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The Relative Importance of Firms, Universities, Governments, and Nonprofits as Innovation Intermediaries

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Abstract

While many organizational actors, including firms, governments, universities, and nonprofit organizations may have an impact on the innovative capacity of the firms with which they engage, we have little knowledge of their relative importance. The literature on innovation intermediaries reports on the impact of specific types of organizations, but researchers have not yet conducted comparative analyses of the relative efficacy of multiple types of organizations. And while the innovation surveys of statistical agencies consider the relative importance of various actors, the data they provide is very limited. In the interests of a better understanding of the nature and relative importance of the innovation enabling contributions of a range of organizational actors, we conduct a comparative examination of the contributions of firms, universities, governments, industry associations, and research institutes. Based on survey data from a sample of 499 firms from four countries, we find that firms are identified as the most important facilitators of learning, universities as the most important sources of expertise, governments as the most important coercive actors, and industry associations as the most important facilitators of collaboration. We also consider regional and sectoral variations.

Governments everywhere invest heavily in dedicated innovation intermediaries, government programs and nonprofit organizations whose purpose is to facilitate innovation in order to increase the prospects for firm founding, growth, profitability, and survival. But it is not clear that these investments are yielding the hoped for socio-economic returns. While some researchers have found evidence of a positive impact (Debackere & Veugelers, 2005; Grindley, Mowery, & Silverman, 1994; Human & Provan, 1997; Lee, Yoon, & Park, 2009; Sakakibara & Branstetter, 2003; Sapsed, Grantham, & DeFillippi, 2007), others have found no impact or even negative impact (Baum, Calabrese & Silverman, 2000; King & Lenox, 2000; Muscio, 2010; Shearmur & Doloreux, 2000; Wallsten, 2000). With strong evidence of the important role that for-profit firms play in facilitating innovation amongst other firms in their ecosystem (Chesbrough, 2003; Dyer & Hatch, 2006), some observers may believe that social welfare would benefit from reduced support for government-subsidized, dedicated innovation intermediaries.

In the interests of a better understanding of the relative contributions of a range of organizational actors whose activities may, either intentionally or unintentionally, have an innovation facilitating effect on the firms with which they engage, we conduct a comparative examination of the relative importance of firms, universities, governments, industry associations, and research institutes as innovation intermediaries. This small but highly heterogeneous group of organizational actors engages in a wide range of activities for a wide range of different purposes. So to make our study tractable, we abstract from the vast differences in the purposes, resources, and activities of these organizational actors, and in the nature of engagements between these actors and sample firms, to consider only the outcomes of innovation facilitating activities. In this exploratory study, we consider ten innovation intermediation outcomes that include those related to learning, the facilitation of collaboration, and those that are a consequence of changing

regulations or social pressure.

Our study builds on the contributions of the literature on innovation intermediaries and the studies that have used Community Innovation Survey (CIS) data. The literature on innovation intermediaries provides rich descriptions of the activities and reports on the impact of specific types of intermediaries. University-based technology transfer offices help firms to learn new technologies (Debackere & Veugelers, 2005); business clinics (Sapsed et al., 2007) and consultants (Hargadon & Sutton, 1997) provide access to business-related information and advice; industry associations and innovation networks enable access to opportunities for networking and knowledge sharing (Author, 2006; Human & Provan, 1997); and research consortia facilitate collaboration (Grindley et al., 1994; Sakakibara & Branstetter, 2003). But to date there has been no attempt to conduct a comparative analysis of the impact of a range of innovation intermediaries. We have knowledge of the impact of innovation intermediaries such as SEMATCH (Grindley et. al., 1994), the Small Business Innovation Research Program (Lerner, 1999), and Swedish science parks (Löfsten & Lindelöf, 2002), but we know nothing of their relative magnitude of their contributions.

CIS data benefit from large random samples and provide insights into various aspects of the innovation process (OECD, 2005). But CIS surveys conflate a wide range of activities into a single definition of innovation (Tether, 2001), lack a set of indicators that reflect specific innovation activities or processes (Arundel, 2007), and provide limited information on how innovation linkages and networks function and develop (Salazar & Holbrook, 2004). The most relevant limitation for the present purposes is that only two aspects of innovation intermediation are considered: Sources of information and the nature of cooperation partners. Furthermore,

the possible responses to the sources of information and cooperation partners questions are not limited to actors but also include roles (e.g. customer, supplier), venues (e.g. conferences, trade shows), and artifacts (e.g. patents, embodied technology) (OECD Oslo Manual, 2005: p81). This makes it impossible to compare the importance of various organizational actors unless it is assumed, as is often the case, that roles such as customer and supplier are always performed by for-profit firms (Amara & Landry, 2005; Freel, 2000; Laursen & Salter, 2006; Segarra & Arauzo, 2008; Veugelers & Cassiman, 2005). As a consequence of this assumption, the literature may overestimate the impact of for-profit firms as information sources and cooperation partners, and underestimate the impact of governments, universities, and nonprofit organizations that may also act as customers and suppliers.

