD	.05	.03	.08	-.02	-.06	-.003	-.004	.21	.08	1.0					
11.ACQUISITION	.07	-.10	.10	.03	-.05	.02	-.09	.10	.07	.17	1.0				
12.INNOV_EXPEND	.15	-.13	.01	.03	-.07	-.06	-.07	.20	.08	.31	.18	1.0			
13.BACHELOR	-.05	-.04	-.11	-.08	.08	.02	.05	.04	-.01	-.02	.01	.00	1.0		
14.R&D-STAFF	.02	-.03	-.03	.04	-.01	-.02	-.04	.06	.00	-.04	.02	-.02	.20	1.0	
15.TRAINING	.12	.07	.13	.04	-.07	-.07	-.06	.21	.14	.16	.14	.13	-.05	.04	1.0

4.2. Factor analysis

Table 4 displays the results of factor analysis of the 18 innovation barrier factors. Factor loadings above 0.40 were retained for factor grouping. The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.92, 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 0.93. Based on factor analysis, barriers to innovation can be categorised into 5 factors, namely ‘human resource and organisation capabilities’ (HR & ORG), ‘institutional infrastructure’ (INSFRA), ‘financial and risk’ (FIN & RISK), ‘information and cooperation’ (INFO & COOP), and ‘market domination and uncertainty’ (MKT & UNCER).

Table 4 Components loading for innovation barriers

INNOVATION BARRIERS	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
INFUND			0.64		
EXFUND			0.62		
COST			0.67		
RISK			0.53		
STAFF-RESIST	0.71				
MGR-RESIST	0.81				
ORG-RIGID	0.79				
PERSONNEL	0.61				
TECH-INFO				0.58	
MKT-INFO				0.58	
COOPERATION				0.48	
LABOUR					
MARKET-DOM					0.45
UNCER-DEMAND					0.43
CUSTOM-ACCEPT					
INFRASTRUCTURE		0.52			
IND-STANDARD		0.81			
GOVREG		0.81			
Eigenvalue	3.28	2.69	2.29	1.60	1.08
<i>Cronbach's alpha</i>			0.93		
<i>Kaiser-Meyer-Olkin (KMO)</i>			0.92		
<i>% of total variance explained</i>			0.91		

Notes:

Factor 1 *Human resources and organisation capabilities (HR & ORG);*

Factor 2 *Institutional infrastructure barriers (INSFRA);*

Factor 3 *Financial & risk barriers (FIN & RISK);*

Factor 4 *Information and cooperation barriers (INFO & COOP);*

Factor 5 *Market domination and uncertainty barriers (MKT & UNCER)*.

4.3. *The impact of innovation barriers on firms' openness*

Table 5 displays ordered logistics and logistics regressions outputs of the impact innovation barriers on firms' openness. Constraints related to HR and ORG are positively and significantly effect external search breadth and depth, cooperation, and acquisition activities. This type of constraints may relevant to a phenomenon so-called 'not-invented-here' syndrome (Katz and Allen, 1982) that hinder firm openness (Burcharth *et al.*, 2014). This finding suggests that the greater firms experiencing resistance against change and innovation from inside the firms, the more likely firms' response by performing greater external search breadth and depth, external R&D, cooperation, and acquisition. Constraints related to INSFRA have a positive and significant association with breadth and depth. This indicates that the greater the firms lack sufficient infrastructure, industry standard, and government regulation, the more likely the firms source information from external broadly and deeply. However, there is no positive evidence between INSFRA constraints and the rest of openness indicators. This finding supports the previous study in a developing country context (Fu *et al.*, 2014).

Turning to constraints related to FIN and RISK, table 5 shows that overall the constraints tend to have negative direction on firms' openness, however, a significant impact can be found in cooperation. This indicates that when firms face FIN and RISK constraints, the less likely firms do cooperation with external parties. Since any cooperation activities require financial resources and involve risk. This finding supports not only the previous study that used cooperation activities as the firm openness indicator (Drechsler and Natter, 2012) but also a majority studies on the relationship between financial constraints and innovation.

The remaining innovation barriers, i.e. INFO and COOP, tend to have no significant association with firm openness indicators. A marginal positive and significant association can be found between INFO and COOP barriers and external search depth. By contrast, a marginal

negative and significant correlation exists between MKT and UNCER and acquisition. Based on the explained findings, hence, hypothesis 1 is partially supported.

Turning to control variables, of AC indicators, innovation activities expenditure and training activity tend to have consistent positive impacts on firm openness indicators. Firm size has a positive and significant impact on external search breadth and external R&D. This indicates that larger firms tend to source external knowledge broadly and perform external R&D. This is a reasonable finding since larger firms tend to have better financial and non-financial resources to support external knowledge sourcing and external R&D than smaller firms. While, firm ownership and sectors, overall have no significant impact on firm openness indicators.

Table 5 The impact of innovation barriers on firms' openness

Barriers	BREADTH	DEPTH	EXT_RD	COOPERATE	ACQUISITION
HR & ORG.	.23**(.10)	.51***(.12)	.22(.15)	.29**(.12)	.26**(.12)
INSFRA.	.64***(.10)	.39***(.13)	-.06(.15)	0.07(.12)	.08(.12)
FIN & RISK	-.14(.11)	.08(.14)	-.17(.16)	-.31**(.13)	-.16(.13)
INFO & COOP	.06(.11)	.26*(.15)	.08(.18)	.20(.15)	.12(.14)
MKT & UNCER	.08(.13)	.08(.16)	.12(.20)	.09(.16)	-.27*(.16)
Innovation activities expend.	.31***(.09)	.12(.11)	.53***(.12)	.21*(.11)	.34***(.11)
% Staff with bachelor's degree	.006*(.003)	.0001(.004)	.01(.005)	.005(.004)	.003(.004)
% R&D staff	.01(.01)	.005(.01)	-.02(.01)	-.0003(.01)	.003(.01)
Training	.70***(.19)	.52**(.25)	.62**(.31)	1.01***(.25)	.44**(.21)
Firm size	.28**(.14)	.05(.17)	.51***(.19)	.24(.16)	.12(.17)
Ownership: <i>National</i>					
Ownership: <i>Multi- National</i>	-.30(.53)	.49(.62)	.35(.65)	-1.43*(.81)	-.01(.71)
Ownership: <i>Joint Venture</i>	.17(.35)	-.57(.57)	.54(.47)	.72*(.42)	-.32(.43)
Log likelihood	-529.877	-292.337	-205.377	-279.608	-297.582
Number of obs.	535	535	535	535	535
LR chi2(14)	114.39	58.35	77.2	67.93	50.65
Prob > chi2	.00	.00	.00	.00	.00
Pseudo R2	.097	.091	.158	.108	.078

Significant levels: * < 0.10; ** < 0.05; *** < 0.01; Standard errors are in parentheses

4.4. Firms' openness decision on innovation performance

Table 6 displays the outputs of Tobit regression on the impact of firms' openness on innovation performance. Surprisingly, only external search depth significantly and positively influences the share of product innovation new to the market. This suggests that the depth of external sourcing information is positively associated with innovation performance. In the previous studies, both external search breadth and depth positively influence share of product innovation new to the market of Indonesian manufacturing firms (Hartono and Kusumawardhani, 2018) as well as in the UK manufacturing firms (Laursen and Salter, 2006). While external R&D has a positive marginal impact on share of product innovation new to the firms, acquisition has a negative impact on share of incremental innovation. A possible reason could be that acquisition of machinery, equipment and software will demotivate firms to perform incremental product innovation as this can be replaced by performing acquisition activities. Based on such findings, hence, hypothesis 2 is partially accepted.

Turning to the AC construct, results are more ambiguous. While, innovation activities expenditure is positively related to the introduction of new to the market novelties, they are negatively associated with new to the firm innovations. The same pattern is observed for the percentage of staff with bachelor's degree seems to negatively – though not in a statistically significant manner – influence innovation performance. On the other hand, training is positively related to both innovation performance types. Lastly, all firm sectors tend to perform more innovation new to the market than to the firms.

