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Do technology transfer, R&D collaboration and co-operation matter for R&D along the supply chain? Evidence from Vietnamese young SMEs

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A B S T R A C T

Technology transfer, collaboration, and co-operation in the R&D innovation increase their importance when firms integrate into the world economy, especially along the global supply chain. By using a specially designed sample of 3,253 Vietnamese young small and medium-sized enterprises in 2010-2013, the article examines the impact of technology transfer and R&D collaboration and co-operation on a firm's R&D innovation input, and innovation output, along the supply chain. The estimation results indicate that technology transfer collaboration and co-operation are complementary during the innovation process, initiating the application of innovation both in terms of input and output. In addition, R&D collaboration and co-operation are complementary in enhancing the innovation output.

1. Introduction

Integration into global markets is affecting the way that firms organize their activities related to R&D innovation, supply chain – those are heavily based on increasing collaboration and/or co-operation (Soosay et al., 2008; Arshinder et al., 2011; Becker & Dietz, 2004). A number of studies have paid attention to collaborative, and cooperative activities that help enterprises enhance R&D activities and overcome challenges posed by globalization (Polenske, 2004; Markusen, 1996; Paul, 1991). In the past decade, we have observed an emerge of open innovation model, where firms complement and supplement their own technological resources with those of other firms (Chesbrough, 2003). The increase of new and innovative products requires a working network involving several firms and institutions (Nooteboom, 1999). Information exchange and resource transfers with different counterparts are decisive acting components in the innovation (Becker & Dietz, 2004). The crucial role of technology transfer (TT) and R&D collaboration and co-operation has accelerated as a consequence of network complexity, both inside and outside challenges and large budget requirements of innovation (Coombs, 1988; Dodgson, 1993); Hagedoorn & Schakenraad, 1992). Arora and Gambardella (1994) discover, for large US chemical and pharmaceutical firms, R&D collaborations are increasing.

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Colombo (1995) studies the information technology industries and identifies a complementary between firm co-operation and intensity level of R&D. Veugelers (1997) finds positive influences of R&D co-operation on the level of R&D investments in the Flemish manufacturing industry. Fritsch and Lukas (1999) find differences in firms' tendency to conduct collaboration in R&D and the types of co-operation business partners for German manufacturing enterprises. Becker and Dietz (2004) assess the impact of R&D co-operation on a firm's innovation in the German manufacturing industry and prove that R&D collaboration and co-operations possess a complementary interaction. Regarding the innovation input, their study finds that inhouse R&D with highly intensive level also energize the odds and the number of R&D co-operation activities with other firms and institutions.

According to Vietnam Enterprise Survey (VES) in 2013, the percentage of firms investing some form of R&D in 2012 accounts for 6.4% (in the sample, approximately 514 of the 8,010 firms). It is estimated that research expenditure makes up 53% and mainly focuses on developing technology that is new to the market where the firm operates in. Meanwhile, over the total of research expenditure (from a sample of 504 firms), the 'frontier research' represents an insignificant amount, at 4%. The proportion of research development investment in technology that is new towards enterprises constitutes the remaining 43%. Although R&D on 'frontier research' is low, examining factors related to innovative activities is key to issuing an appropriate industrial policy for Vietnam in terms of R&D investment.
According to Czarnitzki and Delanote (2013), individual firms are differentiated in characteristics of such size and age and those are interrelated and thus this has led to the definition of a new category of young and small firms. Over the last decade, scholars turn their interest in this category of companies (see, for example, Schneider and Veugelers (2010), and Veugelers (2008)). In general, the influence of R&D collaboration and co-operation on firms' R&D innovation is relatively less investigated. Previous studies have mostly examined the role of network settings in separate industries and the importance of either R&D collaboration or co-operation. Using the Vietnam Technology and Competitiveness Survey (TCS) in combination with the VES in three years, namely: 2011, 2012 and 2013, we construct a unique panel dataset of 3,253 young SMEs to analyses the impacts of TT and R&D collaboration and co-operation on the R&D innovation outcomes by young SMEs along the supply chain. By doing so, the present paper contributes three points to the literature. First, it integrates collaboration and co-operation with the supply chain, both in terms of R&D innovation and TT. Second, activities such as collaboration and co-operation are used to explain R&D innovation among young SMEs in Vietnam. Third, the analysis pays attention to the impact of R&D collaboration and co-operation on both of firm's input and output related to innovation.