Our contribution is, we believe, the first comparison of the relative importance of a range of organizational actors as innovation intermediaries. We draw on a sample of 499 firms from four countries to consider the relative importance of ten innovation intermediation outcomes and the degree to which firms, universities, governments, industry associations, and research institutes, are associated with each of these outcomes. We find that enabling outcomes are judged to be more important than outcomes that arise as consequence of coercive regulations or social pressure, and that learning outcomes are judged to be more important than the facilitation of collaboration outcomes. We find that firms are identified as the most important facilitators of learning about technology and new markets, universities as the most important sources of expertise, governments as the most important coercive actors, and industry associations as the most important facilitators of collaboration. We also consider regional and sectoral variations.

In the next section we draw on the literature on innovation intermediation to identify ten

innovation intermediation outcomes that may be the result of interventions by a range of organizational actors. We then develop hypotheses regarding the outcomes that are most likely associated with, respectively, the interventions of firms, universities, governments, and industry associations. In the methods section we present our sample and measures, and in the results section we report on the outcomes of our regression analysis. We conclude with a discussion of our findings and their implications.

CONCEPTUAL DEVELOPMENT

Innovation Intermediation Outcomes

While researchers have documented the activities of dedicated innovation intermediaries and the effects of these activities on focal firms, the activities of other organizational actors such as firms, universities, and governments may also have an effect on the resources and capabilities of focal firms and thereby on firm founding, growth, profitability, or survival. While possible effects or outcomes are infinite in number and variety, in this exploratory study we focus on just ten possible effects that are selected on the basis of their importance, and their intangible and social nature. Many organizations provide firms with access to tangible resources: Equity investors and governments may provide access to financing, alliance and outsourcing partners may provide access to manufacturing services, and business incubators and science parks may provide physical space on advantageous terms. But as the origin of tangible resources is more easily traced, much is known about their provenance. For this reason we focus on innovation intermediation outcomes related to learning and the facilitation of collaboration, social processes whose initial outcomes are intangible (Sorensen & Chambers, 2008). We also consider

innovation intermediation outcomes that are not the result of enabling processes but that are the outcome of coercive processes intended to balance the interests of firms with the interests of other stakeholders and the environment.

We build on the two innovation intermediation process questions included in CIS surveys: sources of information and collaboration partners. In the first instance, we build on the sources of information question by considering the means by which firms learn about technology, markets, and business information and advice. Studies in the innovation literature have emphasized the importance of learning about both technologies and markets (Kline & Rosenberg, 1986; Dougherty, 1990) and the literature on small firm innovation has identified the important role of business advice in enhancing the growth of small firms (Bennett & Robson, 1999).

We build on the collaboration partners question by considering two aspects of the facilitation of collaboration: the identification of partners for collaboration and the building or strengthening of ties between partners. We distinguish between two types of partners: knowledgeable individuals, and organizational partners. Many innovation intermediaries, such as university technology transfer offices, identify knowledgeable individuals that may serve as collaboration partners (Gregorio & Shane, 2003; Grossman, Morgan, & Reid, 2001; Perkmann & Walsh, 2008; Sorensen & Chambers, 2008). The identification of partner firms and organizations similarly plays an important role in the initial stages of building collaborative relationships, and participation in standards committees allow firms, especially those with fewer alliances, to identify suitable alliance partners (Rosenkopf, et al., 2001).

We consider three ways in which ties between collaborating partners may be built or

strengthened: the facilitation of collaboration, the promotion of enabling standards, and the undertaking of innovative activities on behalf of firms. Networks facilitate inter-organizational exchanges amongst small- and medium-sized firms (Human & Provan, 1997), and US government programs facilitate collaboration by offering financial support (Lerner, 1999; Sakakibara & Branstetter, 2003). The Cambridge-MIT Institute is an example of a program that supports university-industry collaboration and knowledge sharing (Acworth, 2008). Industry associations help small and medium firms build cooperative ties and compensate for limited trust between network members (Lee, et al., 2009).

The development of enabling standards facilitates innovation (Shapiro & Varian, 1998), and SEMATECH is an example of an intermediary that promotes common enabling standards for collaboration between supplier firms and user firms (Grindley et al., 1994). In Finland, the government-funded "Smart and Modular Building Automation" (SaMBA) program promotes open interface standards and thereby assists SMEs in the commercialization of their innovative products (Hyvattinen, 2006). Finally, some organizations have the trust and expertise required to undertake innovative activities on behalf of firms. SEMATECH improves and qualifies products on behalf of its member firms (Grindley et al., 1994), and the US National Institute of Standards and Technology conducts research to help the semiconductor industry produce and improve innovative devices (Rowe & Temple, 2011). Federal laboratories also conduct basic research on behalf of firms (Rogers & Bozeman, 1997).

While the CIS surveys consider only the effect of enabling processes, we also consider the outcomes of coercive processes that force firms to innovate by balancing the interests of the firms with the interests of other agents or the environment. Environmental regulations may oblige

firms to innovate (Porter & Linde, 1995), or they may have a negative impact on innovation (Ramanathan, Black, Nath, & Muyldermans, 2010). Firms are also influenced by implicit social norms. Firms may participate in the Chemical Care program of the Chemical Manufacturing Association as a consequence of social pressure, a possibility supported by the fact that their environmental performance is worse than that of non-member firms (King & Lenox, 2000). Canadian forestry products firms perceive that social pressure, such as environmental protests and lobbying, has a positive influence on eco-design sustainability decisions (Sharma & Henriques, 2005). Table 1 lists the ten innovation intermediation outcomes described above.