Table 6 The impact of firms' openness on innovation performance

	NEW2MARKET ¹	NEW2FIRMS ²
BREADTH	0.87(0.98)	0.04(0.86)
DEPTH	3.61**(1.58)	0.87(1.43)
EXTERNAL_RD	-0.77(6.40)	10.24*(5.76)
COOPERATION	8.47(5.23)	6.90(4.70)

ACQUISITION	3.07(5.15)	-10.17**(4.48)
Innovation Expenditure	6.77***(2.38)	-6.93***(2.15)
% Staff with bachelor's degree	-0.09(0.09)	-0.05(0.08)
% R&D staff	0.13(0.18)	-0.12(0.16)
Training	11.85**(5.02)	9.34**(4.44)
Firm size	-4.07(3.55)	-1.66(3.22)
Ownership: <i>National</i>	-	-
Ownership: <i>Multi-National</i>	0.67(13.62)	10.66(12.12)
Ownership: <i>Joint Venture</i>	8.35(9.40)	0.96(8.55)
Log likelihood	-1538.74	-2054.93
Number of obs.	535	535
LR chi2(14)	56.38	36.75
Prob > chi2	0.00	0.01
Pseudo R2	0.018	0.01

Notes: Sig. levels * <0.10 ; ** <0.05 ; *** <0.01 ; standard errors are in parentheses

¹ Sales' proportion of product innovation new to the market;

² Sales' proportion of product innovation new to the firms

5. Discussion and conclusion

Opening up the innovation process has become an important strategy for firms to overcome any internal and external constraints that may hinder innovation activities. This study aims to examine the impact of barriers that impede innovation activities on firm openness using data derived from Indonesia Innovation Survey (IIS) 2014. This study extends the previous innovation barrier studies using a broader firm openness indicator that consists of external search breadth and depth, external R&D, cooperation, and acquisition activities. Subsequently, the study examines the impact of firm openness decision on innovation performance that is measured by share of product innovation new to the market and to the firms. Innovation barriers faced by Indonesian firms can be divided into human resource and organisation attitude, institution, financial and risk, knowledge, and market. The first key finding of this study is that different barriers to innovation lead to different firm openness decisions. Sourcing external information broadly and deeply, performing cooperation and acquisition activities are openness decision conducted by the firms if they are experiencing human resource and organisation

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3 related barriers. While focusing on external search breadth and depth is openness decision as
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5 the response of the firms face institution barriers. Less performing cooperation activities is the
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7 firm's response if they experience financial and risk constraints.
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10 Concerning the control variables, the study shows that absorptive capacity (i.e. the
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12 innovation activities expenditure and training activities) facilitates the firms to be more open.
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14 This indicates that to be more open, firms not only need innovation funding but also skill and
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16 knowledge gained from training activities. Regarding the firm size, larger firms are more open
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18 than smaller firms. This can be seen from the positive association between firm size and
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20 external search breadth and between firm size and external R&D.
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24 In terms of firm openness and innovation performance relationship, the major key finding
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26 is that dependent on the decision firms make in regard to openness, the innovation performance
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28 is influenced differently. In particular, sourcing external search depth leads to positive impact
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30 on the share of product innovation new to the market, while external R&D contributes to the
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32 share of product innovation new to the firms. However, acquisition activities lowering sales'
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34 proportion of product innovation new to the firms. Looking at the control variables, absorptive
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36 capacity (i.e. innovation activities expenditure and training) consistently and positively affect
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38 innovation performance. Lastly, all firm sectors tend to contribute positively on the share of
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40 product innovation new to the market.
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44 *5.1. Implications for theory and practice*

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46 This study contributes to the innovation barrier literature by empirically testing whether
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48 experiencing barriers to innovation is associated with involvement a broader firm openness
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50 decision that has not been accommodated in the previous CIS-innovation barrier studies.
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52 Previous studies tend to link innovation barriers with a narrow firm openness decision. The
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54 important finding is that different openness decision can be used to overcome different
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56 constraints to innovation. Internal constraints from inside firms related to human resource and
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3 organisation resistance to innovation were responded by firms implementing the greater
4 number of openness indicator than other types of constraints. In addition, firms also tend to
5 avoid any openness decision, e.g. external R&D and cooperation, that involve financial and
6 risk constraints. Hence, to facilitate firms to be more open, this study suggests that firms need
7 to invest in a greater amount of innovation activities expenditure and training activities. In this
8 case, larger firms have better ability in facilitating such investment, as a result, larger firms are
9 more open than smaller firms. This study also enriches the innovation studies literature on the
10 understanding that different firm openness decision has a different impact on innovation
11 performance. In this study, of firm openness decision, sourcing external information
12 intensively and performing external R&D contribute to innovation performance. While the
13 decision on acquisition will diminish return of incremental innovation.
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28 From a practitioner point of view, this research calls attention not to merely focus on a
29 narrow firm openness decision to overcome internal and external innovation constraints.
30 Moreover, firms should think beyond sourcing external information widely and deeply that has
31 been recommended enormously by previous OI studies. However, the more open the firms, the
32 greater innovation activities expenditure. In this case, there is an emerging challenging decision
33 to balancing between innovation barriers, firm openness, and innovation performance. On the
34 one hand, in order to improve their resilience, firms need to be more open. On the other hand,
35 to be more open and to increase innovation performance, firms need greater financial
36 investment to support innovation activities such as external R&D, cooperation, acquisition and
37 training activities.
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54 *5.2. Limitations and future research direction*

55 Some limitations of the study are worth mentioning alongside the opportunities for future
56 research they recommend. First, the analysis of innovation barriers' impact on firm openness
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3 decision was based on cross-sectional data. Hence, this database did not facilitate the
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5 consideration of dynamic effects of innovation barriers on firm openness decision. Hence,
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7 further studies should cover the long-term effect of innovation barriers on firm openness
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9 decision using panel data of innovation survey. Second, only a single developing country (i.e.
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11 Indonesia) is used in this study, thus, the findings may be subjectively applying to Indonesian
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13 firms only as country-specific conditions may involve the pattern of innovation barriers and
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15 firms' openness decision. A further comparison study among developing countries would be
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17 interesting to be conducted to identify the common pattern on innovation barriers, firms'
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19 openness and innovation performance.
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International Journal of Innovation Science - Decision on Manuscript ID IJIS-10-2020-0218

1 message

International Journal of Innovation Science <onbehalf@manuscriptcentral.com>

22 January 2021 at 13:55

Reply-To: geijis2020@sibmpune.edu.in

To: arif.hartono@uii.ac.id

22-Jan-2021

Dear Dr. Hartono:

Manuscript ID IJIS-10-2020-0218 entitled "Linking open innovation, innovation barriers, and performance of Indonesian firms" which you submitted to the International Journal of Innovation Science, has been reviewed. The comments of the reviewer(s) are included at the bottom of this letter.

The reviewer(s) have recommended revisions to the submitted manuscript, before it can be considered for publication. Therefore, I invite you to respond to the reviewer(s)' comments and revise your manuscript.

To revise your manuscript, log into <https://mc.manuscriptcentral.com/ijis> and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision.

You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript using a word processing program and save it on your computer. Please also highlight the changes to your manuscript within the document by using the track changes mode in MS Word or by using bold or coloured text.

Once the revised manuscript is prepared, you can upload it and submit it through your Author Centre. The deadline for uploading a revised manuscript is 06-Feb-2021 from receiving this email. If it is not possible for you to resubmit your revision within this timeframe, we may have to consider your paper as a new submission.

When submitting your revised manuscript, you will be able to respond to the comments made by the reviewer(s) in the space provided. You can use this space to document any changes you make to the original manuscript. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response to the reviewer(s).

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Once again, thank you for submitting your manuscript to the International Journal of Innovation Science and I look forward to receiving your revision.

Sincerely,

Dr. R Raman

Guest Editor, International Journal of Innovation Science

geijis2020@sibmpune.edu.in, shaileshrastogi@sibmpune.edu.in

Reviewer(s)' Comments to Author:

Reviewer: 1

Recommendation: Minor Revision

Comments:

PI incorporate the suggestion given including the following research which should be cited

Kline, S. J., & Rosenberg, N. (2010). An overview of innovation. In *Studies On Science And The Innovation Process: Selected Works of Nathan Rosenberg* (pp. 173-203).

Additional Questions:

1. Originality: Does the paper contain new and significant information adequate to justify publication?: Yes

2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: Yes,

The following should be cited

Kline, S. J., & Rosenberg, N. (2010). An overview of innovation. In *Studies On Science And The Innovation Process: Selected Works of Nathan Rosenberg* (pp. 173-203).

3. Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: Yes

The author should mention the time period of the study.

Author should also demonstrate transparency by mentioning the how the respondents were chosen?

4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: Yes

5. Practicality and/or Research implications: Does the paper identify clearly any implications for practice and/or further research? Are these implications consistent with the findings and conclusions of the paper?: Yes

6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: Yes

Reviewer: 2

Recommendation: Accept

Comments:

The paper is well conceptualized and presented. However, adding the latest citation can be done. In RM using quantitative techniques can be justified for clarity of readers. Overall a good work.

Additional Questions:

1. Originality: Does the paper contain new and significant information adequate to justify publication?: Yes, the paper is good and provides good clarity to the reader about the need for research. It is good to see clearly defined objectives of the study.

2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: Most of the related literature is cited however, recent work in the field is missing. The paper quality will be improved by combining recent work.
3. Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: Yes the RM is strong and well explained and presented.
4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: The results are well presented and adequate.
5. Practicality and/or Research implications: Does the paper identify clearly any implications for practice and/or further research? Are these implications consistent with the findings and conclusions of the paper?: Yes.
6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: Yes, paper has a good quality of communication and clearly expresses the concepts.

03

- **Bukti Dokumen Respons Kepada Reviewer**
- **Bukti Artikel Yang Disubmit Ulang (Resubmit)**
- **Bukti Konfirmasi Submit Review Putaran Pertama – R1 (22 Januari 2021)**

RESPONSES TO REVIEWERS' COMMENTS:

Dear Editor in Chief of International Journal of Innovation Science,

We are very excited to have been given the opportunity to revise our manuscript. We carefully considered reviewers comments. Herein, we explain how we revised the paper based on those comments and recommendations in the following table. We want to extend our appreciation for taking the time and effort necessary to provide such insightful guidance.

