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Influence of Chinese entrepreneurial companies' internationalization on independent innovation: Input incentive effect and efficiency improvement effect



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ABSTRACT

Within the special environment of the ChiNext market, we study how an internationalization strategy affects the independent innovation of Chinese entrepreneurial companies from two dimensions: R&D input and patent output. An internationalization strategy has a significant incentive effect on R&D input and a significant efficiency improvement effect on patent output. Entrepreneurial companies with higher degrees of internationalization have higher R&D inputs and patent outputs. After endogeneity is controlled, these effects still exist. Internationalization strategy has more pronounced effects on independent innovation in strategic emerging industries. The results elucidate the internationalization strategy and independent innovation of Chinese entrepreneurial companies, and have valuable implications for Chinese regulators in making international development policies for strategic emerging industries and independent innovation.

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1. Introduction

In the context of a rapidly growing knowledge economy and increasing economic globalization, independent innovation and internationalization have become inevitable means for many companies to achieve lasting survival and development and a lasting competitive edge. In view of the significance and urgency of indepen-

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dent innovation and internationalization, China has established a development strategy focused on building an innovative nation and “going global.” Innovation and internationalization are the “new normal” for Chinese companies’ strategic behaviors. However, the mutual influence of the two major strategies, the independent innovation strategy and the internationalization strategy, has not been fully recognized, which is not helpful for implementing them or forming synergies. The core issue is whether internationalization can promote Chinese companies’ independent innovation and improve their capacity for innovation. In the long run, investigating this question may reveal the mechanisms underlying how internationalization affects corporate behavior and firm performance. To become strong in innovation, China must better integrate global resources to deepen and promote Chinese companies’ independent innovation and further accelerate its sustainable development. Therefore, exploring the effects of companies’ internationalized operations on independent innovation not only improves Chinese companies’ capacity for independent innovation using foreign resources, but also facilitates an understanding of the economic consequences of internationalization and evaluates its outcomes. This way, it can guide the implementation of the Chinese going global strategy.

Research on the relations between companies’ internationalized operations and innovation is important in both economics and management sciences. However, no universal conclusion about their relations has been reached. Scholars have various views regarding whether companies’ internationalization can promote independent innovation (Hitt et al., 1997; Von Zedtwitz and Gassmann, 2002; Sanna-Randaccio and Veugelers, 2007; Lileeva and Treffer, 2010; Bustos, 2011; Bratti and Felice, 2012). The empirical evidence has not been converged. In addition, according to recent research, a self-selection effect exists between internationalization and independent innovation (Clerides et al., 1998; Bernard and Jensen, 1999; Melitz, 2003). Independent innovation and internationalization have reverse causality. Innovation-driven competitive edge can promote internationalization and expand overseas markets (Roper and Love, 2002; López and García, 2005; Cassiman and Golovko, 2011; Altomonte et al., 2013). Therefore, the endogeneity problem exists between companies’ internationalization and independent innovation, which causes inconsistent and even opposite conclusions regarding their relations. Controlling endogeneity is a key strategy for identifying the relations between companies’ internationalization and independent innovation.

In China, some scholars have studied the influence of internationalization on productivity from the perspective of exports (Zhang et al., 2008, 2009; Qian et al., 2011) and have provided a preliminary understanding of whether local companies’ internationalization can promote productivity. However, few scholars have focused on the evidence showing that internationalization influences independent innovation. Thus, in-depth research using the actual conditions in China is necessary.

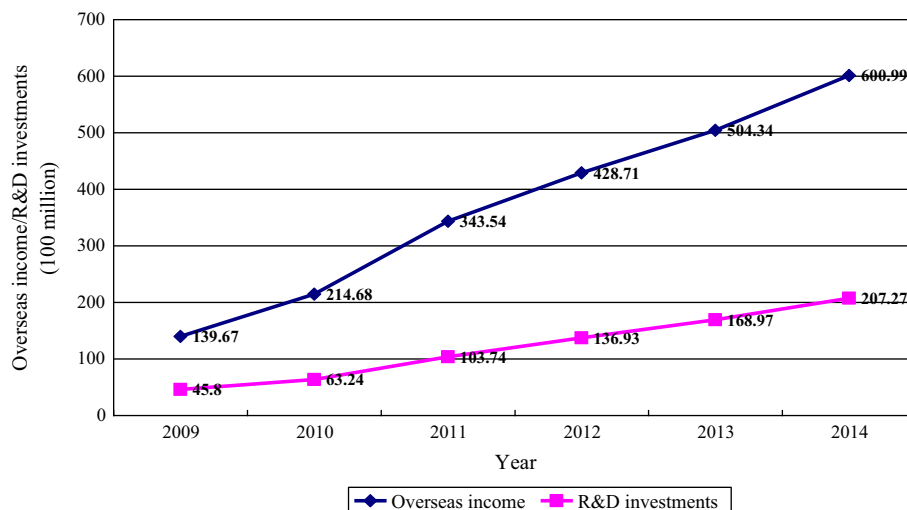


Figure 1. Trend in the overseas income and R&D investments of Chinese ChiNext companies.