Insert Table 1 about here.

Innovation Intermediary Actors

In the following we consider the likely impacts of firms, universities, governments, and industry associations on the innovative capacities of the firms with which they engage. While there is a reasonable consensus on the importance of firms, universities, and governments as innovation intermediaries, there is little systematic evidence of their relative importance. And while some authors have allowed for the importance of industry associations as enablers of innovation (Author, 2006; Lee et al., 2009), others have discounted their innovation enabling capabilities, suggesting that their activities are limited to lobbying and promotion (Human & Provan, 1997). Taking each organizational actor in turn, we consider the types of innovation intermediation outcomes whose importance is most likely to be strongly associated with the importance of the actor in question as a facilitator of that outcome.

The importance of for-profit firms. In our era of open innovation, large firms at the centre of business ecosystems may have a significant impact on the resources and innovative capacities of the firms with which they engage (Chesbrough, 2003; Iansiti & Levien, 2003). Such firms may serve as lead customers (von Hippel, 1986), system integrators (Baldwin & Clark, 2000), or as platform leaders (Gawer & Cusumano, 2002), and in such roles they may facilitate the learning of firms that are their suppliers or complementors (Dyer & Hatch, 2006). Alliances are another means by which firms may learn from other firms (Sampson, 2007). For example, new biotechnology firms access technological knowledge through strategic alliances, although the impact of the alliances on the product development outcomes of the biotechnology ventures depends on the degree to which they have specialized technological capabilities (Haeussler, Patzelt, & Zahra, 2010). Professional service firms may also have a significant impact on the innovative capacities of firms. Such firms include management consultancies that offer business or technological advice (Bennett and Robson, 1999; Bessant & Rush, 1995), design consultancies such as IDEO (Hargadon & Sutton, 1997), or financial and human resources service firms (Zhang & Li, 2010). Even without a sustained direct relationship large firms may have a significant impact on the firms in their region, as they may be a source of spinoffs, corporate venture capital, or knowledge spillovers (Klepper, 2007). In some case foreign multinationals have a positive impact on indigenous firms in the host country (Görg & Strobl, 2002), although more recent research has shown mixed effects, with spillover effects dominating at the national level and competitive effects dominating at the regional level (Chang & Xu, 2008).

But while membership in the networks of dedicated intermediaries is generally open to all firms and allows firms to maintain complete autonomy, membership in the networks of the sometime

intermediaries such as for-profit firms may be limited to their suppliers or clients and may involve compromised autonomy for participating firms. This means that not only are such networks and alliances inaccessible or unsuitable for most firms, they may offer reduced network size, scope, and benefits for participating firms. In addition, firms may abandon their commitment to the facilitation of collaboration in favor of their private interests, as Sun Microsystems (Garud, Jain & Kumaraswamy, 2002) and Intel (Gawer & Cusumano, 2002) have reportedly done.

So, of the innovation intermediation outcomes described in the previous section, firms are well positioned to facilitate learning, but they may not be trusted to facilitate collaboration and may not have the authority or legitimacy required to oblige other firms to innovate through regulatory changes or social pressure. Therefore we expect firms to be the actors most strongly associated with the facilitation of learning and within this category to be associated with helping firms learn about new technologies and new markets, and with the provision of business advice.

Hypothesis 1: For-profit firms are more strongly associated with the facilitation of learning than governments, universities, industry associations, or research institutes. Specifically, firms are the actors most strongly associated with the importance of the following processes:

- *Assistance with learning about new technologies*
- *Assistance with learning about new markets*
- *Provision of business advice*

The importance of universities. Universities are natural facilitators of the innovative activities of firms as universities are generally committed to generating expertise and to the open

dissemination of research results (Dasgupta & David, 1994). Universities provide expertise, both through their role as a source of employees, including highly-qualified employees with advanced degrees, and through their role as a source of researchers that may be engaged on a contract basis. Alliances with star researchers have been shown to have a significant positive impact on firm success (Zucker, Darby & Armstrong, 2002), university technology transfers offices are now ubiquitous, and university business incubators and science parks are common (Debackere & Veugelers, 2005; Rothaermel & Thursby, 2005; Siegel et al., 2003)

But the knowledge generation and education objectives of universities may limit their ability to engage in external partnerships (Salter & Martin, 2001). Even though researchers recognize that their findings are unlikely to be commercialized without further development and testing, they are reluctant to undertake such activities because doing so will detract from their ability to produce measureable outputs such as high quality papers that are likely to be cited. As a consequence, university inventions, even those that are licensed, are embryonic in nature and require further development once they are licensed (Jensen & Thursby, 2001).

Like for-profit firms, universities are not dedicated innovation intermediaries. While universities, and university technology-transfer offices in particular, may promote university-industry engagement, university researchers face competing incentives and must balance their engagement with industry with other demands on their time. As a consequence, universities will be associated with innovation intermediation outcomes that best leverage their resources and capabilities, namely the provision of access to knowledgeable individuals and expertise that allows them to undertake specific innovation-related activities on behalf of partner firms. With respect to the innovation intermediation outcomes identified above, we predict that

universities will be the actors best positioned to serve as a source of knowledge individuals and to undertake innovative activities on behalf of firms.