Kind Regards,
Arif Hartono

Reviewer Comments	Responses
Reviewer 1 – Minor Revision	
Point 2. A suggestion to cite the below authors: Kline, S.J. and Rosenberg, N. (2010), “An Overview of Innovation”, <i>Studies on Science and the Innovation Process</i> , pp. 275–305.	Many thanks for the suggestion regarding the citation of Kline & Rosenberg (2010). We have cited the suggested authors in the page 2-3. We underlined the additional sentences.
Point 3. A suggestion to explain the period of the study. Point 3. A suggestion to explain how respondents were chosen.	We have added explanation on the study period in page 12. We have added explanation on how respondents were chosen and added a table that presents types of firms involved in the study (Please see page 12). We underlined the additional sentences.
Reviewer 2 – Accepted	
Point 2. A suggestion to add more recent literature.	Below are the additional relevant literatures. We also cited a literature from International Journal of Innovation Science. Coad, A., Pellegrino, G., & Savona, M. (2016). Barriers to innovation and firm productivity. <i>Economics of Innovation and New Technology</i> , 25(3), 321–334. https://doi.org/10.1080/10438599.2015.1076193 Hartono, A. (2018). Do Innovation Barriers Drive A Firm to

	<p>Adopt Open Innovation? Indonesian Firms' Experiences. <i>Academy of Strategic Management Journal</i>, 17(6), 1939–6104.</p> <p>Jung, D., Kim, Y., Suh, Y., & Kim, Y. (2016). Perceived innovation barriers and open innovation performance: Insights from Korea. <i>International Journal of Knowledge-Based Development</i>, 7(2), 125–142. https://doi.org/10.1504/IJKBD.2016.076466</p> <p>Oduro, S. (2020). Exploring the barriers to SMEs' open innovation adoption in Ghana: A mixed research approach. <i>International Journal of Innovation Science</i>, 12(1), 21–51. https://doi.org/10.1108/IJIS-11-2018-0119</p> <p>Zhu, Y., Wittmann, X., & Peng, M. W. (2012). Institution-based barriers to innovation in SMEs in China. <i>Asia Pacific Journal of Management</i>, 29(4), 1131–1142. https://doi.org/10.1007/s10490-011-9263-7</p>
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Linking open innovation, innovation barriers, and performance of Indonesian firms

Journal:	<i>International Journal of Innovation Science</i>
Manuscript ID	IJIS-10-2020-0218.R1
Manuscript Type:	Original Research
Keywords:	Open Innovation, innovation barriers, innovation performance, Indonesian firms

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Linking open innovation, innovation barriers, and performance of Indonesian firms

Purpose – This study examines open innovation, that consists a wide range of external knowledge search activities such external search breadth and depth, external R&D, cooperation, and acquisition activities, as a response to different innovation barriers faced by Indonesian firms.

Design/methodology/approach – Data derived from Indonesia innovation survey. Exploratory factor analysis is used to identify and combine innovation barriers variables. Ordered logistic estimation is used to measure the impact of innovation barriers on firm openness decision. Logistic regression is used to measure the impact of innovation barriers on firm openness indicators such as external R&D, cooperation, and acquisition as the variables are binary. Lastly, Tobit regression is used to measure the impact of firm openness decision on innovation performance.

Findings – The main findings indicate that different barriers to innovation lead to different firms' openness decisions and different decisions on openness have differentiated influence on innovation performance.

Originality/value – This study contributes to the innovation barrier literature by empirically testing whether experiencing barriers to innovation is associated with a broader external knowledge search activity. Previous studies tend to link innovation barriers with a narrow activity as indicated by external knowledge searching widely and deeply.

Keywords Open innovation, innovation barriers, innovation performance, Indonesian firms

1. Introduction

A firm's openness has become a prominent issue in both theory and practices over the last decades, especially, after the concept of open innovation (OI) was coined by (Chesbrough, 2003). Firms become more open and permeable to their external environment for several reasons. Many firms lack the adequate resources and capabilities to deal with market and technological uncertainty of innovation, the rising cost of internal R&D and risks, and shorter product life cycles, as consequently, a large majority of firms can hardly address those challenges by relying solely on their resources and capabilities (Chesbrough, 2006). In the context of developing countries, issues related to innovation barriers are more relevant as firms naturally face substantial barriers innovation related to institutional, resources, and capabilities (Fu *et al.*, 2014). Hence, firms in developing countries have been found not to perform R&D (Goñi and Maloney, 2014), unable to catch-up with developed countries (Gorodnichenko and Schnitzer, 2013), to pursue different innovation strategies (Gault, 2010), have underdeveloped absorptive capacity than their counterparts in developed countries (Bilgili *et al.*, 2016), and as a result, to engage with greater breadth and depth of external knowledge to overcome innovation barriers (Fu *et al.*, 2014).

Any factors that impede, delay or completely block innovation can be seen as innovation barriers (Mirow *et al.*, 2008). The terms barriers, hurdles, impediments and obstacles can be used interchangeably (Hueske and Guenther, 2015). It is argued that a better understanding of innovation barriers can help firms to create the development of an environment that supports innovation (Hadjimanolis, 1999). The 3rd edition of Oslo Manual (OECD and EUROSTAT, 2005) that used by many developed countries (e.g. European countries) as guidelines for collecting and interpreting innovation data, divided any factors that hamper innovation activities into cost factors, knowledge factors, market factors, institutional factors, and other reasons for not innovating. Such different factors exist and influence the success of innovation

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3 since the nature of innovation process is “complex, uncertain, somewhat disorderly, and subject
4 to changes of many shorts” (Kline and Rosenberg, 2010, p. 275).
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8 Although a substantial number of studies on innovation barrier have been conducted, the
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10 studies tend to focus on financial factors that hinder innovation activities (Altomonte *et al.*,
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12 2016; Canepa and Stoneman, 2002, 2008; Crisóstomo *et al.*, 2011; Efthyvoulou and Vahter,
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14 2016; Hall *et al.*, 2016; Lööf and Nabavi, 2016; Mohnen, Palm, van der Loeff, *et al.*, 2008;
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16 Savignac, 2008; Silva and Carreira, 2012; Ughetto, 2009) and perception of innovation barriers
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18 (Baldwin and Lin, 2002; D’Este *et al.*, 2008, 2012; Demirbas *et al.*, 2011; Frenkel, 2003; Galia
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20 *et al.*, 2012; Hölzl and Janger, 2013, 2014; Iammarino *et al.*, 2007; Segarra-Blasco *et al.*, 2008;
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22 Shiang and Nagaraj, 2011; Tourigny and Le, 2004; Xie *et al.*, 2010). Issues related to financial
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24 constraints include the importance between financial and non-financial constraints; comparison
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26 financial constraints across firms’ size, sectors, technology intensity, export orientation as well
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28 as the influence of financial constraints on not starting, being delayed or postponed projects.
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30 The issues studied in the perceived innovation barriers include the comparison between
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32 innovative and non-innovative firms; between users and non-users of technology; between
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34 small and large firms; and among firms in European countries.
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40 This study intends to directly link innovation barriers with firms’ openness decision that
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42 has hitherto received little attention in the academic literature. In previous studies, which
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44 employed data from innovation survey (e.g. community innovation survey, also known as CIS),
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46 innovation barriers tend to be linked with narrow firm’s openness indicators and focuses
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48 exclusively on the inbound perspective of open innovation, i.e. the external search for
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50 information and cooperation to innovate internally. More precisely, those indicators encompass
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52 external search breadth and depth based on Laursen and Salter’s (2006) framework (Fu *et al.*,
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54 2014; Garriga *et al.*, 2013; Keupp and Gassmann, 2009), cooperation activities (Antonioli *et*
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56 *al.*, 2017), and breadth of cooperation activities with local and foreign partners (Drechsler and
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3 Natter, 2012). Hence, this paper intends to extend these studies by linking innovation barriers
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5 with a broader firm openness decision (beyond external search breadth and depth) using
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7 innovation data derived from a developing country i.e. Indonesia Innovation Survey 2014 (IIS
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9 2014).
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12 Firm openness decision can be based on different activities that are operationalised
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14 differently by different authors (Barge-Gil, 2010). A broad definition of openness is proposed
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16 by Chesbrough (Chesbrough, 2003), it emphasises that valuable ideas emerge and can be
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18 commercialised from inside and outside the firm. This is the most commonly used definition
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20 in the literature (Dahlander and Gann, 2010). Other scholars identified three cores OI processes
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22 such as the outside-in process, the inside-out process, and the coupled process (Gassmann and
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24 Enkel, 2004). While others identified three strategic characteristics of OI such as opportunity-
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26 seeking prospector, dual-oriented analyser, and market segment securing defender (Bader and
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28 Enkel, 2014). Openness studies using innovation surveys data tended to use the inbound
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30 breadth and depth framework developed by Laursen and Salter (2006). Based on a
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32 bibliographic analysis of previous openness studies, the outside-in process can consist of firms'
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34 sourcing and acquiring activities (Dahlander and Gann, 2010). Other scholars, Drechsler and
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36 Natter (2012) propose the degree of openness based on a firm's external domestic and foreign
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38 collaboration partners. Other scholars use three ways for firms to be open such as information
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40 transfer from informal the network, R&D collaboration, and technology acquisition (Kang and
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42 Kang, 2009). While, Huang and Rice (2009) argue that openness can include acquisitions; the
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44 purchase of technology rights through licensing; the contracting out of internal R&D to external
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46 agents, other firms or research institutions; and the use of formal and informal inter-
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48 organizational networks. Hence, this study employs firm openness decision that differs from
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50 previous CIS-based innovation barrier studies, that encompass external search breadth and
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52 depth, external R&D, cooperation, and acquisition (machinery, equipment, and software).
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3 External R&D, cooperation, and acquisition activities imply that firms' partners share their
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5 resources and knowledge.
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8 This study intends to answer whether firms that face different barriers to innovation are
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10 more likely to open up their innovation process, as can be reflected from external search breadth
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12 and depth, external R&D, cooperation, and acquisition activities. Subsequently, this study
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14 intends to measure the impact of firm openness decision on innovation performance. It is
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16 expected that this research contributes to two key issues in the innovation literature. First, this
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18 study employs a broader firm openness decision than previous CIS-based innovation barrier
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20 studies. Therefore, this study looks at whether a broader firm openness might be a viable
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22 strategy to cope with different barriers to innovation. Second, this study examines the impact
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24 of a broader firm openness decision on innovation performance, while previous CIS-based
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26 studies tended to focus on the impact of external search breadth and depth on innovation
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28 performance.
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36 **2. Literature Review and Hypotheses Development**

