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The Effects of Inter-industry and Country Difference in Supplier Relationships on Radical Innovations

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ABSTRACT

Radical innovations are critical driving forces for firms to engage in corporate growth and new business development. Innovating firms are increasingly generating new knowledge in collaboration with partners. In this paper, we analyze how the knowledge differences between the innovating firms and their suppliers in Canada are likely to result in radical innovations that are new to the world. The knowledge difference is decomposed into two dimensions: the industrial dimension and the geographic dimension in national context. Using the Canadian Innovation database, we found the inter-industry difference has a positive effect and the country difference has a negative effect on the likelihood of generating radical innovation. The findings of this paper suggest that for generating radical innovation, it is important not only to search for suppliers from different industries to get access to various complementary external knowledge sources but also to find suppliers from the same or nearby countries for the sake of communication and coordination.

Key Words— *Radical innovation, knowledge difference, inter-industry difference, country difference, supplier relationships*

1. INTRODUCTION

Innovating firms are increasingly generating new knowledge in collaboration with partners. Studies on strategic management and innovation have recognized that innovation is an interactive, cumulative and cooperative phenomenon between different organizational actors [1]. In this paper, we focus on the role of suppliers as collaborators in the innovation process. More precisely, we analyze how supplier relationships are likely to result in radical innovations that are new to the world.

The novelty and radicalness of innovations result from the difference between the component elements or the novel ways in which these elements are recombined [2]. Dissimilar external knowledge comes from different resources, which can be investigated through different dimensions. We focus on two dimensions that might have major influences in explaining the likelihood of radical innovations. First, knowledge differences between the innovating firms and their suppliers can be explained by *inter-industry difference* between them [3]. Second, firms' geographic localization matters in innovation as well [4]. *Country difference* captures the differences between national contexts in which firms are located [5]. It is important to investigate the role of *inter-industry difference* and *country difference* as sources of dissimilar knowledge in generating radical innovations because the influence of the interplay between *sectoral* and *national* patterns of innovation is still under-developed in the literature.

Supplier relationship is an important source of creativity in innovation. Nevertheless, the relationship between supplier involvement and firms' innovation performance remains unclear in the literature. Research on supplier involvement addressed the importance of involving key suppliers in new product development projects [6]. However, other researchers found that supplier involvement may not always have a positive effect on new product development project because supplier involvement requires great extent of complexity for project management. In this paper, we take the knowledge difference perspective to investigate the complexity of the interactions between suppliers and the focal firms' innovation performance. The central research question of this paper, thus, is: *What are the effects of sectoral difference and country difference between the innovating firm and its suppliers on a firm's ability to generate radical innovations?*

2. THEORY AND HYPOTHESES

In this paper, we distinguish whether an innovation is radical from a firm perspective. We define the radical innovations as those that are new to the firm in technology dimension and create a new market in the world for the first time

Diverse external knowledge from different industries and nations

Innovating firms are increasingly generating new knowledge in collaboration with partners. Single organizations usually do not possess all the knowledge for innovation internally. Difference in knowledge is a crucial condition for learning and innovation to produce Schumpeterian 'novel combination' [7]. Thus radical innovation is more likely to emerge when inter-organizational interactive learning takes place.

Differences in the knowledge base between the innovating firm and its partners can be broken down into multiple dimensions. The uneven distribution of economic competence is not only firm-specific but also *industry-specific*. The diversity among industries take forms as in R &D, production efficiency, market structure, innovation, technology intensity, resource endowment and so forth [3]. Industries also differ in the degree to which firms are able to capture the rents generated by their innovations [8]. The aggregation of these differences across industries results in the inter-industry differences in knowledge base. Therefore, we focus on the *inter-industry difference* as the first dimension along which firms get access to external knowledge source. Differences between firms along the industrial dimension may create a potential for novel combinations.

Second, searching new knowledge also has a geographic dimension. Geographic proximity plays an important role for knowledge flows [9]. At the macro level, the geographic dimension is a matter of difference among nations. The availability of common resources within a region is related to agglomeration economies. Particular countries develop relatively stable and distinct trajectories of technological specialization and display different patterns in R &D and even day-to-day operations. However, differences among countries with respect to language, institution, and culture may form obstacles for communication and coordination between firms [10]. Therefore, the role of *country difference* deserves careful investigation. In this paper, we focus on a specific collaborative relationship—suppliers relationship—to examine the influence of the interplay between *sectoral* and *national* patterns of innovation.

Innovation with supplier involvement

Firms have various types of collaborative relationships. Customer and supplier relationship is one of the most important industrial relationships. Many firms increasingly realize that supplier involvement in new product development is critical to reduce costs and the concept-to-customer development time, to improve quality, and, most importantly, to provide innovative knowledge that can facilitate radical innovations.