The paper is structured as follows: In section 2, an analytical framework for the R&D innovation effects of TT and R&D collaboration and co-operation is discussed. Section 3 highlights the dataset and specifies variables and estimation methods for the empirical analysis. Section 4 analyses estimation results on the impacts of TT and R&D collaboration and co-operation for Vietnamese young SMEs. Section 5 is a conclusion.

2. Technology transfer, R&D Collaboration, Co-operation and Innovation Activities of Firms – Analytical Aspects

According to Polenske (2004), collaboration is defined as direct interaction by two or more participants conducting designing, producing and/or marketing a product (process). The correlation among these factors is normally considered as internal arrangements that are usually vertical, sometimes along supply chains. Joint ventures might be combined. In contrast, Polenske (2004) defines co-operation as formal or informal arrangements by two or more actors to provide managerial and technical training, contribute capital investment, and/or provide information on market competition. These actors play interacted roles along the external and horizontal dimensions. Fig. 1 illustrates how technology transfer and R&D collaboration and co-operation are defined.

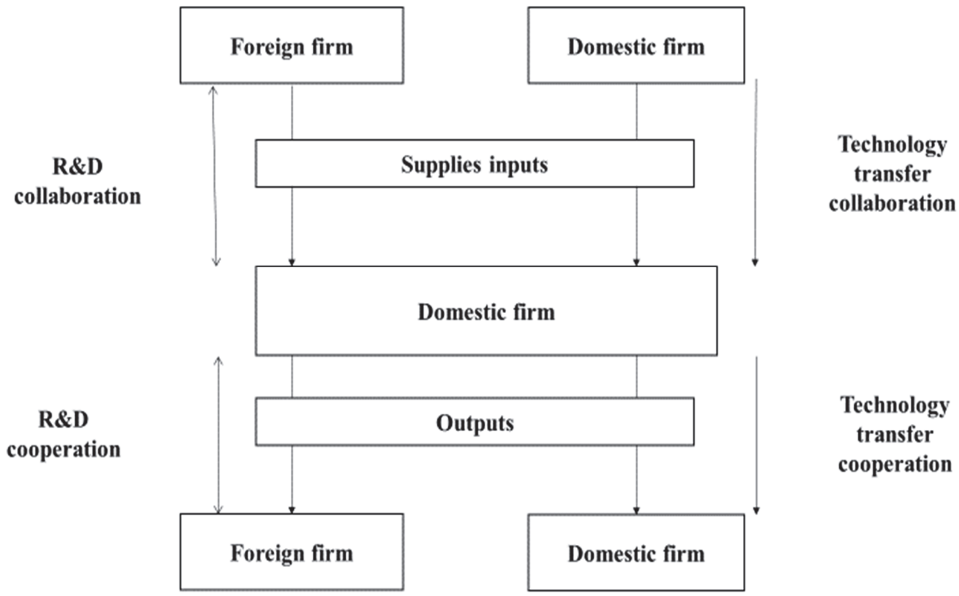

Fig. 1. Definition of TT and R&D collaboration and co-operation

Source: Authors' compilation and modification from (Polenske, 2004)

Technology collaboration occurs when domestic firms receive TT from domestic or foreign suppliers, whereas technology co-operation occurs when domestic firms receive TT from domestic or foreign customers. Similarly, R&D collaboration occurs when domestic or foreign firms involved in any R&D activity with domestic or foreign firms, whereas R&D co-operation occurs when domestic firms involved in any R&D activity with domestic or foreign customers.