37 *2.1. Common barriers to innovation*

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39 The first common factor that hinders innovation activities that have been studied extensively
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41 in the financial factor. Most research was conducted in developed countries empirical setting,
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43 for examples, across European countries (Altomonte *et al.*, 2016; Canepa and Stoneman, 2002;
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45 Efthyvoulou and Vahter, 2016; Hall *et al.*, 2016), in the UK (Canepa and Stoneman, 2008), in
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47 Spain (González *et al.*, 2005), in Sweden (Lööf and Nabavi, 2016), in Netherland (Mohnen,
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49 Palm, van der Loeff, *et al.*, 2008), in France (Savignac, 2008), in Portugal (Silva and Carreira,
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51 2012), and in Italy (Ughetto, 2009). In contrast, there are a few studies that focus on financial
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53 factors as barriers to innovation in developing countries, for instance, a study conducted by
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55 (Crisóstomo *et al.*, 2011).
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3 Based on data used in the financial barriers studies, it can be divided into CIS-based innovation
4 barriers studies (Canepa and Stoneman, 2002, 2008; Efthyvoulou and Vahter, 2016; Mohnen,
5 Palm, Van der Loeff, *et al.*, 2008; Savignac, 2006) and non-CIS-based innovation barrier
6 studies (Altomonte *et al.*, 2016; Crisóstomo *et al.*, 2011; González *et al.*, 2005; Hall *et al.*,
7 2016; Lööf and Nabavi, 2016; Savignac, 2008; Ughetto, 2009). CIS-based innovation barriers
8 studies provide a different insight into how financial factors affect innovation. Financial
9 factors, especially lack of the appropriate source of finance found to be the most important
10 barrier than other factors that affect innovation projects to be delayed, abandoned, or even not
11 started (Canepa and Stoneman, 2002; Mohnen *et al.*, 2008). Financial factors also severely
12 impact innovative activity, especially in high technology sectors and smaller firms (Canepa
13 and Stoneman, 2008). Furthermore, it affects the innovation performance in the production
14 sector stronger than in the service sector (Efthyvoulou and Vahter, 2016). Using data similar
15 to French CIS, Savignac (2006) reveals that innovative firms without financial constraints have
16 a better profile in economic performance, financing structure and risk than non-innovative
17 firms. Besides, firms having innovative projects that face financial constraints tend to reduce
18 the implementation of innovative investments (Savignac, 2006). Based on Portuguese CIS data,
19 (Silva and Carreira, 2012) found that financial constraints hinder investment in R&D and
20 innovation, but subsidy as part of public financial support did not help to overcome such
21 constraints.

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47 Different impacts caused by financial factors on innovation activities also can be found
48 in previous non-CIS studies. For instance, a mutual relationship exists among exporting,
49 productivity, and financial constraint. For example, exporters and high productivity firms are
50 less likely to be credit constrained and better access to credit is associated with firms with larger
51 productivity and a higher probability of exporting (Altomonte *et al.*, 2016). Altomonte *et al.*,
52 (2016) concluded that financial constraints have an indirect effect on innovation by reducing
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3 incentives to innovate, rather than by reducing the ability to innovate. In the case of firms in
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5 an emerging country, the study shows that although recent institutional framework changes and
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7 market advances started since the 1990s, Brazilian firms face financial constraints when they
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9 implement innovation projects (Crisóstomo *et al.*, 2011). A positive impact of financial
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11 incentive in the form of subsidies on R&D activities also has been found. For example,
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13 subsidies stimulate R&D and some firms would stop performing R&D in the absence of
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15 subsidies (González *et al.*, 2005). In the case of exporters, high technology innovative firms
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17 tend to exploit internal cash resources if they face financial shock, while there is no relationship
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19 between financial factors and innovation in medium and low technology exporters (Löf and
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21 Nabavi, 2016).
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26 The second main strand of innovation barriers literature is related to the perception of
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28 innovation barriers. The literature is dominated by CIS-based studies in developed economies
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30 context except for Shiang and Nagaraj's (Shiang and Nagaraj, 2011) study. An interesting
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32 finding from these studies is that barriers to innovation in innovation survey should be
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34 considered as indicating how successfully a firm can overcome barriers (Baldwin and Lin,
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36 2002; Tourigny and Le, 2004). Clausen (Clausen, 2008) suggested that instead of obstacles
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38 variables, the real obstacles are the obstacles perceived by the managers. Hence, innovative
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40 firms are more inclined to perceive obstacles and as a result, the perception of obstacles would
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42 be positively linked with the propensity to innovate. In relation to that, D'Este *et al.*, (2012)
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44 argue that we need to differentiate between deterring barriers to innovation that deter firms
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46 from engaging in innovation activities and revealed barriers that are experienced by firms as
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48 they are performing innovation activities.
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54 Another issue of the perception of innovation barriers discussion is what are the most
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56 important barriers commonly faced by firms. In this case, previous studies consolidate a list of
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58 obstacles from innovation survey into fewer groups of obstacles. The four sets of innovation
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3 barriers that are identified and usually studied are cost factors, knowledge factors, market
4 factors, and regulation factors (Galia *et al.*, 2012). Examples of innovation barriers groups from
5 the previous studies are as follows. Baldwin and Lin (2002) grouped innovation barriers related
6 to cost, institution, labour, organisation, and information. A slightly different group of obstacles
7 also can be found in D'Este *et al.*, (2012) study such as cost, knowledge, market, and regulation.
8 Using principal component analysis (PCA), Galia and Legros (2004) distinguish groups of
9 obstacles faced by firms that postponed and abandoned innovative projects. In the former
10 project, obstacles consist of three groups such as rigidities and information; risk, cost and
11 source of finance; and customer response and skilled personnel. While, in the later project,
12 obstacles can be grouped into organisational rigidities; risk and skilled personnel; and cost,
13 finance, institution, and market. A fewer group of innovation barriers can be found in the study
14 using Spanish CIS such as the cost of innovation, lack of knowledge, and market characteristics
15 (Segarra-Blasco *et al.*, 2008).
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33 In the context of Indonesia, using data derived from IIS 2011, Hartono &
34 Kusumawardhani (2019) explore the nature and importance of innovation constraints faced by
35 manufacturing firms and its impact on innovation performance was examined. The study
36 groups innovation constraints into “market and institution”, “employee and organisation
37 attitude”, “finance and risk”, and “knowledge and cooperation”. Factors related to financial
38 and risk are perceived to be the most important constraints. The study shows that different
39 innovation barriers influence types of innovation and innovation performance differently.
40 Since the IIS 2011 only surveyed Indonesian manufacturing firms, insights on how non-
41 manufacturing firms experiencing innovation barriers do not exist. The IIS 2014 data used in
42 this study covers seven industry sectors, including both manufacturing and services firms,
43 extends that body of knowledge by providing insights covering a wider context.
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2.2. *Innovation barriers and firms' openness relationship*

In the context of a developing country, Fu et al., (2014) use push and pull framework to group barriers innovation into institutional, financial, and knowledge/skill and subsequently link the barriers with breadth and depth of OI performed by Chinese manufacturing firms. They found that the three groups of obstacles are significantly associated with the firms' breadth and depth of openness in innovation. This suggests that the Chinese firms facing to a higher extent three groups of barriers are more likely to engage with OI in greater breadth and depth to mitigate the barriers. Furthermore, the firms' openness varies across different firms' ownership, size, and technology intensity. Lastly, Fu et al., (2014) suggest that future studies that link innovation barriers and firm openness should beyond inbound or outside-in process as the indicator of firm openness.

Using the exploration-exploitation framework, Keupp and Gassmann (Keupp and Gassmann, 2009) examine the impact of information- and capability-related constraints and risk-related constraints on firms' openness based on Swiss CIS data. They found that the two types of constraints positively and significantly influence the breadth and depth of OI. This suggests that firms face greater the two constraints are more likely to use external knowledge broader and deeper. Using similar CIS, i.e. Swiss CIS, Garriga et al., (2013) linking constraints on resources to firms' openness i.e. breadth and depth of OI. It turned out that such constraints have a different direction of impact on the firms' openness. The constraints positively influence the breadth of OI, by contrast, the constraints have a negative impact on the depth of OI. This indicates that the firms are more likely to engage in wider external knowledge search and are less likely to engage in deeper external knowledge search to overcome constraints related to firms' resources.