Hypothesis 2: Universities are more strongly associated with the provision of expertise than for-profit firms, governments, industry associations, or research institutes. Specifically, universities are the actors most strongly associated with the following processes:

- *Identification of knowledgeable individuals*
- *Undertaking innovation activities on behalf of focal firms*

The importance of governments. Government agencies enable the innovation process by providing financial support and facilitating collaborations involving multiple organizations. An important example of the provision of direct financial support is the Small Business Innovation Research (SBIR) program of the US (Lerner, 1999), but governments may also offer indirect support through the provision of tax credits (Czarnitzki, Hanel, & Rosa, 2011). Governments can also be said to facilitate collaboration insofar as they sponsor research consortia (Aldrich & Sasaki, 1995; Feldman & Kelly, 2006; Sakakibara & Branstetter, 2003). And in some instances governments may go beyond intermediation to provide innovation leadership. Fuchs (2010) describes the activities of DARPA (the US Defense Advanced Research Projects Agency) as going beyond network broking and engaging in leadership activities that as it "re-architects social networks among researchers so as to influence technology directions in the US".

But governments prefer to support median voter, not special interest groups (Weisbrod, 1991). As a consequence government efforts at stimulating innovation are generally, though not always, broad programs that appeal to firms in all industries and regions under their jurisdiction. The

US SBIR program is a case in point. At the same time, governments play a unique role in establishing regulations that may have an innovation inducing effect. For example, well-designed environmental policies may lead to enhanced efficiency, efficient production technology (Porter & Linde, 1995), and the founding of firms that supply energy from renewable sources (Sine et al., 2002). In so doing, government agencies attempt to satisfy the interests of majorities by balancing the interests of focal firms and the interests of other constituents in society, such as the public welfare, social security, and the environment.

On balance we believe that governments will not be the most important actor associated with any enabling process. But they do play an important role in creating and maintaining institutional frameworks, which may or may not be enabling. Of the ten innovation intermediation outcomes that we consider, we believe governments will be the most important actors associated with processes that oblige firms to innovate as a consequence of changes in regulations, or that oblige firms to innovate as a consequence of normative social pressures.

Hypothesis 3: Government agencies are more strongly associated with the importance of coercive processes than for-profit firms, universities, industry associations, or research institutes. Specifically, governments are the actors most strongly associated with the following processes:

- *Innovation necessitated by changing regulations*
- *Innovation necessitated by social pressure*

The importance of industry associations. While some researchers distinguish between organizations that facilitate innovation, and industry associations whose activities they regard as confined to lobbying and promotion (Human & Provan, 1997), other researchers have found that

industry associations have a positive impact on the innovative capacities of the firms with which they engage. Murmann (2003) reports on the important role played by industry associations in the co-evolution of the capabilities of German industry and academe during the 19th and early 20th century. Author (2006) reports that when Statistics Canada included industry associations as a source of ideas and as a potential collaboration partner on an innovation survey, respondents were significantly more likely to identity industry associations as responses than either universities or government research laboratories. Lee et al. (2009) describe a Korean industry association that allows member firms to identify partners and facilitate innovation collaborations, and participation in the standards committees of industry associations has been shown to influence the formation of alliances (Rosenkopf, et al., 2001).

But the impact of industry associations on the innovative capacities of firms may not always be positive. Baum, Calabrese, and Silverman (2000) find a negative relationship between participation in industry associations and growth in revenues and R&D spending. They attribute this finding to the fact that founders without personal networks may be more likely to join industry associations to compensate for their lack of contacts. Similarly, King and Lenox (2000) examine the effect of participation in the Chemical Care program of the Chemical Manufacturing Association in the US and find that participating firms are less likely to reduce their toxic emissions than non-participating firms.

Every national economic system consists primarily of numerous small and medium enterprises (SMEs). As SMEs typically do not perform R&D, they may not avail themselves of the services of universities or research institutes. In some cases they may engage with few external actors and in such cases industry associations may be important in helping them establish

networks with other enterprises. Such firms may find industry associations reliable and trustworthy partners because of their geographic and cognitive proximity. On the basis of the foregoing we believe that industry associations will be the actors that are most strongly associated with the identification of partner firms and organizations, the facilitation of collaboration, and the promotion of enabling standards.

Hypothesis 4: Industry associations are more strongly associated with the importance of collaborative outcomes than for-profit firms, governments, universities, or research institutes. Specifically, industry associations are the actors most strongly associated with the following processes:

- *Identification of partner firms and organizations*
- *Facilitation of collaboration involving multiple organizations*
- *Promotion of enabling standards*

METHODOLOGY

Sample

We use data from an extensive international innovation survey conducted in 2005-2007. The survey was sent to the vice-presidents of research and development or the chief technology officers of approximately 4000 mostly large firms from a wide range of sectors and countries. 940 firms completed most of the 11-page survey for a general response rate of 25% (Floricel, Dougherty, Miller, & Ibanescu, 2008; Floricel & Ibanescu, 2008: p.460).