Since its establishment in 2009, the ChiNext market has provided a large amount of capital support for cultivating and developing strategic and emerging industries and optimizing and upgrading industrial structures. Various high-tech companies, such as LENS Technology Co., Ltd., LEPU Medical Co., Ltd. and JINFU Technology Co., Ltd., have emerged and driven China's innovative economy. According to statistics from Wind Database, the total R&D input of ChiNext market companies jumped from 4.58 billion yuan in 2009 to 20.727 billion yuan in 2014, with an annual average growth rate of 70.5%. ChiNext companies have actively implemented internationalization strategies to expand overseas markets. Correspondingly, the total revenue of overseas businesses also jumped from 13.967 billion yuan in 2009 to 60.099 billion yuan in 2014, with an annual average growth rate of 92.3% (see Fig. 1). In particular, the proportion of the overseas revenue of LENS Technology has topped 95%. Thus, ChiNext companies have become typical examples of combining internationalization and independent innovation. In this context, studying whether Chinese companies' internationalization positively affects independent innovation is of policy significance and urgency.

We use Chinese ChiNext companies as research objects and study the influence of Chinese entrepreneurial companies' internationalization strategies on independent innovation¹ from the dimensions of R&D input and patent output. We consider the special environment of the Chinese ChiNext market as a natural setting in which to examine the influence of entrepreneurial companies' internationalization on independent innovation and to test relevant theories. First, Chinese ChiNext companies are positioned to promote emerging industries and innovative companies. Thus, independent innovation is an important standard for Chinese ChiNext companies. By the end of 2012, the proportion of companies in strategic emerging industries to all ChiNext companies was as high as 64%. Compared with companies on the main board and the small and medium enterprise board, ChiNext companies better reflect the influence of internationalization on independent innovation. Second, innovation and internationalization levels are influenced by organizational scale. However, choosing Chinese ChiNext companies as research objects eliminate the scale effect on internationalization and innovation. In innovation economics, company scale is a key factor influencing innovation (Schumpeter, 1942). However, the relation between scale and innovation is still controversial. Schumpeter (1942) argues that only large companies can afford R&D expenditures, take failures through large-scale innovation and enjoy the advantages of innovation, namely the "Schumpeter Hypothesis." However, Porter (1985) and Barney (1991) argue that although small companies have no scale advantages, they can flexibly focus on their competitive technological fields. Different from small companies, large companies can bear the high sunk costs and exploration costs of overseas markets and the high risks of international trade. Therefore, large companies can expand into overseas markets more easily (Teece, 1986; Clerides et al., 1998; Melitz, 2003). Studies have also proved that export-oriented manufacturers are large in scale (Bernard and Jensen, 1999; Greenaway et al., 2005). Thus, it is necessary to control the scale effect on internationalization and innovation. As most ChiNext companies are small companies in the start-up and growth phases, the scale effects of large companies can be eliminated, improving the study of the influence of small companies' internationalization on independent innovation. Third, in economics, product diversification exerts extensive influences on innovation (Schumpeter, 1942; Hoskisson and Johnson, 1992; Hitt et al., 1997; Miller, 2004). Thus, the influence of industrial diversification on innovation should be controlled in studying internationalization. *Interim Measures on Administration of Initial Public Offering and Listing on ChiNext* promulgated by the China Securities Regulatory Commission on March 31, 2009 and *Measures on Administration of Initial Public Offering and Listing on ChiNext* on February 11, 2014 explicitly state that "issuers in the ChiNext market shall mainly engage in one main business." Accordingly, emphasis on business simplification excludes the possibility of diversification, providing a natural setting in which to study the influence of internationalization on independent innovation.