Using French CIS, Antonioli et al., (2017) conducted a recent study the impact of obstacles related to cost, market, and knowledge on the firms' probability to cooperate with

any partners and specific partners such as firms and research organisation. The study shows that financial constraint is a robust and significant driver of cooperation, both in general and across different partners. Firms experiencing financial constraints tend to cooperate with research organisations. Furthermore, interaction among the three barriers to innovation and its impact on cooperation activities are also tested. One of the most consistent findings is that the combination of cost and knowledge barriers significantly decrease the propensity to engage in cooperation activities. Based on the German CIS, scarce firm resources that consist of financial and knowledge gaps are also linked to the degree of firms' openness in innovation that is measured by the breadth of firms' involvement in cooperation activities with local and foreign partners (Drechsler and Natter, 2012). The finding shows that scarce financial resources drive firms to increase their openness.

Based on the previous studies review, the following hypothesis related to the impact of innovation barriers on a broader firm openness can be drawn:

H1 Firms experiencing greater innovation barriers are more likely to adopt greater openness of innovation that can be reflected from external search breadth and depth, external R&D, cooperation, and acquisition activities.

2.3. *The impact of firms' openness on innovation performance*

Studies on the relationship between innovation barriers and firms' openness tend to treat innovation barriers as determinants of OI and do not link firm openness to innovation performance (Drechsler and Natter, 2012; Fu *et al.*, 2014; Keupp and Gassmann, 2009). Laursen and Salter (2006), pioneering a study to examine the impact of firm openness, as indicated by external search breadth and depth, on innovation performance using a large scale data derived from UK innovation survey. The study found that breadth and depth positively affect innovation performance, however, over searching on external knowledge tend to

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3 diminish the return of innovation performance. Following Laursen and Salter (2006), several
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5 CIS-based OI studies have been conducted; however, the studies tend to be conducted in
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7 developed economies context. Evidence from OI studies in developing economies are rather
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9 scarce and research methods used limited to qualitative because data collection is rather
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11 complicated (Podmetina *et al.*, 2014).
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16 Studies on firm openness and innovation performance relationship in both developing
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18 and developed economies tend to support Laursen and Salter's (2006) work. An OI study using
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20 data from IIS 2011 found that firm openness, that is measured by external search breadth and
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22 depth, positively influence innovation performance of Indonesian manufacturing firms
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24 (Hartono and Kusumawardhani, 2018). However, decreasing returns in over searching on
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26 external search breadth and depth also can be found among Indonesian manufacturing firms.
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28 A survey on how innovative performance is affected by the breadth, depth, and orientation of
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30 firms' external search strategies among Chinese firms has been conducted (Chen *et al.*, 2011).
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32 The study found that the greater breadth and depth improve innovation performance, however,
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34 decreasing returns of innovation performance are not always present and are contingent on the
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36 innovation modes. Another study based on Indian firms shows that 'inbound open innovation
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38 is crucial in helping firms to catch-up and move toward the technological frontier' (Kafouros
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40 and Forsans, 2012, p. 362). CIS-based OI studies using various innovation surveys in different
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42 developed countries (Ahn *et al.*, 2014; Battisti *et al.*, 2015; Ebersberger *et al.*, 2012; Laursen
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44 *et al.*, 2007; Salge *et al.*, 2012) also reveal a significant and positive relationship between firms'
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46 openness and innovation performance.
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53 Hence, the following hypothesis related to firms' openness and innovation performance
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55 (measured by the share of product innovation new to the markets and the firms) relationship
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57 can be proposed:
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H2 Firm openness as indicated by external search breadth and depth, external R&D, cooperation, and acquisition are positively affecting sales' proportion of product innovation new to the market and the firms.

3. Research Methodology

3.1. Data

Data used in this study is collected and managed by Centre for Science and Technology Development Studies (PAPPIPTEK), Indonesian Science Institute (LIPI). Data were drawn from the IIS 2014 and multi-stage random sampling is used and a total of usable 927 questionnaires were successfully collected. The IIS 2014 covered innovation activities performed by Indonesian firms during 2011 – 2013. The surveyed firms are classified based on the International Standard Industrial Classification (ISIC) Rev. 3.1. Both manufacturing and services firms were surveyed in the IIS 2014. Table 1 presents classification of the surveyed firms based on the ISIC Rev. 3.1. codes.

Table 1 The Surveyed Firms' Classification

No	ISIC Rev. 3.1. Codes	Types of the Firms	%
1	ISIC 10 – 14	Mining & quarrying	5
2	ISIC 15 – 37	Manufacturing	8
3	ISIC 40 – 43	Electricity, gas & water supply	7
4	ISIC 45	Construction	5
5	ISIC 50 – 55	Trading, hotel & restaurants	55
6	ISIC 60 – 64	Transport, storage & communication	8
7	ISIC 65 – 67; 71 – 74	Financial intermediation	12

Source: The IIS 2014

The IIS 2014 used the Oslo Manual (OECD and EUROSTAT, 2005) as the guideline for collecting and interpreting innovation data. For the analysis purpose, the sample comprises only innovative firms, that is firms producing any product, process, organisational and marketing innovation and expend non-zero or positive innovation activities expenditure during

the 2011 – 2013 period. From the IIS 2014 dataset of 927 Indonesian firms, a sample of 535 innovative manufacturing and services firms was finally retained.

A firm size indicator is based on the number of employees i.e. small (5-19 employees), medium (20-99 employees) and large (more than 100 employees) firms. Of 535 firms, small firms outnumbered the proportion (55.33%), then followed by medium (32.52%) and large (12.15%) firms. In terms of firm ownership, the proportion of national firms is highly dominated, i.e. around 91%. While the rest of them accounted for small proportion i.e. multi-national firms (2.80%) and joint venture (5.79%).

3.2. Variable definition and measurement

Innovation barriers. The IIS 2014 contains 18 Likert-scale items used to question firms regarding the extent to which a specific barrier had significant negative consequences on innovation activities. The items are rated from 0 (no negative consequence) to 4 (strong negative consequence). Table 2 displays the innovation barrier variables used in this study.

Table 2 Innovation barriers and its definition

Abbreviations	Definition
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: The IIS 2014

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3 *Firm openness.* This study employs BREADTH, DEPTH, external R&D, cooperation, and
4 acquisition (e.g. acquisition of machinery, equipment, and software) as the firm openness
5 indicators. Construct of BREADTH and DEPTH follows Laursen and Salter (2006) study
6 based on 9 external sources of knowledge used for innovation present in the IIS 2014 dataset,
7 such as suppliers of equipment, materials, components or software (SUPPLIERS); clients or
8 customers (CUSTOMERS); competitors or other enterprises (COMPETITORS); consultants,
9 commercial laboratories or private R&D institutes (CONSULTANTS); universities or other
10 higher education institutions (UNIVERSITIES); government or public research institutes
11 (GOV_RD); professionals and industry associations (ASSOCIATIONS); conferences, trade
12 fairs, exhibitions (EVENTS); and scientific journals and trade/technical publications
13 (SCIENCE_PUB).

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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. Each of the 9 sources
is coded as a binary variable, 0 being no use and 1 being the 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.

In the case of DEPTH measurement, firstly, each of the 9 sources is 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. Each BREADTH and DEPTH then classified into the
following ordinal variables: 1 (1-3) means low; 2 (4-5) means medium; 3 (6-9) means high.

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3 *Innovation performance.* Sales' proportion of product innovation new to the market
4 (NEW2MARKET) and new to the firms (NEW2FIRMS) are used in this study as the indicator
5 of innovative performance.
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10 *Control variables.* In this study, the following common control variables in OI literature
11 is included such as absorptive capacity (AC), firm size, firm ownership, and firm sectors.
12 Absorptive capacity. To date, there is no consensus on the measurement of the AC construct.
13 Instead of using a single indicator of AC variable that is commonly used in previous innovation
14 barriers studies, for instance, R&D intensity (Keupp and Gassmann, 2009) and internal and
15 external R&D (Fu *et al.*, 2014), this study modified an integrated AC used in the previous
16 studies (Escribano *et al.*, 2009; Kostopoulos *et al.*, 2011). In this study, the integrated AC
17 consists of (1) the firm total innovation activities expenditures, (2) proportion of employees
18 with bachelor's degrees, (3) proportion of employees work in R&D department, and (4) a
19 dummy that equals to 1 if a firm had provided training. In terms of innovation activities
20 expenditures, this study classifies into 1 for very small, 2 for small, 3 for medium, and 4 for a
21 high amount of budget.
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37 *Firm size.* Based on IIS 2014, there are three different firms' size i.e. small, medium, and
38 large firms. This study measures firm size based on the number of employees. Subsequently, a
39 discrete variable that equals to 1 for small firms, 2 for medium firms, and 3 for large firms was
40 created. Firm Ownerships. The ownership is also divided into three i.e. national (coded 1),
41 multinational (coded 2), and joint venture (coded 3). Lastly, firm sectors, it consists of seven
42 sectors such as mining and quarrying (ISIC 10-14); manufacturing (ISIC 15-37); electricity,
43 gas & water supply (ISIC 40-43); construction (ISIC 45); trading, hotel & restaurants (ISIC
44 50-55); transport, storage & communication (ISIC 60-64); and financial intermediation (ISIC
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3.3. Statistical analysis procedures

The following are statistical procedures used in this study. Exploratory factor analysis is used to identify and combine innovation barriers variables. Ordered logistic estimation is used to measure the impact of innovation barriers on firm openness decision i.e. BREADTH and DEPTH as the two dependent variables are ordinal. Logistic regression is used to measure the impact of innovation barriers on firm openness indicators such as external R&D, cooperation, and acquisition as the variables are binary. Tobit regression is used to measure the impact of firm openness decision on innovation performance that consists of sales' proportion of product innovation new to the market and to the firms.