We use a subset of the survey data to measure the relative importance of five actors on innovation

intermediation outcomes. As only 499 firms answered the pertinent questions, we conduct bias tests to compare the characteristics of the firms in the study sample of 499 firms to the characteristics of firms in the full sample. In our bias tests we consider 12 variables including five general variables that reflect the firm size, rate of growth, profitability, investment in R&D, and investment in human resource; three industry-cluster variables (science-based industries, large-scale industries, and high-competitive industries); and four country variables (Canada, the United States, China, and South Korea). The three industry clusters were identified using cluster analysis on another 10 variables that captured industry characteristics because not all firms responded to the industry membership question at the end of the survey. Firms in the science-based industries cluster include firms with high level of scientific content in products and services (e.g. electrical equipment manufacturers, computer system designers, aerospace product manufacturers, architectural, engineering and related service providers, and management, scientific and technical consulting service providers). Firms in the large-scale industries cluster include firms with stable technical knowledge bases and that experience a high level of regulatory intervention and government support (e.g. basic chemical manufacturers, pharmaceutical and medicine manufacturers, semiconductor manufacturers, and transportation manufacturers). Firms in the highly competitive industries cluster include firms that are cost sensitive and that face severe competition in markets (e.g. software publishers, management, scientific and technical consulting service providers, architectural, engineering and related service providers, and automotive manufacturers).

As shown in Table 2 below, the study sample is biased. Compared to the omitted sample, the firms in study sample have less R&D investment over sales and a lower proportion of the total time and energy of employees devoted to innovation than firms in the omitted sample, but higher

annual sales growth and average net profit on sales over the last three years. The results of chi-square tests show that the differences between the proportions of firms in three industry clusters are not statistically significant, but that there is a high proportion of firms from Asia in the study sample, and a high proportion of firms from North America in omitted sample. As the growth in GDP of Asian countries has been higher than the growth of GDP in North American countries in recent years, and as Asian firms are considered to be less innovative than Western firms (Breznitz & Murphree, 2011; Gu & Lundvall, 2006), the differences in firm nationalities in the study and omitted samples may explain the differences in the general variables in the two samples. As a consequence of this sample bias, care must be taken in the interpretation of our results.

Insert Table 2 about here.

Measures

Outcome importance. The importance of each of the ten innovation intermediation outcomes is represented as a dependent variable that is measured on a scale of 1 to 7 in the survey (1: Not at all important; 7: Extremely important). As shown in Table 3 below, two learning outcomes, namely, helping firms learn about new technologies (mean=5.21) and helping firms learn about new markets (mean=4.98), are considered most important. In contrast, the outcomes of coercive processes, namely, forcing firms to innovate by regulations (mean=3.78) and forcing firms to innovate through social pressure (mean=3.51), are considered least important.

Insert Table 3 about here.

Actor importance. For each innovation intermediation outcome, respondents were asked to identify the actors that were important to the achievement of that outcome. Actor importance equals 1 if actor i is important for outcome j, and 0 otherwise.

In addition to the dependent and independent measures, we control for firm attributes. We consider five variables that are measures of the firm size (number of employees), rate of growth (annual sales growth over the last three years), profitability (average net profit over the last three years), and innovativeness (investments in human resources and investments in R&D). We use the natural logarithm of the number of employees because we expect the effect of size to increase at a diminishing rate. Descriptive statistics on control variables are shown in Table 3 above.

We examine the matrix of correlations between the variables in each of the ten models that include one dependent variable, five independent variables, and five control variables[1]. There are high correlations between the dependent variable and the corresponding independent variables in some cases, but the correlations amongst the independent variables are generally low (below 0.3 in all cases). The low correlations between independent variables suggest satisfactory discriminant validity (Cohen et al., 2003). Variance inflation factors for each of the ten models are all less than five, well below the cutoff of 10 (Draper & Smith, 1998), suggesting that the multi-collinearity is not a problem.

Rationale of Analytic Approach

[1] The table of correlations is not shown but is available from the authors.

We use ordinal logistic regression to test the relationships between innovation intermediation outcomes and organizational actors. The assumption of a normally distributed dependent variables does not hold in our case as the dependent variables are measured on a 7-point scale. Thus, we use ordinal logistic regression as it makes no assumption about the distribution of dependent variable. Its primary assumption is the proportional odds assumption (Ruefli & Wiggins, 2003), and we test this assumption in our models using chi-square tests that examine whether the proportional odds assumption is violated. The results of chi-square tests are significant, indicating that the assumption (except in the case of Model 10) has been violated (Wang & Schaan, 2008). To remedy this we merge adjacent values of the dependent variable (Strömberg, 1996). Given *n* possible values of the dependent variable, the number of merged groups may range from 2 to *n* (Greenland, 1993). For each model, we find the first merging scheme for which the *p*-value of the Chi-square test exceeds the cutoff 0.05, indicating that the proportional odds assumption has been met[2].