Each industry has its unique knowledge base. The key question is how the knowledge difference across industries between the innovation firm and its suppliers contributes to the generation of radical innovation. Radical innovations require firms to apply completely new technology to create a new market, which is a highly explorative activity [11]. Exploration is usually defined as consisting of activities that search for unfamiliar, distant, and remote knowledge. Firms with large inter-industry difference in knowledge base are more likely to get access to complementary information, resources and knowledge. Therefore, we hypothesize accordingly:

Hypothesis 1: Inter-industry difference between the innovating firm and its suppliers has a positive effect on the likelihood of generating radical innovations.

However, as novelty provides source for innovation, firms also need sufficient organizational capabilities to digest the novel knowledge and to develop it into marketable products or process. The critical organizational capability has been recognized at the organizational level as the *absorptive capacity* [12]. Absorptive capacity includes organizational capabilities to assimilate externally developed information, internally distribute it, and implement knowledge in various activities. Due to different experiences, technologies, markets and organizational histories, organizations have different foci, which yields the cognitive distance between organizations [1]. On the one hand, learning takes place where differences in knowledge exist. On the other hand, too large cognitive distance makes basic mutual understanding unachievable. Therefore, it is important for firms to cooperate with a minimum degree of similarity in knowledge base to maintain sufficient absorptive capacity.

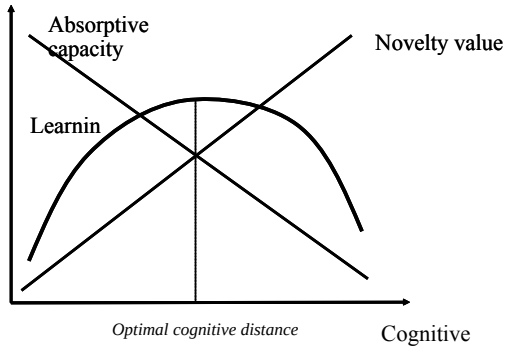

Figure 1: Implications of cognitive distance on novelty and absorptive capacity (Nooteboom 1999).

Given the possible positive effect of knowledge difference on novelty and the possible negative effect on firms' absorptive capacity, the combined effect of cognitive distance on innovation is expected to be a curvilinear function of innovation performance (see figure 1). The inter-industry difference between the innovating firm and its suppliers can be interpreted as one of the specific dimensions of cognitive distance. Hence, the rationale of cognitive distance in relation with innovation can be applied to inter-industry difference as well. Accordingly, we hypothesize:

Hypothesis 2: Inter-industry difference between the innovating firm and its suppliers has a curvilinear effect (inverted U shape) on the likelihood of generating radical innovations.

The innovating firm and its suppliers that are involved in innovation are also subject to the different national context. Knowledge takes on specific national characteristics due to, among others, different institutions, culture, language, technology specialization. On the one hand, in terms of national technology specialization, the difference between the innovating firm and its suppliers in the national context creates potentials for novel combination of knowledge. Successful innovations rely on learning from the world by searching technology and market intelligence that are scattered across the globe [13]. Accordingly, we hypothesize:

Hypothesis 3a: Country difference between the innovating firm and its suppliers has a positive effect on the likelihood of generating radical innovations.

On the other hand, specifically for the supplier relationship, the differences in institution, culture and language may hinder the generation of radical innovation. That is because radical innovations usually depart from the existing knowledge base and create a new technology trajectory and a new market segment. They are usually unique and specific, which are not suitable for mass production [1]. Therefore, the unique feature of radical innovations usually involves sticky-knowledge, which is more likely to be transmitted within a close geographical area with sufficient interactions and joint practices. It requires close communication between the innovating firm and its suppliers, thus it's better to choose suppliers from countries with similar language and culture. Besides, from a transaction cost economy perspective, for the sake of logistic cost, the innovating firms should choose suppliers from nearby countries. We argue that in the particular case of radical innovations, the negative effect of country difference based on the learning and communication concern may overwhelm the possible positive effect based on national technology specialization. Hence, we build a counter hypothesis against hypothesis 3a:

Hypothesis 3b: Country difference between the innovating firm and its suppliers has a negative effect on the likelihood of generating radical innovations.