4. Data analysis and results

4.1. Descriptive statistics

Table 3 reports the results of the descriptive statistics. On average, the innovative firms produce a higher proportion of product innovation new to the firms (NEW2FIRMS) than product innovation new to the market (NEW2MARKET), 32.13% versus 19.91%, respectively.

Table 3 Descriptive statistics

VARIABLES	OBS	MEAN	SD	MIN.	MAX.
<i>Innovation performance</i>					
NEW2MARKET (%)	535	19.912	27.060	0	100
NEW2FIRMS (%)	535	32.125	32.931	0	100
<i>Innovation barriers</i>					
INFUND	535	2.550	1.102	0	4
EXFUND	535	2.273	1.114	0	4
HIGH-COST	535	2.695	1.049	0	4
HIGH-RISK	535	2.660	1.020	0	4
STAFF-RESIST	535	2.265	1.046	0	4
MGR-RESIST	535	2.099	1.074	0	4
ORG-RIGID	535	2.142	1.075	0	4
PERSONNEL	535	2.409	1.077	0	4
TECH-INFO	535	2.348	1.058	0	4
MKT-INFO	535	2.333	1.046	0	4
COOPERATION	535	2.398	1.086	0	4
LABOUR	535	2.176	0.994	0	4

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3	MARKET-DOM	535	2.507	1.084	0	4
4	UNCER-DEMAND	535	2.394	1.015	0	4
5	CUSTOM-ACCEPT	535	2.265	1.011	0	4
6	INFRASTRUCTURE	535	2.391	1.084	0	4
7	IND-STANDARD	535	2.314	1.099	0	4
8	GOVREG	535	2.144	0.870	0	3
9						
10	<i>Firm openness</i>					
11	BREADTH	535	5.222	2.612	0	9
12	DEPTH	535	1.533	1.483	0	8
13	EXTERNAL_RD	535	0.170	0.376	0	1
14	COOPERATION	535	0.273	0.446	0	1
15	ACQUISITION	535	0.708	0.455	0	1
16						
17	<i>External sources of information</i>					
18	SUPPLIERS	535	2.725	1.124	1	4
19	CUSTOMERS	535	3.318	0.868	1	4
20	COMPETITORS	535	2.779	1.040	1	4
21	CONSULTANT	535	1.852	1.009	1	4
22	UNIVERSITIES	535	1.527	0.827	1	4
23	PUBLIC_RD	535	1.439	0.749	1	4
24	EVENTS	535	2.021	1.069	1	4
25	PUBLICATION	535	1.763	0.963	1	4
26	ASSOCIATION	535	1.968	1.053	1	4
27						
28	<i>Absorptive capacity</i>					
29	INNOVATION_EXPEND.	535	1.817	1.053	1	4
30	BACHELOR_STAFF (%)	535	20.056	26.685	0	100
31	R&D_STAFF (%)	535	5.363	12.654	0	100
32	TRAINING	535	0.634	0.482	0	1
33						
34	<i>Firms characteristics</i>					
35	Firm Size	535	1.568	0.699	1	3
36	Ownership: <i>National</i>	535	0.914	0.281	0	1
37	Ownership: <i>Multi-national</i>	535	0.028	0.165	0	1
38	Ownership: <i>Joint-venture</i>	535	0.058	0.234	0	1
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Surprisingly, there is no big gap between the mean of innovation barriers. The average of barriers related to high cost and risk of innovation is slightly higher than the rest of innovation barriers i.e. around 2.60. In terms of firms' openness, on average, Indonesian firms use between 5 and 6 sources of external knowledge in innovation activities. While the firms source external knowledge intensively from 1 to 2 external knowledge providers. Acquisition activities of machinery, equipment and software, on average, have a greater proportion (i.e. around 70%) than external R&D and cooperation that accounted for lower than 30%. Table 3 displays

correlation outputs among the studied variables. In general, no correlation coefficient may indicate multicollinearity among the variables.

Table 4 Correlation outputs

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.NEW2MARKET	1.0														
2.NEW2FIRMS	-.12	1.0													
3.STAFF & ORG.	.01	.04	1.0												
4.INSTITUTION	.06	.00	.03	1.0											
5.FINANCE & RISK	-.06	-.10	.06	.13	1.0										
6.KNOWLEDGE	-.02	-.02	.17	.06	.13	1.0									
7.MARKET	.00	.03	.06	.09	.09	.11	1.0								
8.BREADTH	.12	.00	.15	.31	-.04	.02	.05	1.0							
9.DEPTH	.14	.01	.20	.18	.08	.10	.07	.38	1.0						
10.EXT-RD	.05	.03	.08	-.02	-.06	-.003	-.004	.21	.08	1.0					
11.ACQUISITION	.07	-.10	.10	.03	-.05	.02	-.09	.10	.07	.17	1.0				
12.INNOV_EXPEND	.15	-.13	.01	.03	-.07	-.06	-.07	.20	.08	.31	.18	1.0			
13.BACHELOR	-.05	-.04	-.11	-.08	.08	.02	.05	.04	-.01	.02	.01	.00	1.0		
14.R&D-STAFF	.02	-.03	-.03	.04	-.01	-.02	-.04	.06	.00	-.04	.02	-.02	.20	1.0	
15.TRAINING	.12	.07	.13	.04	-.07	-.07	-.06	.21	.14	.16	.14	.13	-.05	.04	1.0

4.2. Factor analysis

Table 5 displays the results of the factor analysis of the 18 innovation barrier factors. Factor loadings above 0.40 were retained for factor grouping. The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.92, 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 0.93. Based on factor analysis, barriers to innovation can be categorised into 5 factors, namely “human resource and organisation capabilities” (HR & ORG), “standard and regulation” (STANDREG), “financial and risk” (FIN & RISK), “knowledge and cooperation” (KNOW & COOP), and “market domination and uncertainty” (MKT & UNCER).

Factor 1, HR & ORG, consists of four items including staff resistance (being not open) towards change; manager resistance (being not open) towards change; organizational rigidities within the enterprise; and lack of qualified personnel. This classification is in line with previous

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3 studies that classified barriers related to organisation such as organisational barriers (Oduro,
4 2020), employee and organization attitudes (Hartono, 2018; Hartono and Kusumawardhani,
5 2019), and organisational rigidities (Jung *et al.*, 2016).
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10 Factor 2 is innovation barriers related to STANDREG which consists of three factors
11 such as lack of sufficient infrastructure to support innovation activities; lack of industry
12 standard; and lack of government regulation. STANDREG barriers also emerged in the
13 previous studies such as regulation factor (Coad *et al.*, 2016; D'Este *et al.*, 2012) and laws and
14 regulations (Zhu *et al.*, 2012).
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22 The third factor is the most common barriers faced by the firms which related to FIN &
23 RISK. Such barriers include lack of funds within your enterprise or group; lack of finance from
24 sources outside your enterprise; innovation costs too high; and excessive perceived economic
25 risks. This finding supports a large number of studies such as Coad *et al.*, (2016); Hartono
26 (2018); Hartono and Kusumawardhani (2019); Jung *et al.*, (2016); Moraes Silva *et al.*, (2020);
27 and Shiang and Nagaraj (2011).
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35 Factor 4 is impediments related to KNOW & COOP which include lack of information
36 on technology; lack of information on markets; and lack of ability to find cooperation partners
37 for innovation. Such barriers also can be found in the previous studies such as Hartono (2018);
38 Hartono and Kusumawardhani (2019); Hölzl and Janger (2013, 2014); Keupp and Gassmann
39 (2009); and Xie *et al.*, (2010).
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47 The last factor is MKT & UNCER barriers that related to domination of established firms
48 in the market and uncertain demand for innovative products. Similar obstacles also have been
49 discussed in the previous studies (Coad *et al.*, 2016; D'Este *et al.*, 2012; Hartono, 2018;
50 Hartono and Kusumawardhani, 2019; Jung *et al.*, 2016).
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Table 5 Components loading for innovation barriers

INNOVATION BARRIERS	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
INFUND			0.64		
EXFUND			0.62		
COST			0.67		
RISK			0.53		
STAFF-RESIST	0.71				
MGR-RESIST	0.81				
ORG-RIGID	0.79				
PERSONNEL	0.61				
TECH-INFO				0.58	
MKT-INFO				0.58	
COOPERATION				0.48	
LABOUR					
MARKET-DOM					0.45
UNCER-DEMAND					0.43
CUSTOM-ACCEPT					
INFRASTRUCTURE		0.52			
IND-STANDARD		0.81			
GOVREG		0.81			
Eigenvalue	3.28	2.69	2.29	1.60	1.08
<i>Cronbach's alpha</i>			0.93		
<i>Kaiser-Meyer-Olkin (KMO)</i>			0.92		
<i>% of total variance explained</i>			0.91		

Notes:

Factor 1 *Human resources and organisation capabilities (HR & ORG)*;

Factor 2 *Industry standard and government regulation barriers (STANDREG)*;

Factor 3 *Financial & risk barriers (FIN & RISK)*;

Factor 4 *Knowledge and cooperation barriers (KNOW & COOP)*;

Factor 5 *Market domination and uncertainty barriers (MKT & UNCER)*.