We further increase the reliability of our analysis by removing influential observations that may have an undue impact on our results. We use the leverage approach that identifies influential observations on the basis of distance between specific observation predictor values and mean observation predictor values. We remove from each model those observations whose leverage values are greater than $(2k+2) / n$, where k is the number of independent variables in the model and n is the number of observations (Li, 1985).

[2] Details are available from the authors.

RESULTS

To test our hypotheses we use the results of the ordinal logistic regression shown in Table 4. We first consider the importance of firms as innovation intermediaries and note that firms and industry associations are the only actors significantly associated with the importance of all innovation intermediation outcomes (Table 4, Models 1-10). Hypothesis 1 states that for-profit firms are the actor most strongly associated with the facilitation of learning, specifically assistance with learning about new technologies, learning about new markets, and the provision of business advice. Firms are the most important actors in helping other firms learning about new technologies (Model 1: $\beta = 0.72$, $p < .001$) and helping other firms learn about new markets (Model 2: $\beta = 0.85$, $p < .001$), but are not the most important providers of business advice. The surprising emergence of research institutes as the most important source of business advice (Model 3: $\beta = 0.78$, $p < .001$) is a consequence of the important role of research institutes for North American firms in large-scale industries in the sample (more on this below).

Insert Table 4 about here.

Hypothesis 2 suggests that universities are the actor most strongly associated with the provision of expertise through the identification of knowledgeable people and through undertaking innovative activities on behalf of firms. As these are the outcomes for which universities are identified as the most important actors –identifying knowledgeable individuals (Model 4: $\beta = 0.91$, $p < .001$), and undertaking innovative activities on behalf of firms (Model 8: $\beta = 0.94$, $p < .001$) – Hypothesis 2 is supported. We note that universities are also strongly associated with

the facilitation of learning about technology and the facilitation of collaboration.

Hypothesis 3 states that governments are the actors most strongly associated with the importance of coercive outcomes, innovation required by changing regulations or social pressure. Our results show that governments are the actors most strongly associated with innovation required by changing regulations (Model 9, $\beta = 0.85$, $p < .001$), and innovation required in response to social pressure (Model 10, $\beta = 1.11$, $p < .001$), so Hypothesis 3 is supported. It is interesting to note that governments are also the second most important actor, after industry associations, for the facilitation of collaboration (Model 6), and that governments are not significantly associated with any of the learning outcomes (Models 1-3) or with the identification of knowledgeable people (Model 4).

Finally, Hypothesis 4 suggests that industry associations are the actor most strongly associated with the importance of collaborative outcomes, specifically the identification of partner firms and organizations, the facilitation of collaboration, and the promotion of enabling standards. The results show that industry associations are the actor most strongly associated with the facilitation of collaboration (Model 6: $\beta = 0.95$, $p < .001$). But industry associations are not the actors most strongly associated with the identification of partner firms and organizations (Model 5) or with the promotion of enabling standards (Model 7), so Hypothesis 4 is not supported. Firms are the actor most strongly associated with the identification of partner firms and organizations (Model 5: $\beta = 0.93$, $p < .001$), and governments are the actor most strongly associated with the promotion of enabling standards (Model 7: $\beta = 0.95$, $p < .001$). But industry associations are the second most important actors for the facilitation of learning about new markets (Model 2), the promotion of standards (Model 7), and innovation necessitated by social pressure (Model 10).

Although research institutes only emerge as the most important actor for the attainment of the provision of business advice, it is of interest to note that research institutes are the second most important actor for the facilitation of learning technologies (Model 1) and the identification of partners (Model 5) – three of the outcomes with which firms are most strongly associated.

We also analyze the data segmented by region and industrial sector, and summarize the results as follows[3]. When the data is segmented by region, industry associations emerge as the actor most strongly associated with the facilitation of learning about new markets (β =1.31, p < .001), the provision of business advice (β =1.02, p < .001), and the identification of partners (β =1.07, p < .001) in Asia, whereas firms are the actor most likely to perform this role in North America. The lower levels of inter-firm collaborative and trust amongst Chinese firms (Gu and Lundvall, 2006) may lead to a reliance on industry associations as inter-firm mediators in Asia. But while industry associations are the actors most strongly associated with the promotion of enabling standards in North America (β =1.54, p < .001), governments are the actor most strongly associated with that role in Asia (β =1.53, p < .001), consistent with the higher level of government intervention in Asia (Breznitz & Murphee, 2011). The remaining five results hold for both regions: universities are the actor most strongly associated with the identification of knowledgeable people and undertaking innovation activities on behalf of firms, industry associations are the actor most strongly associated with the facilitation of collaboration, and governments are the actor most strongly associated with the innovation necessitated by regulations or through social pressure.

[3] The details of analysis are not shown but are available from the authors.

When the data are segmented into the three industry clusters (science-based industries, large-scale industries, and highly-competitive industries) considerable variation in the results is revealed. Not surprisingly, universities take on a more pronounced role in science-based industries where they emerge as the actor most strongly associated with the facilitation of learning new technologies (β =0.85, $p < .05$), the facilitation of collaboration (β =1.79, $p < .001$), and innovation necessitated by social pressure (β =1.28, $p < .05$). Research institutes emerge as the actor most strongly associated with the facilitation of learning about new technologies (β =1.26, $p < .01$) and the provision of business advice (β =1.71, $p < .01$) in large-scale industries where research institutes may be larger and have a longer history. And industry associations emerge as the actor mostly strongly associated with the provision of business advice (β =1.72, $p < .001$) and the promotion of enabling standards (β =1.18, $p < .001$) in highly competitive industries, and as the actor most strongly associated with the provision of business advice in science-based industries. Three results are invariant across the three industry clusters: the effect of universities on the identification of knowledgeable people, the effect of firms on the identification of partners, and the effect of governments on innovation necessitated by regulations.