3. Data and Estimation Methods

3.1. Data Set and Variables

Our data are from four rounds of TCS, which collected detailed information on TT along the supply chain for a nation-wide representative sample of about 4,000 Vietnamese domestic SMEs in 2011, 2012, and 2013. Our sample is a subset of domestic firms covered by the VES (which includes over 50,000 domestic enterprises) conducted annually by the General Statistics Office of Vietnam. TCS data are matched with information on firm activities and financial accounts by using firm identifications.
The dependent variables reflect the firms' innovation input and output in the Vietnam manufacturing industry. The innovation input dummy variable is defined as the R&D projects is ongoing in the survey year. Firms' innovation output is measured by a dummy variable assigned to the R&D projects complete in the survey year. Table 1 lists explanatory variables for the firms' innovation behavior in the Vietnamese manufacturing industry. To cover the influences of R&D collaboration and co-operation, two sets of variables are inserted in the estimations. One dummy variable is employed for firms within R&D collaboration and co-operation. To measure the importance of TT collaboration and co-operation, we distinguish technology co-operation (TT from customers), and TT collaboration (TT from input suppliers). In general, external resources (knowledge) determine the capabilities of the firm in positive movement (if external resources increase their level of importance, the firms' capabilities become stronger) in order to innovate and involve in the innovation process (Arvanitis & Hollenstein, 1994; Gambardella, 1992; Levin & Reiss, 1989). We generate three dummy variables to proxy for the effects of collaboration and co-operation in R&D: (1) collaboration and co-operation in R&D within province in Vietnam, (2) collaboration and co-operation in R&D outside province but within Vietnam,

and (3) collaboration and co-operation in R&D outside Vietnam. By doing so, we investigate how the type of networking affects R&D innovation activities.

Table 1

Explanatory variables in R&D innovation model

Variable	Description
R&D collaboration and co-operation	Dummy: a firm having R&D collaboration and co-operation (Yes=1; No=0)
TT collaboration	Dummy: a firm having TT collaboration (Yes=1; No=0)
TT co-operation	Dummy: a firm having TT co-operation (Yes=1; No=0)
Networking	(1) Dummy: a firm having collaboration and co-operation in R&D within province in Vietnam (Yes=1; No=0), (2) Dummy: a firm having collaboration and co-operation in R&D outside province but within Vietnam (Yes=1; No=0), and (3) Dummy: a firm having collaboration and co-operation in R&D outside Vietnam (Yes=1; No=0).
Aims of innovation	Dummy: general purpose (Yes=1; No=0) Dummy: special purpose (Yes=1; No=0)
Market-related factors	Firm size: Sales lagged one period (log form) Export share in sales (%) (ShareExp)
Technological opportunities	Dummy: a firm having relationship with FDI domestic suppliers (FDIDomSup) (Yes=1; No=0) Dummy: a firm having relationship with FDI domestic customers (FDIDonCus) (Yes=1; No=0)
Market competition	Dummy: a firm facing competition in the main field of activity (Yes=1; No=0) Competition variables indicate the level of competition (measured by the number of competitors) faced by the firm at the district level (ComD), the provincial level (ComP), and the country level (ComC). Dummy: a firm as a "price taker" (Yes=1; No=0) Dummy: a firm with limited autonomy setting prices (ltdautonomy) (Yes=1; No=0) Market variables indicate the market shares at the district level (MarketShareD), the provincial level (MarketShareP), and the country level (MarketShareC).

Source: Author's compilation

To explore the influence of characteristics from other specific firms, dummy variables of different purposes of innovation activities defined as general or special ones are used. In addition, we distinguish two kinds of technological opportunities: the one stemming from FDI suppliers (FDIDomSup), and the one from FDI customers (FDIDomCus). In general, external resources (knowledge) fluctuates positively with the capabilities of firms so that they are able to generate innovative outputs (Arvanitis and Hollenstein (1994); Gambardella (1992); Levin and Reiss (1989)). Moreover, a higher level of technological opportunities leads to a powerful desire of a firm to involve in the innovation. To keep pace with market influence in association with its determinants, the variables firm size, involvement in exportation and degree of export intensity are explored in the models, reflecting the importance of innovation demand. It is a priori difficult to anticipate the role of firm size because this variable "... is determined as a proxy for various economic effects" (Arvanitis & Hollenstein, 1996, p. 18). From the perspective raised by Schumpeter (2013), a positive relationship between firm size and its innovation-decision can be expected. It is assumed that involvement in exportation (Felder, Licht, Nerlinger, and Stahl (1996); Wakelin (1998)) and degree of exporting activities (Kamien and Schwartz (1982); Nelson (1959)) stimulate firms' innovation activities. To seize the influence of market competition, some variables are modelized. The effect of competition towards the innovation of firms is still unclear while empirical results point out positive impacts of market concentration on R&D intensity (Geroski (1995); Martin (1994); Vossen (1999)). On the other hand, competition affects weakly the firms' innovation activities, once technological opportunity variables can be controlled (Arvanitis and Hollenstein (1996); Crepon, Duguet, and Kabla (1996)). A dummy variable indicating a firm facing competition in the main field of activity is used. In addition, a dummy variable demonstrating a firm as a "price taker" is employed. Moreover, since the fact that the firm size is heterogeneous within an industry, the market shares of firms (within the province and within the country) are additional indicators of market structure. Once the firm has to deal with, as the monopolist, in the whole market, R&D seems to be experienced the decrease even falling whereas it can be increased in market concentration.