We make a number of theoretical contributions to the literature. First, we depict internationalization from several dimensions, such as export sales intensity, export sales proportion and overseas institutions. We also study the influence of Chinese entrepreneurial companies' internationalization on independent innovation from the dimensions of R&D input and patent output. This facilitates a comprehensive understanding of the influence of internationalization on independent innovation. We supplement empirical evidence of the

¹ There exist different dimensions and perspectives of innovation. The innovation discussed herein refers to technology innovation. The authors appreciate the referee's advice very much.

influence of internationalization on innovation output and partly reveal the mechanisms underlying the influence of internationalization on companies' behaviors and firm performance. After controlling endogenous factors, internationalization strategies exert input incentive effects on R&D and companies with higher degrees of internationalization have higher R&D inputs; furthermore, internationalization strategies exert efficiency improvement effects on patent production and companies with higher degrees of internationalization have higher patent output efficiencies. Second, different from studies in which mature companies are the objects, we mainly study Chinese entrepreneurial companies. Third, we study in-depth how an internationalization strategy affects the independent innovation of strategic emerging industries in the Chinese ChiNext market. In strategic emerging industries, internationalization has a more pronounced input incentive effect and efficiency improvement effect on independent innovation. This provides evidence of and policy references for the implementation of the going global strategy of Chinese companies and industries.

The remainder of this paper is organized as follows. Section 2 reports the theoretical analysis and research hypotheses. Section 3 describes the research design. Section 4 documents the empirical results and analysis. Section 5 discusses the influence of internationalization on strategic emerging industries. Section 6 concludes the paper.

2. Theoretical analysis and research hypothesis

The relationship between international operation and innovation has always been an important topic in economics and management, but no unified conclusion has been reached on this issue. Recent empirical evidence has given rise to three hypotheses.

2.1. Internationalization promotes innovation

In this hypothesis, internationalization, as the process of studying and knowledge accumulation, can help companies obtain more resources, information, ideas, technologies and opportunities (Kotabe, 1990; Kobrin, 1991; Hitt et al., 1997); use the international market to dilute and reduce R&D costs (Cheng and Bolon, 1993; Granstrand et al., 1993; Kotabe et al., 2002); and form innovative strategic alliances (Santos et al., 2004). The learning effect (Grossman and Helpman, 1991; Bratti and Felice, 2012; Love and Ganotakis, 2013) and the competitive incentive effect (Hitt et al., 1997; Bratti and Felice, 2012) of internationalization can increase companies' attention to innovation, improve their capacity for innovation and earn more exclusive income of innovation (Teece, 1986; Kafouros et al., 2008). The learning effect of internationalization is the significant theoretical basis of the hypothesis that internationalization promotes innovation, and is the focus of empirical research. Thus, a company's internationalization has a positive effect on innovation.

2.2. Internationalization hinders innovation

In this hypothesis, internationalization increases companies' risk of leaking knowledge and technology (Sanna-Randaccio and Veugelers, 2007); increases costs in management, coordination and information exchange; and increases misunderstandings between different R&D teams and opportunistic behavior (Fisch, 2003), impeding R&D team cohesion (Von Zedtwitz and Gassmann, 2002). Therefore, internationalization increases the risks and costs of company innovation, thereby hindering it.

2.3. Internationalization is irrelevant to innovation: Self-selection

In this hypothesis, companies enter the international market and possess higher innovative capability as a result of the self-selection effect. In the global market, companies undertake extremely high sunk costs, high risk and more fierce competition, so they must demonstrate heterogeneity in scale, technical innovation and performance, which generates the self-selection effect of internationalization (Clerides et al., 1998; Melitz, 2003; Helpman et al., 2004). Unlike non-international companies, international companies possess higher innovative capabilities and higher productivities before they enter overseas markets. In addition, they can bear high sunk costs, developing costs and high-risk international transactions, making them more likely to expand

into overseas markets (Bernard and Jensen, 1999; Melitz, 2003). Recently, the self-selection effect has been supported by more empirical evidence (Baldwin and Gu, 2004; Greenaway et al., 2005), which challenges the causal relationship of the hypothesis that internationalization promotes innovation.

Moreover, recent research has found that corporate innovation has the reverse effect on the internationalization of companies (Altomonte et al., 2013) and that innovation can strengthen companies' market power and thus facilitates international expansion (Roper and Love, 2002; López and García, 2005; Cassiman and Golovko, 2011). Internationalization itself can also be seen as an innovative firm process (Bilkey and Tesar, 1977; Prashantham, 2005). Therefore, strong endogeneity exists between the internationalization and innovation of an enterprise, which has led to inconsistencies in the research.

Some of the typical microeconomic studies summarized in Table 1 show that no consistent understanding has been achieved regarding whether internationalization promotes independent innovation. There are various contradictions and controversies surrounding the empirical evidence, especially that from different regions and countries. Empirical research has focused more on total factor productivity (TFP) to measure companies' innovation and performance. However, productivity is not the most appropriate and direct innovation measure. First, sales revenue is used to calculate productivity. As price and quantity data cannot be separated, they cannot distinguish between the influence of price (market force) and quantity (productivity). Second, productivity indirectly measures innovation, but it cannot embody companies' learning effects. However, Grossman and Helpman (1991) argue that companies' innovation demonstrates the learning effect. Thus, the proxy variable that directly measures innovation is used to further study the learning effect of internationalization.