DISCUSSION

This study was motivated by the need for a better understanding of the outcomes of investments in innovation intermediation. As innovation intermediaries have only recently been understood as an overarching class of organizations (Howells, 2006), researchers have not yet developed methodologies for measuring outcomes that are applicable across different types of

intermediaries. Outcomes associated with investments in research consortia have been measured using patents (Sakakibara & Branstetter, 2003) and the ability to attract venture capital financing (Feldman & Kelley, 2006) as the dependent variables, while outcomes associated with investments in science parks have been measured using regional employment (Shearmur & Doloreux, 2000) and firm growth in terms of revenues and employment (Löfsten & Lindelöf, 2002) as the dependent variables.

We have employed an approach to considering the impact of innovation intermediation activities that can, in principle, be applied across intermediary types. By considering a range of immediate outcomes we were able to detect the impact of a wide range of organizational actors on the innovative capacity of the firms in our sample. In this exploratory study we considered the impact of for-profit firms, universities, governments, industry associations, and research institutes. In future research it may be useful to compare the impact of more specific sets of actors such as those active in particular country or region.

Our approach considered the immediate impact of external actors on firm resources and capabilities, specifically on the firm's ability to learn, gain access to expertise, and engage in collaboration. We also considered the impact of regulations and social pressure. By asking respondents about immediate impacts that may be directly attributable to the external actor in question, we minimized the cognitive burden on respondents and the bias in responses. Had we instead asked about the impact of external actors on longer term outcomes such as increased revenues or employment, the respondent would have had to tease out the impact of the contribution of the external actor from the many other factors that impact firm revenues and employment. Our focus on immediate impacts was inspired by the Oslo Manual guidelines for

innovation surveys that suggest asking about information sources and collaboration (OECD, 2005). But the Oslo Manual considers only two potential outcomes of innovation intermediation processes –information sources and collaboration partners, whereas we considered ten.

Past research suggests that for-profit firms are the most important sources of information and collaboration (Amara & Landry, 2005; Freel, 2000; Laursen & Salter, 2006; Segarra & Arauzo, 2008; Veugelers & Cassiman, 2005) and our findings confirm and extend this work by showing that firms are the actors most strongly associated with providing assistance in learning about technology and learning about new markets, the two most important innovation intermediation outcomes we considered. But we also show that firms are not always the most important actors in facilitating innovation; our findings show that firms are not the actor most strongly associated with seven of the ten innovation intermediation outcomes. Policy makers should also consider the role of universities in identifying knowledgeable individuals and undertaking innovative activities on behalf of focal firms and the role of industry associations in facilitating collaboration. In terms of regional and sectoral variations, the enabling effect of for-profit firms is more significant in North America than in Asia, while the effect of industry associations is more significant in Asia than in North America. It is also interesting to note the important role of universities in the science-based industries cluster, research institutes in the large-scale industries cluster, and industry associations in the highly competitive industries cluster.

Our empirical results are limited by the nature of our sample and our measures. Our sample contained a high proportion of Asian firms and this bias diminished the importance of for-profit firms and increased the importance of industry associations in some of our models, although

industry associations were the actor most strongly associated with the facilitation of collaboration in both the Asian and North American subsamples. In terms of our measures, we were limited to considering only ten fairly high-level innovation intermediation outcomes, and only five organizational actors. In future research it may be useful to enlarge upon this set of possible outcomes and actors.

CONCLUSION

While our study can only be considered exploratory, our findings suggest that different organizational actors offer different capabilities as innovation intermediaries. We find that firms are identified as the most important learning facilitators, universities as the most important sources of expertise, governments as the most important coercive actors, and industry associations as the most important facilitators of collaboration. We interpret our results to suggest that firms need access to a wide range of external resources and capabilities and that government investments in dedicated innovation intermediaries may well yield the sought-after socio-economic returns.

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Table 1: Ten Innovation Intermediation Outcomes

Nature of Outcome	Specific Outcomes
Facilitation of Learning	1. Helps our firms learn about new technologies 2. Helps our firms learn about new markets 3. Provides our firm with business advice
Facilitation of Collaboration Identification of partners	4. Identifies knowledgeable individuals 5. Identifies partner firms and organizations
Collaborative activities	6. Facilitates collaboration 7. Promotes enabling standards 8. Undertakes innovation activities on behalf of firms
Coercive Outcomes	9. Forces us to innovate by changing regulations 10. Forces us to innovate through social pressure