3.2. Econometric Specifications

The different R&D innovation strategies considered are innovation input and innovation output. Innovation input measures firms' ongoing to conduct R&D innovation. Innovation output indicating the completion of R&D innovations in the survey year. We build a set of two equations reflecting three different R&D innovation choices. The equation demonstrates the probability that a firm conducts a particular R&D innovation choice. The dependent variable y_{2i} is a dummy variable that takes a value equal to 1 when a firm decides to conduct a particular R&D innovation choice. This second equation will have the following form:

$$y_{it} = \begin{cases} 1 \;\; if \; y^*_{it} = f(X_{it}\beta \;\; + Z_{it}\delta \;\; + \; \eta_i + u_{it}) > 0 \\ \qquad\qquad 0 \; otherwise \end{cases} \tag{1}$$

where y^*_{it} is the latent dependent variable, X_{it} is a vector of time-invariant firm-specific variables, Z_{it} is a vector of time-variant firm-specific variables, β_t and δ_t corresponds to the vector of coefficients to be estimated, η_i, are farm-specific unobserved heterogeneity effects (random effects), and u_i is the error term which follows $N(0, \sigma^2)$. Equation (1) will depend on the following set of time-variant firm-specific variables (Z_i): R&D collaboration and co-operation, TT collaboration, TT co-operation, a set of networking variables, a set of variables referring to aims of innovation, a set of market-related factors, and a set of competition variables (see Table 4). We examine the impact of TT and R&D collaboration and co-operation. This is achieved through the estimation of Eq. (1a):

$$y_{it} = \begin{cases} 1 \;\; if \; y^*_{it} = f\begin{pmatrix} X_{it}\beta \;\; + Z_{it}\delta \;\; + \\ +\gamma_1 R\&D\_Coll\_Coop_{it} \; + \gamma_2 Tech\_Coll_{it} + \\ \gamma_3 Tech\_Coop_{it} \; + \; \eta_i + \; u_{it} \end{pmatrix} > 0 \\ \qquad\qquad 0 \; otherwise \end{cases} \tag{1a}$$

where R&D_Coll_Coop is an indicator of R&D innovation collaboration and co-operation. Tech_Coll and Tech_Coop indicate TT collaboration and TT co-operation, respectively. We use a lagged variable of sales to avoid endogeneity problems that may arise in our empirical estimation. Possible associations between the random effects and the other exogenous variables may exist, and thus we conduct a model in which the unobserved heterogeneity (random effects) is a function of the means of the time-varying explanatory variables as follows (Mundlak, 1978):

$$\eta_i = \; a_0 + \; \bar{Z}_i\Psi + \; a_i \tag{2}$$

where $\bar{Z}_i$ is an average of Z_{it} over time for each firm and a_0 is a constant term. We assume that time-invariant a_i, is distributed as $N(0, \sigma^2_a)$ and is uncorrelated with Z_{it} and other time-invariant exogenous variables.

4. Empirical Results

The main objective of our analysis is to clarify and identify the extent to which the impacts of TT and R&D collaboration and co-operation on the R&D innovation outcomes by young domestic non-SO SMEs along the supply chain. We begin by estimating the basic specification for innovation input given in Eq. (1a). In the next parts, remarkable findings related to the importance of TT and R&D collaboration and co-operation as innovation factors are discussed.

4.1. Effects of TT, R&D collaboration and co-operation on Innovation Input

The estimation strategy is as follows: we do not include all of the variables related to TT and R&D collaboration and co-operation in one regression since it can result in the multicollinearity problem and high standard errors of these variables. We include region dummies and time dummies and mean variables as suggested by (Mundlak, 1978). The regression result of TT and R&D collaboration and co-operation on innovation input is presented in Table 2. In line with this, we examine whether external resources within such collaborations/co-operations are applied as alternatives or complements to activities that are relevant to innovation by firms.