Griliches (1990) points out that innovation is an activity that at least includes R&D input and patent output. A patent is the direct output of R&D, and R&D input and patent output reflect innovation to some degree. We use R&D input and patent output to measure companies' innovation, which can demonstrate the influence of internationalization on independent innovation from the input-output perspective.

Internationalization and innovation are two engines of economic growth. However, compared with the priority and establishment of the internationalization strategy, Chinese attention to innovation is far behind. In view of China's resource endowment, the Chinese government established the export-oriented strategy in the 1980s. Currently, exports contribute much more to China's GDP than innovation. At the micro level, this macroeconomic outcome reflects that companies engage in export and other international behavior earlier than they do independent innovation. In the context of economic development transformation, internationalization can promote independent innovation, which can improve companies' sustainable development and China's sustainable economic growth. In China, some scholars have studied the impact of internationalization on productivity from the export perspective (Zhang et al., 2008, 2009; Qian et al., 2011), which provides an initial understanding of the influence of local companies' internationalization on productivity. However, the domestic literature still lacks direct evidence of how internationalization affects independent innovation. Bernard et al. (2006) indicate that it is of little significance to argue the learning effect or the self-selection effect on companies' productivity in developing countries. Instead, the focus should be shifted from technology introduction and learning to independent innovation according to the different developmental stages of developing countries, and to the relevant realization conditions and feasible paths. Thus, the key is to promote independent innovation through internationalization and boost the sustainable improvement of productivity. Given the insufficient evidence of the influence of internationalization on R&D input and patent output, in-depth research on the basis of China's special situation is necessary. Therefore, we propose the following hypotheses.

Hypothesis 1. If the other conditions remain unchanged, internationalization has an incentive effect on corporate R&D, and higher internationalization entails higher R&D input.

Hypothesis 2. If the other conditions remain unchanged, internationalization can improve the efficiency of companies' patent outputs, and higher internationalization entails higher patent output.

Table 1
Empirical evidence of internationalization and technology innovation.

Study	Sample	Journal	Results and conclusions
Hitt, Hoskisson and Kim (1997)	295 US listed companies from 1988 to 1990	Academy of Management Journal	They find that companies' international diversification has a positive effect on R&D input intensity. They think that international diversification provides more income support for innovation investment. In the meantime, they point out that internationalization and innovation interact.
Clerides, Lach and Tybout (1998)	Cross-country research: All Colombian companies with more than 10 people from 1981 to 1991, 2800 large Mexican companies from 1986 to 1990, all Moroccan companies with more than 10 people from 1984 to 1991	Quarterly Journal of Economics	A self-selection effect exists in Colombian and Mexican companies, whereas the learning effect exists in Moroccan companies.
Bernard and Jensen (1999)	50,000 to 60,000 American manufacturing companies from 1984 to 1992	Journal of International Economics	They find that there is a self-selection effect and, unlike noninternational companies, international companies with heterogeneous characteristics are more innovative before entry into overseas markets. They achieve better performance and become export-oriented companies.
Baldwin and Gu (2004)	10,106 Canadian companies from 1984 to 1990 and 9036 Canadian companies from 1990 to 1996	Oxford Review of Economic Policy	They find that export-oriented market participation is positively related with company productivity. The learning effect, the international market competition effect and economies of scale promote productivity. The participation of the international market enables companies to increase R&D input. However, before and after entry into overseas markets, export-oriented companies are more innovative than non-export-oriented companies and a self-selection effect exists.
Greenaway, Gullstrand and Kneller (2005)	3570 Swedish manufacturing companies from 1980 to 1997	Review of World Economics	Export-oriented companies and non-export-oriented companies have incredibly similar performance characteristics and there is no heterogeneity. Before and after these companies enter overseas markets, there is no significant difference between their productivities.
Van Biesebroeck (2005)	Cross-country research: 105 Burundi companies in 1993, 234 Cameroonian companies from 1992 to 1994, 207 Ethiopian companies in 1996, 209 Ghanaian companies from 1991 to 1993, 188 Ivory Coast companies from 1994 to 1995, 267 domestic Kenyan companies from 1992 to 1994, 241 Tanzanian companies from 1992 to 1994, 262 Zambian companies from 1992 to 1994 and 203 Zimbabwean companies from 1992 to 1994	Journal of International Economics	There is a learning effect in nine Sub-Saharan African countries. Export-oriented companies have better productivities than non-export-oriented companies. After entry into overseas markets, the productivity of export-oriented companies improves.
Salomon and Jin (2010)	1744 Spanish manufacturing companies from 1990 to 1997	Strategic Management Journal	Exporting is associated with the ex post increase in innovative productivity for both technologically leading and lagging firms. However, subsequent to exporting, technologically leading firms apply for more patents than technologically lagging firms.