Table 2: Bias Tests Comparing Study Sample to Omitted Sample

Variable	N	Test	Result
General Variables			
1. R & D investment over sales	714	2-sample t-test	-2.69**
2. Number of employees	714	2-sample t-test	1.51
3. Time and energy of the firm's employees that is devoted to innovation	714	Mann-Whitney test	2.04**
4. Annual sales growth	714	Mann-Whitney test	-2.30**
5. Average net profit	714	Mann-Whitney test	-3.89**
Industry Variables			
6. Proportion of firms in science-based industries	186	Chi-square test	0.00
7. Proportion of firms in large-scale and stable technology industries	182	Chi-square test	1.00
8. Proportion of firms in highly competitive industries	375	Chi-square test	0.73
Country Variables			
9. Proportion of firms in Canada	302	Chi-square test	126.01***
10. Proportion of firms in the United States	178	Chi-square test	1.09
11. Proportion of firms in China	201	Chi-square test	156.55***
12. Proportion of firms in South Korea	60	Chi-square test	7.82**

**$p < .01$
*** $p < .001$

Table 3: Dependent and Control Variables Descriptive Statistics

Variables	Min	Max	Mean	SD
Dependent Variables				
Helps learn new technology	1	7	5.21	1.22
Helps learn new markets	1	7	4.98	0.87
Provides with business advice	1	7	4.49	0.85
Identifies knowledgeable people	1	7	4.61	1.02
Identifies partner firms and organizations	1	7	4.61	1.13
Facilitates collaboration	1	7	4.31	1.14
Promotes enabling standards	1	7	3.39	0.87
Undertakes innovative activities	1	7	4.39	1.16
Forces innovation by regulations	1	7	3.78	1.51
Forces innovation by social pressure	1	7	3.51	1.82
Control Variables				
Number of employees (firm size)	1	360000	13095	42591
Annual sales growth	1	6	4	1
Net profit over sales	1	6	3	1
R&D investment	0	100	13.18	17.18
HR investment	1	8	4	2

Table 4: Models of the Relative Importance of Organizational Actors for Each of Ten Innovation Intermediation Processes

Variables	Model 1 Help learn-technology	Model 2 Help learn-market	Model 3 Provide business advice	Model 4 Identify people	Model 5 Identify partners
Firms	0.72***	0.85***	0.65***	0.68***	0.93***
	(0.16)	(0.17)	(0.16)	(0.17)	(0.17)
Universities	0.61***	0.42	0.61*	0.91***	0.39
	(0.16)	(0.34)	(0.27)	(0.17)	(0.25)
Governments	0.14	0.30	0.07	0.23	0.49*
	(0.20)	(0.20)	(0.23)	(0.23)	(0.19)
Industry associations	0.33*	0.81***	0.62**	0.50**	0.65***
	(0.16)	(0.17)	(0.17)	(0.17)	(0.16)
Research institutes	0.70***	0.75**	0.78***	0.37	0.72**
	(0.21)	(0.26)	(0.26)	(0.23)	(0.23)
Ln(Firm size)	-0.01	-0.02	-0.04	-0.03	-0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Sales growth	0.08	0.13	0.14	0.10	0.15*
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
R & D investment	0.01	0.00	0.01	0.01	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
HR investment	-0.01	0.03	-0.05	-0.05	-0.06
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Profit on sales	0.05	-0.03	0.09	0.02	0.10
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
n	483	473	68.31***	480	477
Chi-square	60.31***	76.69***	0.13	71.74***	99.62***
Nagelkerke R^2	0.11	0.15	0.65	0.14	0.18

Standard errors are in parentheses.

* $p < .05$

** $p < .01$

*** $p < .001$

Table 4: Models of the Relative Importance of Organizational Actors for Each of Ten Innovation Intermediation Processes (Continued)

Variables	Model 6 Facilitate collaboration	Model 7 Promote enabling standards	Model 8 Undertake innovative activities	Model 9 Force innovation-regulations	Model 10 Force innovation-social pressure
Firms	0.59***	0.65***	0.38*	0.13	0.80***
	(0.18)	(0.19)	(0.18)	(0.20)	(0.22)
Universities	0.83***	0.46	0.94***	0.13	0.71**
	(0.21)	(0.24)	(0.17)	(0.25)	(0.29)
Governments	0.85***	0.95***	0.69**	0.85***	1.11***
	(0.18)	(0.16)	(0.23)	(0.16)	(0.16)
Industry associations	0.95***	0.81***	0.62**	0.18	0.93***
	(0.17)	(0.16)	(0.20)	(0.16)	(0.19)
Research institutes	0.14	0.50*	0.62**	0.21	0.64*
	(0.24)	(0.23)	(0.21)	(0.24)	(0.28)
Ln(Firm size)	0.04	0.10***	0.00	0.13***	0.13***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Sales growth	0.12	0.17*	0.13	0.08	0.17*
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
R & D investment	0.01*	0.00	0.00	0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
HR investment	-0.05	-0.04	-0.04	-0.15*	-0.17**
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Profit on sales	-0.01	-0.03	-0.01	-0.01	-0.07
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
n	478	480	477	478	483
Chi-square	106.39***	111.76***	59.35***	102.32***	131.12***
Nagelkerke R^2	0.20	0.20	0.11	0.23	0.23

Standard errors are in parentheses.
* $p < .05$
**$p < .01$
*** $p < .001$