Table 2
Estimation of on-going R&D innovation choice

Variable	R&D Collaboration and co-operation	TT Collaboration	TT Co-operation
R&D collaboration and co-operation	-0.196		
TT collaboration		0.370***	
TT co-operation			0.553***
Collaboration and co-operation in R&D within province in Vietnam (Yes=1; No=0)	0.00775**		
Collaboration and co-operation in R&D outside province but within Vietnam (Yes=1; No=0)	0.0163***		
Aims of innovation: general purpose (Yes=1; No=0)	3.064***	3.011***	3.031***
Firm having relationship with FDI domestic suppliers (Yes=1; No=0)	0.443***	0.363***	0.439***
Firm facing competition in the main field of activity (Yes=1; No=0)	0.399***	0.428***	0.418***
Firm as a "price taker" (Yes=1; No=0)	-0.284***	-0.246***	-0.268***
Firm with limited autonomy setting prices (Yes=1; No=0)	-0.272***	-0.258***	-0.283***
Market share at the provincial level	-0.0115***	-0.0110***	-0.0121***
Market share at the country level	0.0105**	0.00936**	0.00971**
Market share at the provincial level, squared	8.86e-05**	8.49e-05**	9.54e-05**
Market share at the country level, squared	-8.34e-05*	-7.17e-05	-7.71e-05*
Number of competitors faced by the firm at the country level	-0.00355***	-0.00331***	-0.00438***
Sales lagged one period (log form)		0.0919***	
Number of competitors faced by the firm at the provincial level (squared)			2.50e-06
Region dummies	*Yes*	*Yes*	*Yes*
Time dummies	*Yes*	*Yes*	*Yes*
Means of the time-varying explanatory variables suggested by Mundlak (1978)	*Yes*	*Yes*	*Yes*
Observations	*12,002*	*11,992*	*12,002*
Number of id	*4,167*	*4,167*	*4,167*
Log Likelihood	*-1791*	*-1786*	*-1788*

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Source: Author's estimation from TCS-VES 2011-2013

TT collaboration and co-operation with other firms increase the innovation participation of young SMEs in Vietnam. In both specifications in the last two columns of Table 2, the coefficients for TT collaboration and co-operation are highly significant (at the 0.01 level), which proves that there is an interdependent relationship between co-operative agreements in TT and innovation input of firms. These findings are in coincidence with past studies in other countries (Colombo, 1995; Leyden & Link, 1999; Sakakibara, 1997; Veugelers, 1997). The sign of R&D collaboration and co-operation is negative in the first column in Table 2, indicating a substitute relationship between R&D collaboration and co-operation and firms' innovation input. However, the magnitude is not significant. The estimation of the first form of Model (1a) underline impressively the networking effects. The collaboration and co-operation in R&D within the province in Vietnam and outside province but within Vietnam affect the

R&D collaboration and co-operation positively. This implies the networking effects are significant in the innovation (Autio, 1997; Love & Roper, 1999; Malerba, 1992).

Other exogenous variables illustrating the results in each form of model (1a) in Table 2 mostly confirm the theoretically expected signs of effects. Looking at the variables related to the potential aims of innovation activities, a firm with a general-purpose in R&D has a positive effect on innovation input (significant at the 0.01 level). Regarding market-related variables, the effect of firm size (as measured by lagged sales) on the magnitude of firms' innovation input is positive and statistically significant (at the 0.01 level) in model with TT collaboration. These findings are in line with contributions in previous studies from different countries (Acs & Audretsch, 1990; Arvanitis, 1997; Evangelista, Perani, Rapiti, and Archibugi (1997). In contrast, we do not find a significant impact of exportation (as measured by export shares in sales), seemingly resulting no evidence of the demand-pull hypothesis (see for example Felder et al., 1996; Kleinknecht & Verspagen, 1990; Wakelin, 1998). In this context, Love and Roper (1999) figure out German innovative and noninnovative firms do not differ with respect to their export performance. The result of the variables of technological opportunities is confirmed in the first form of model (1a). The coefficient for FDI domestic suppliers as an external knowledge source is positive and highly significant (at the 0.01 level). In Table 2 also, the coefficients for market competition explain that market share and innovation input maintain a U-shaped relationship at the province level and an inverted U-shaped relationship between innovation input and market share at the country level. All of these coefficients are jointly significant at the 0.01 level.