3. DATA AND METHOD

The dataset used for this study is the Canadian Technological Innovation Dataset. It is a longitudinal dataset covering 1635 new or improved industrial products or processes introduced in Canada from 1945 to 1980. It involves about 550 innovating firms and roughly 2500 other companies (customers and suppliers) that were related to the innovating companies with respect to the corresponding innovation. The Canadian Data covers the most significant innovations from the viewpoint of their novelty. Innovations are labeled according to their novelty into three categories: *new-to-world*, *new-to-Canada*, and *new-to-firm only*. To establish the population of innovating firms, the Canadian survey used difference sources, such as industrial experts, trade journals, research and development performers and patent holders. We applied a few criteria to select a sample from this Canadian data. This selection finally results in a set of 510 innovations under our observation.[1]

Dependent variable

The dependent variable is a binary variable which indicates whether an innovation is radical or not. Note that all the innovations included in the Canadian data are technologically new to the firm. Innovations are labeled according to their novelty into three categories: *new-to-world, new-to-Canada*, and *new-to-firm only*. We define a *New to the world* innovation as radical innovation, while *New to Canada* and *New-to-the-firm-only* innovations are not radical.

Independent variables

1. Inter-industry difference. The Canadian data used a three-digit SIC system to indicate the main industry to which the firms belong. We assume that the SIC classification of a firm is an appropriate approximation of a firm's technology base and the difference in the SIC of two firms is a proxy for the technological distance between them. The Canadian dataset used its unique 3-digit hierarchical classification of the industries.

2. Country difference. We measure country difference from various dimensions that are crucial for collaborative learning. First, to ensure good communication between technical personnel and managers from different firms and cultivate an innovative culture, the language plays an important role. Second, countries also differ in institutional factors, which are also found to be crucial for innovation [14]. Finally, the culture parameters of Hofstede (1980) measures national culture difference in a unique manner, which has been widely used in strategic management studies. Therefore, we measure country difference in terms of *language*, *institution* and *Hofstede's culture parameters*. Next, we conducted a factor analysis to find if there is any common factor for *country difference*. The result indicates a single factor is sufficient to capture almost 88% of the variance in *country difference*. Thus, we used one variable to measure country differences. The factor score is the value for this variable[2] .

Control variables

[1] Due to limited space in paper, the sample selection criteria can be obtained upon request.

[2] A detailed explanation of scales on language difference, institutional difference, Hofstede's culture parameters and the statistics of the factor analysis is available upon request.

The following variables are controlled. They are *firm size*, *Prior experience*, *SIC category of innovating firms* and *time*.

Method

Our data has no skewed distribution (with 39 percent of the sample valued at 1, and 61% percent at 0). We use a binary logistic regression model to test our hypotheses, given the binary nature of the dependent variable.

4. RESULTS AND DISCUSSIONS

Table 2 presents the results of binary logistic regression to test our hypotheses. We started with a base-line model with only control variables included in the regression, and then introduce country difference, inter-industry difference and the quadratic terms of inter-industry difference into the model step by step. Compared to the base-line model, the likelihood ratio test shows that other models have stronger explanatory power. The results demonstrate some support for our hypotheses. First, the coefficients of inter-industry difference have a positive sign and statistically significant (model 3, 4, 5 and 6, respectively, $\beta= 0.349$, $p<0.01$; $\beta= 0.300$, $p<0.01$; $\beta= 0.890$, $p<0.05$; $\beta= 0.779$, $p<0.05$). Thus, Hypothesis 1 is supported. Second, we include the quadratic term of inter-industry difference in model 5 and model 6 (the full model). The coefficients show a negative sign but not statistically significant. Thus, hypothesis 2 found no support. A possible reason for this is that the measurement of inter-industry difference using SIC constrains this variable from having large values. Thus, we only found the left side of the inverted U-shape relationship (which is demonstrated by the positive effect of inter-industry difference on radical innovation), but not the right side of the relationship. It is also possible that the key source of creativity lies in the technology distance between firms, regardless in which industry a firm is active. Therefore, using SIC-codes may not well represent the differences in technology profiles between the innovating firm and its suppliers. Finally, the coefficients of country difference have a negative sign and are statistically significant (model 2, 4 and 6, respectively, $\beta= -0.313$, $p<0.01$; $\beta= -0.220$, $p<0.1$; $\beta= -0.220$, $p<0.1$). Thus, hypothesis 3b is supported. We also found that the coefficient of *firm size* has a negative sign and the coefficient of *prior experience* has a positive sign. Both of them have a significant effect in the base-line model (Model 1, respectively, $\beta= -0.176$, $p<0.05$; $\beta= 0.529$, $p<0.1$). That implies that, first, during the period of 1940's till 1980's small Canadian firms are more likely to generate radical innovations while large firms are usually trapped with what they are good at although they might have greater resources than the small firms. Second, firms with greater successful experiences in generating radical innovations perhaps learn how to deviate from their existing knowledge base and feel more comfortable to explore new opportunities. This implication is different than some viewpoints in the existing literature on exploitation and exploration, which argue that successful exploration leads to exploitation and eventually drives out further exploration. We argue that in the short run, to maximize the benefit of radical innovation, the following exploitation is inevitable. However, in a long run, firms with successful experience in making radical innovations benefit from high return, which gives firms strong incentive to explore again to find the new wave of profit. With their successful experience, they are more likely to know how to escape their own knowledge traps and ensure survival in the long run.