4.3. The impact of innovation barriers on firms' openness

Table 6 displays ordered logistics and logistics regressions outputs of the impact innovation barriers on firms' openness. Constraints related to HR and ORG are positively and significantly affect external search breadth and depth, cooperation, and acquisition activities. This type of constraints may relevant to a phenomenon so-called 'not-invented-here' syndrome (Katz and Allen, 1982) that hinder firm openness (Burcharth *et al.*, 2014). This finding suggests that the greater firms experiencing resistance against change and innovation from inside the firms, the more likely firms' response by performing greater external search breadth and depth, external

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3 R&D, cooperation, and acquisition. Constraints related to STANDREG have a positive and
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5 significant association with breadth and depth. This indicates that the greater the firms lack
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7 sufficient infrastructure, industry standard, and government regulation, the more likely the
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9 firms' source information from external broadly and deeply. However, there is no positive
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11 evidence between STANDREG constraints and the rest of openness indicators. This finding
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13 supports the previous study in a developing country context (Fu *et al.*, 2014).
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17 Turning to constraints related to FIN and RISK, table 5 shows that overall, the constraints
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19 tend to have negative direction on firms' openness, however, a significant impact can be found
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21 in cooperation. This indicates that when firms face FIN and RISK constraints, the less likely
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23 firms do cooperation with external parties. Since any cooperation activities require financial
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25 resources and involve risk. This finding supports not only the previous study that used
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27 cooperation activities as the firm openness indicator (Drechsler and Natter, 2012) but also a
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29 majority of studies on the relationship between financial constraints and innovation.
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33 The remaining innovation barriers, i.e. KNOW and COOP, tend to have no significant
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35 association with firm openness indicators. A marginal positive and significant association can
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37 be found between KNOW and COOP barriers and external search depth. By contrast, a
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39 marginal negative and significant correlation exists between MKT and UNCER and
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41 acquisition. Based on the explained findings, hence, hypothesis 1 is partially supported.
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45 Turning to control variables, of AC indicators, innovation activities expenditure and
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47 training activity tend to have consistent positive impacts on firm openness indicators. Firm size
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49 has a positive and significant impact on external search breadth and external R&D. This
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51 indicates that larger firms tend to source external knowledge broadly and perform external
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53 R&D. This is a reasonable finding since larger firms tend to have better financial and non-
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55 financial resources to support external knowledge sourcing and external R&D than smaller
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firms. While, firm ownership and sectors, overall have no significant impact on firm openness indicators.

Table 6 The impact of innovation barriers on firms' openness

Barriers	BREADTH	DEPTH	EXT_RD	COOPERATE	ACQUISITION
HR & ORG.	.23**(.10)	.51***(.12)	.22(.15)	.29**(.12)	.26**(.12)
STANDREG	.64***(.10)	.39***(.13)	-.06(.15)	0.07(.12)	.08(.12)
FIN & RISK	-.14(.11)	.08(.14)	-.17(.16)	-.31**(.13)	-.16(.13)
KNOW & COOP	.06(.11)	.26*(.15)	.08(.18)	.20(.15)	.12(.14)
MKT & UNCER	.08(.13)	.08(.16)	.12(.20)	.09(.16)	-.27*(.16)
Innovation activities expend.	.31***(.09)	.12(.11)	.53***(.12)	.21*(.11)	.34***(.11)
% Staff with bachelor's degree	.006*(.003)	.0001(.004)	.01(.005)	.005(.004)	.003(.004)
% R&D staff	.01(.01)	.005(.01)	-.02(.01)	-.0003(.01)	.003(.01)
Training	.70***(.19)	.52**(.25)	.62**(.31)	1.01***(.25)	.44**(.21)
Firm size	.28**(.14)	.05(.17)	.51***(.19)	.24(.16)	.12(.17)
Ownership: <i>National</i>					
Ownership: <i>Multi- National</i>	-.30(.53)	.49(.62)	.35(.65)	-1.43*(.81)	-.01(.71)
Ownership: <i>Joint Venture</i>	.17(.35)	-.57(.57)	.54(.47)	.72*(.42)	-.32(.43)
Log likelihood	-529.877	-292.337	-205.377	-279.608	-297.582
Number of obs.	535	535	535	535	535
LR chi2(14)	114.39	58.35	77.2	67.93	50.65
Prob > chi2	.00	.00	.00	.00	.00
Pseudo R2	.097	.091	.158	.108	.078

Significant levels: * < 0.10; ** < 0.05; *** < 0.01; Standard errors are in parentheses

4.4. Firms' openness decision on innovation performance

Table 7 displays the outputs of Tobit regression on the impact of firms' openness on innovation performance. Surprisingly, only external search depth significantly and positively influences the share of product innovation new to the market. This suggests that the depth of external sourcing information is positively associated with innovation performance. In the previous studies, both external search breadth and depth positively influence the share of product innovation new to the market of Indonesian manufacturing firms (Hartono and

Kusumawardhani, 2018) as well as in the UK manufacturing firms (Laursen and Salter, 2006).

While external R&D has a positive marginal impact on the share of product innovation new to the firms, the acquisition has a negative impact on the share of incremental innovation. A possible reason could be that acquisition of machinery, equipment and software will demotivate firms to perform incremental product innovation as this can be replaced by performing acquisition activities. Based on such findings, hence, hypothesis 2 is partially accepted.

Turning to the AC construct, results are more ambiguous. While innovation activities expenditure is positively related to the introduction of new to the market novelties, they are negatively associated with new to the firm innovations. The same pattern is observed for the percentage of staff with a bachelor's degree seems to negatively – though not in a statistically significant manner – influence innovation performance. On the other hand, training is positively related to both innovation performance types. Lastly, all firm sectors tend to perform more innovation new to the market than to the firms.

Table 7 The impact of firms' openness on innovation performance

	NEW2MARKET ¹	NEW2FIRMS ²
BREADTH	0.87(0.98)	0.04(0.86)
DEPTH	3.61**(1.58)	0.87(1.43)
EXTERNAL_RD	-0.77(6.40)	10.24*(5.76)
COOPERATION	8.47(5.23)	6.90(4.70)
ACQUISITION	3.07(5.15)	-10.17**(4.48)
Innovation Expenditure	6.77***(2.38)	-6.93***(2.15)
% Staff with bachelor's degree	-0.09(0.09)	-0.05(0.08)
% R&D staff	0.13(0.18)	-0.12(0.16)
Training	11.85**(5.02)	9.34**(4.44)
Firm size	-4.07(3.55)	-1.66(3.22)
Ownership: <i>National</i>	-	-
Ownership: <i>Multi-National</i>	0.67(13.62)	10.66(12.12)
Ownership: <i>Joint Venture</i>	8.35(9.40)	0.96(8.55)
Log likelihood	-1538.74	-2054.93
Number of obs.	535	535
LR chi2(14)	56.38	36.75
Prob > chi2	0.00	0.01
Pseudo R2	0.018	0.01

Notes: Sig. levels * <0.10 ; ** <0.05 ; *** < 0.01 ; standard errors are in parentheses

¹ Sales' proportion of product innovation new to the market;

² Sales' proportion of product innovation new to the firms

5. Discussion and conclusion

Opening up the innovation process has become an important strategy for firms to overcome any internal and external constraints that may hinder innovation activities. This study aims to examine the impact of barriers that impede innovation activities on firm openness using data derived from Indonesia Innovation Survey (IIS) 2014. This study extends the previous innovation barrier studies using a broader firm openness indicator that consists of external search breadth and depth, external R&D, cooperation, and acquisition activities. Subsequently, the study examines the impact of firm openness decision on innovation performance that is measured by the share of product innovation new to the market and the firms. Innovation barriers faced by Indonesian firms can be divided into human resource and organisation attitude, institution, financial and risk, knowledge, and market. The first key finding of this study is that different barriers to innovation lead to different firm openness decisions. Sourcing external information broadly and deeply, performing cooperation and acquisition activities are openness decision conducted by the firms if they are experiencing human resource and organisation related barriers. While focusing on external search breadth and depth is openness decision as the response of the firms face institution barriers. Less performing cooperation activities is the firm's response if they experience financial and risk constraints.

Concerning the control variables, the study shows that absorptive capacity (i.e. the innovation activities expenditure and training activities) facilitates the firms to be more open. This indicates that to be more open, firms not only need innovation funding but also skill and knowledge gained from training activities. Regarding the firm size, larger firms are more open than smaller firms. This can be seen from the positive association between firm size and external search breadth and between firm size and external R&D.