4.2. Effects of TT, R&D collaboration and co-operation on Innovation Output

We use the same explanatory variables as for the equation of the innovation input level to estimate the effects of TT and R&D collaboration and co-operation on the innovation output and follow the same estimation strategy as in Section 4.1. Table 3 presents the estimation results.

Table 3
Estimation of completed R&D innovation project

Variable	R&D Collaboration and co-operation	TT Collaboration	TT Co-operation
R&D collaboration and co-operation	0.640*		
TT collaboration		0.727***	
TT co-operation			0.617***
Firm having relationship with FDI domestic suppliers (Yes=1; No=0)		0.528***	0.603***
Firm facing competition in the main field of activity (Yes=1; No=0)		0.528***	
Firm as a "price taker" (Yes=1; No=0)		-0.211**	
Market share at the provincial level		-0.0110**	-0.00846**
Market share at the provincial level (squared)		0.000111**	8.28e-05*
Number of competitors faced by the firm at the country level	0.00965***	0.00852***	0.00913***
Number of competitors faced by the firm at the country level (squared)	-3.66e-05***	-3.21e-05**	-3.56e-05**
Region dummies	*Yes*	*Yes*	*Yes*
Time dummies	*Yes*	*Yes*	*Yes*
Means of the time-varying explanatory variables suggested by Mundlak (1978)	*Yes*	*Yes*	*Yes*
Observations	*12,004*	*12,004*	*12,001*
Number of id	*4,167*	*4,167*	*4,167*
Log Likelihood	*-1365*	*-1311*	*-1329*

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's estimation from TCS-VES 2011-2013

Looking at TT and R&D collaboration and co-operation with other firms, positive innovation output effects are confirmed. R&D collaboration and co-operation with other firms enhance the probability of finalizing R&D project (at the 0.10 level), while TT collaboration and co-operation with other firms have stimulating impacts on of finalizing R&D project (at the 0.01 level), demonstrating an interdependent relationship between TT and R&D collaboration and co-operation and firms' innovation output. The estimation results for the other explanatory variables are also listed in Table 3. Not surprising, the effect of technological opportunities is confirmed in the second and third form of model

(1a). The coefficient for FDI domestic suppliers as an external knowledge source is positive and highly significant (at the 0.01 level). In Table 3, as in the model of innovation input, the coefficients for market competition demonstrate a U-shaped relationship between innovation input and market share at the province level and an inverted U-shaped relationship between innovation input and market share at the country level. All of these coefficients are jointly significant at the 0.01 level.

5. Conclusion

Firms engaged in the innovation process understand the necessity of conducting TT and R&D collaboration and co-operation to overcome the constraints of such as expertise, financial fund, and working organization. Thus, collaborations/co-operations, TT and R&D provide an essential means of making external resources usable for firms during the innovation process since they open possible pathways for knowledge transfer, resource exchange, and managerial and operational learning. Against this background, the paper investigates the effects of TT and R&D collaboration and co-operation on a firm's R&D innovation input, and innovation output, using a specially designed sample of 3,253 Vietnamese young SMEs in 2010-2013. In this respect, the importance of TT and R&D collaboration and co-operation as an innovation factor is empirically investigated for Vietnamese young SMEs. The estimation results show that in the Vietnamese young SMEs, TT collaboration and co-operation are complementary, supporting the use of the innovation input and output measured by the on-going R&D and finalized R&D. In addition, R&D collaboration and co-operation are complementary in enhancing the innovation output of firms. On the input side, networking effects in the innovation process positively. R&D with a general-purpose has a positive effect on innovation input. Research efficiency is intensified in a specific method by heterogeneous firms. Technological opportunities stimulate the probability of innovation. At the small scale of market competition as provinces, for instance, there is a U-shaped correlation between innovation input and market share. In contrast, at the large scale of market competition as a country, for example, this relationship is demonstrated as an inverted U-shaped. On the output side, technological opportunities stimulate the probability of innovation. Also, market competition demonstrates a U-shaped relationship between innovation input and market share at the small level of the market (such as province) and an inverted U-shaped relationship between innovation input and market share at the large level of the market (such as country).

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