5. CONCLUSION

This study investigates the impact of knowledge difference between firms on the likelihood for a firm to generate radical innovations. It decomposes the knowledge differences into two dimensions: the industrial dimension and the geographic dimension in national context. Our result shows that the country difference have a negative effect on the likelihood of generating radical innovations, which implies that the learning and communication concern may overwhelm the possible positive effect based on technology specialization across nations. Further, the theory of organizational cognitive distance [1] is used to explain why that the inter-industry difference between the innovating firm and its suppliers has a curvilinear effect (inverted U-shape) on the likelihood of radical innovations.

Our study contributes to the existing literature in several ways. First, studies on the influence of knowledge difference usually use patent data to measure technological distance or geographical proximity, which inevitably overlook the distinctive industrial relationships between firms. Other studies that investigate the relationship between supplier involvement and innovation fail to explore the impact of external knowledge differences *between* firms in multiple dimensions. Our paper, thus, investigates a specific relationship between firms—supplier relationship. It focuses on the influence of knowledge difference in two dimensions between the innovating firms and their suppliers on a particular type of innovation—radical innovation. The findings of our analysis suggest the importance of distinguishing certain types of inter-firm relationship when examining the role of knowledge difference between firms on firms' innovation performance. Second, this paper recognized the importance of defining types of innovation by the relevant unit of adaptation. We explicitly clarify our definition of "radical innovation" at the firm level by separate its technological dimension and market dimension. Next, the findings of our analysis refute the thesis of "death of geography", which claims the diminishing differences in nation-state because of the advancement of communication tools, the growth of multinationals and global market [15].

Our study also has several limitations. First, the data is collected for the period of 1940's till 1980's, when IT technology has not been well developed yet. One can reasonably expect that communication between firms is much easier than ever by means of IT technology in the 21 century. Whether country difference still plays the same role for stimulating innovation as we reveal in this paper may be questionable in the new era. Second, the innovating firms in our dataset are all Canadian firms. Thus the generalizability of findings is limited. Finally, we found that, in general, the coefficients of squared term of inter-industry difference are not significant. It could be because our measure for inter-industry differences using SIC-code is only a raw proxy. Future research that uses other measures to indicate inter-industry difference may deliver a better understanding of the impact of inter-industry difference between firms.

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Table 2: Binary logistic regression—Effects of Inter-industry and Country difference on the possibility of generating radical innovations [a, b]:

Variable	Model 1 (Base)	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	-20.324 (40195.817)	-20.239 (40193.159)	-21.769 (40189.789)	-21.502 (40202.228)	-21.728 (40186.765)	-21.468 (40192.678)
Country difference		-0.313*** (0.109)		-0.220* (0.113)		-.220* (0.113)
Inter-industry difference			0.349*** (0.096)	0.300*** (0.101)	0.890** (0.387)	0.779** (0.391)
Inter-industry difference^2					-0.178 (0.123)	-0.157 (0.124)
Firm Size	-0.176** (0.072)	-0.120 (0.076)	-0.096 (0.075)	-0.069 (0.078)	-0.109 (0.076)	-0.080 (0.079)
Prior experience	0.529 * (0.306)	0.417 (0.312)	0.423 (0.310)	0.355 (0.314)	0.425 (0.309)	0.356 (0.313)
Likelihood ratio test (relative to model X)	--	18.65*** (model 1)	13.81*** (model 1)	27.60*** (model 1)	2.10 (model 3)	13.55*** (model 5)
Cox & Snell R^2	0.089	0.106	0.115	0.123	0.118	0.126

N=510,

* $p< 0.1$; ** $p< 0.05$; *** $p< 0.01$

[a]. Coefficients for dummy variables *Decade* (D50, D60, D70) and *Industry category* (SIC00, 01, 02 through 09) as control variables are included in all models, but not listed in the table.

[b]. Instead of using the four separate dummy variables for four Decades, we also used two different ways to control the effect of time. First, we introduce a Year-trend variable with continuous measure of year; second, we used dummy variables to control every five years. The results show that the model fit and

significance of effects for each main variable are similar to the models using four separate dummy variables for four decades. Therefore, hereby we only report the results by using four separate dummy variables for decades.