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3 In terms of firm openness and innovation performance relationship, the major key finding
4 is that dependent on the decision firms make regarding openness, the innovation performance
5 is influenced differently. In particular, sourcing external search depth leads to a positive impact
6 on the share of product innovation new to the market, while external R&D contributes to the
7 share of product innovation new to the firms. However, acquisition activities lowering sales'
8 proportion of product innovation new to the firms. Looking at the control variables, absorptive
9 capacity (i.e. innovation activities expenditure and training) consistently and positively affect
10 innovation performance. Lastly, all firm sectors tend to contribute positively to the share of
11 product innovation new to the market.
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26 *5.1. Implications for theory and practice*

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28 This study contributes to the innovation barrier literature by empirically testing whether
29 experiencing barriers to innovation is associated with involvement a broader firm openness
30 decision that has not been accommodated in the previous CIS-innovation barrier studies.
31 Previous studies tend to link innovation barriers with a narrow firm openness decision. The
32 important finding is that different openness decision can be used to overcome different
33 constraints to innovation. Internal constraints from inside firms related to human resource and
34 organisation resistance to innovation were responded by firms implementing the greater
35 number of openness indicator than other types of constraints. Besides, firms also tend to avoid
36 any openness decision, e.g. external R&D and cooperation, that involve financial and risk
37 constraints. Hence, to facilitate firms to be more open, this study suggests that firms need to
38 invest in a greater amount of innovation activities expenditure and training activities. In this
39 case, larger firms have better ability in facilitating such investment, as a result, larger firms are
40 more open than smaller firms. This study also enriches the innovation studies literature on the
41 understanding that different firm openness decision has a different impact on innovation
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3 performance. In this study, of firm openness decision, sourcing external information
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5 intensively and performing external R&D contribute to innovation performance. While the
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7 decision on acquisition will diminish the return of incremental innovation.
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10 From a practitioner point of view, this research calls attention not to merely focus on a
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12 narrow firm openness decision to overcome internal and external innovation constraints.
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14 Moreover, firms should think beyond sourcing external information widely and deeply that has
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16 been recommended enormously by previous OI studies. However, the more open the firms, the
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18 greater the innovation activities expenditure. In this case, there is an emerging challenging
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20 decision for balancing innovation barriers, firm openness, and innovation performance. On the
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22 one hand, in order to improve their resilience, firms need to be more open. On the other hand,
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24 to be more open and to increase innovation performance, firms need greater financial
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26 investment to support innovation activities such as external R&D, cooperation, acquisition and
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28 training activities.
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35 *5.2. Limitations and future research direction*

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37 Some limitations of the study are worth mentioning alongside the opportunities for future
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39 research they recommend. First, the analysis of innovation barriers' impact on firm openness
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41 decision was based on cross-sectional data. Hence, this database did not facilitate the
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43 consideration of dynamic effects of innovation barriers on firm openness decision. Hence,
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45 further studies should cover the long-term effect of innovation barriers on firm openness
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47 decision using panel data of innovation survey. Second, only a single developing country (i.e.
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49 Indonesia) is used in this study, thus, the findings may be subjectively applying to Indonesian
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51 firms only as country-specific conditions may involve the pattern of innovation barriers and
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53 firms' openness decision. A further comparison study among developing countries would be
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interesting to be conducted to identify the common pattern on innovation barriers, firms' openness and innovation performance.

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RESPONSES TO REVIEWERS' COMMENTS:

Dear Editor in Chief of International Journal of Innovation Science,

We are very excited to have been given the opportunity to revise our manuscript. We carefully considered reviewers comments. Herein, we explain how we revised the paper based on those comments and recommendations in the following table. We want to extend our appreciation for taking the time and effort necessary to provide such insightful guidance.

Kind Regards,

Arif Hartono

Reviewer Comments	Responses
Reviewer 1 – Minor Revision	
Point 2. A suggestion to cite the below authors: Kline, S.J. and Rosenberg, N. (2010), “An Overview of Innovation”, <i>Studies on Science and the Innovation Process</i> , pp. 275–305.	Many thanks for the suggestion regarding the citation of Kline & Rosenberg (2010). We have cited the suggested authors in the page 2-3. We underlined the additional sentences.
Point 3. A suggestion to explain the period of the study. Point 3. A suggestion to explain how respondents were chosen.	We have added explanation on the study period in page 12. We have added explanation on how respondents were chosen and added a table that presents types of firms involved in the study (Please see page 12). We underlined the additional sentences.
Reviewer 2 – Accepted	
Point 2. A suggestion to add more recent literature.	Below are the additional relevant literatures. We also cited a literature from International Journal of Innovation Science. Coad, A., Pellegrino, G., & Savona, M. (2016). Barriers to innovation and firm productivity. <i>Economics of Innovation and New Technology</i> , 25(3), 321–334. https://doi.org/10.1080/10438599.2015.1076193 Hartono, A. (2018). Do Innovation Barriers Drive A Firm to

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	<p>Adopt Open Innovation? Indonesian Firms' Experiences. <i>Academy of Strategic Management Journal</i>, 17(6), 1939–6104.</p> <p>Jung, D., Kim, Y., Suh, Y., & Kim, Y. (2016). Perceived innovation barriers and open innovation performance: Insights from Korea. <i>International Journal of Knowledge-Based Development</i>, 7(2), 125–142. https://doi.org/10.1504/IJKBD.2016.076466</p> <p>Oduro, S. (2020). Exploring the barriers to SMEs' open innovation adoption in Ghana: A mixed research approach. <i>International Journal of Innovation Science</i>, 12(1), 21–51. https://doi.org/10.1108/IJIS-11-2018-0119</p> <p>Zhu, Y., Wittmann, X., & Peng, M. W. (2012). Institution-based barriers to innovation in SMEs in China. <i>Asia Pacific Journal of Management</i>, 29(4), 1131–1142. https://doi.org/10.1007/s10490-011-9263-7</p>
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International Journal of Innovation Science - IJIS-10-2020-0218.R1

1 message

International Journal of Innovation Science <onbehalf@manuscriptcentral.com>

5 February 2021 at 10:34

Reply-To: brett@iaoip.org

To: arif.hartono@uii.ac.id

05-Feb-2021

Dear Dr. Hartono:

Your manuscript entitled "Linking open innovation, innovation barriers, and performance of Indonesian firms" has been successfully submitted online and is presently being given full consideration for publication in the International Journal of Innovation Science.

Your manuscript ID is IJIS-10-2020-0218.R1.

Please mention the above manuscript ID in all future correspondence or when calling the office for questions. If there are any changes in your street address or e-mail address, please log in to ScholarOne Manuscripts at <https://mc.manuscriptcentral.com/ijins> and edit your user information as appropriate.

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Sincerely,
International Journal of Innovation Science Editorial Office

04

**Bukti konfirmasi penerimaan artikel/fully
accepted (LoA) (12 Februari 2021)**

International Journal of Innovation Science - Decision on Manuscript ID IJIS-10-2020-0218.R1

1 message

International Journal of Innovation Science <onbehalf@manuscriptcentral.com>

12 February 2021 at 13:07

Reply-To: geijis2020@sibmpune.edu.in

To: arif.hartono@uii.ac.id, abdurrafik@uii.ac.id

12-Feb-2021

Dear Hartono, Arif; Rafik, Abdur

It is a pleasure to accept your manuscript IJIS-10-2020-0218.R1, entitled "Linking open innovation, innovation barriers, and performance of Indonesian firms" in its current form for publication in International Journal of Innovation Science. Please note, no further changes can be made to your manuscript.

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Thank you for your contribution. On behalf of the Editors of International Journal of Innovation Science, we look forward to your continued contributions to the Journal.

Sincerely,

Dr. R Raman

Guest Editor, International Journal of Innovation Science

geijis2020@sibmpune.edu.in, shaileshrastogi@sibmpune.edu.in

05

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	AE: Behan, Francis EIC: Trusko, Brett GE: Not Assigned <ul style="list-style-type: none"> Reject (08-Feb-2022) Archiving completed on 22-May-2022 view decision letter ✉ Contact Journal	IJIS-07-2021-0117	Sourcing, Transforming and Exploiting Knowledge for Innovation: A Comparison Between Indonesia and UK Firms <i>Files Archived</i> 🗄	03-Jul-2021	08-Feb-2022
Forms Completion submitted (12-Feb-2021) - view	AE: Not Assigned EIC: Trusko, Brett GE: Raman, Ramakrishnan <ul style="list-style-type: none"> Accept (12-Feb-2021) view decision letter ✉ Contact Journal	IJIS-10-2020-0218.R1	Linking open innovation, innovation barriers, and performance of Indonesian firms	05-Feb-2021	12-Feb-2021
a revision has been submitted (IJIS-10-2020-0218.R1)	AE: Not Assigned EIC: Trusko, Brett GE: Raman, Ramakrishnan <ul style="list-style-type: none"> Minor Revision (22-Jan-2021) a revision has been submitted view decision letter ✉ Contact Journal	IJIS-10-2020-0218	Linking open innovation, innovation barriers, and performance of Indonesian firms View Submission	30-Oct-2020	22-Jan-2021
Revision option expired on 06-Aug-2020	AE: Raman, Ramakrishnan EIC: Trusko, Brett GE: Not Assigned <ul style="list-style-type: none"> Major Revision (01-Jul-2020) Revision option expired on 06-Aug-2020 Archiving completed on 02-Feb-2021 view decision letter	IJIS-05-2020-0071	Do different knowledge sourcing activities affect innovation performance differently? Evidence from Indonesian firms <i>Files Archived</i> 🗄	24-May-2020	01-Jul-2020



ACTION	STATUS	ID	TITLE	SUBMITTED	DECISIONED
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