Bratti and Felice (2012)	1635 Italian manufacturing companies from 1998 to 2003	The World Economy	Support the theory of promotion and find that export can increase the probability of introducing product innovation. The learning effect exists.
Altomonte, Aquilante, Békés and Ottaviano (2013)	Cross-country research: 14,759 European manufacturing companies from the EFIGE database in 2008, such as those from Austria, France, Germany, Hungary, Italy, Spain and the UK	Economic Policy	Export itself is only an aspect of companies' internationalization. Internationalization is more than exportation. Companies' internationalization is significantly related with innovation. In the long term, companies' internationalization is probably driven by innovation.
Love and Ganotakis (2013)	412 UK small and medium-sized high-tech companies from 2001 to 2004	International Business Review	Support the theory of promotion and find that after export, the probability of company innovation is higher than that for non-export companies, but that innovation intensity does not increase.

Table 2
Variable definitions.

	Variable	Symbol	Definition
Dependent variables	R&D intensity	RD_intensity	R&D intensity = R&D expenditures/total assets at year-end.
	Changes in R&D intensity	Δ RD_intensity	Δ RD_intensity = (R&D expenditures for this year – R&D expenditures for last year)/total assets at last year-end.
	Technological innovation performance	Δ Patents	The number of new patents granted by the China Intellectual Property Office in the year, including the number of inventions, utility patents and design patents.
Explanatory variables	Internationalization of firm	Overseas_Sales	Overseas revenue intensity = overseas sales revenue/total assets at year-end.
		Export_Rate	The proportion of overseas revenue = overseas revenue/total revenue at year-end.
		Overseas_Agency	Dummy variable. If the company has overseas branches or investment institutions, the value is 1; otherwise, the value is 0.
	Changes in companies' internationalization	Δ Overseas_Sales	Changes in overseas revenue intensity = (overseas revenue for this year – overseas revenue for last year)/total assets at last year-end.
Control variables		Δ Export_Rate	Changes in the proportion of overseas revenue = (overseas revenue for this year – overseas revenue for last year)/total revenue at last year-end.
	Total sales of firm	Total_Sales	Total_Sales = (domestic revenue for this year + overseas revenue for this year)/total assets at year-end.
	Changes in total sales of firm	Δ Total_Sales	Δ Total_Sales = (domestic revenue for this year + overseas revenue for this year – domestic revenue for last year – overseas revenue for last year)/total assets at year-end.
	Domestic revenue of firm	Domes_Sales	Domestic revenue intensity = domestic revenue for this year/total assets at year-end.
	Changes in domestic revenue of firm	Δ Domes_Sales	Δ Domes_Sales = (domestic revenue for this year – domestic revenue for last year)/total revenue at last year-end.
	Firm investment opportunities	Tobin's Q	Tobin's Q = firm's market value/firm's replacement cost = (number of tradable shares * this year's closing price + non-tradable shares * book value of net assets per share + book value of liabilities)/total assets at year-end.
	Changes in investment opportunities of firm	Δ Tobin's Q	Tobin's Q = (number of tradable shares * this year's closing price + non-tradable shares * book value of net assets per share of this year + book value of liabilities of this year – number of tradable shares * last year's closing price + non-tradable shares * book value of net assets per share of last year + book value of liabilities of last year)/total assets at last year-end.
	Financial risk	Lev	Asset-liability ratio = total liabilities/total assets at year-end.
	Change in financial risk	Δ Lev	(Total liabilities for this year – total liabilities last year)/total assets at year-end.
	CEO gender	Ceo_Gender	If the CEO is male, the value is 1; otherwise, the value is 0.
	CEO age	Ceo_Age	The age of the CEO.
	Educational background of CEO	Ceo_Education	If the CEO has a Bachelor's, Master's or Doctoral degree, the value is 1; otherwise, the value is 0.
	Overseas experience of CEO	Ceo_Experience	If the CEO has experience studying or working abroad, the value is 1; otherwise, the value is 0.
	CEO duality	Dual	Dummy variable equal to 1 for CEO duality and 0 otherwise.
	Proportion of the largest shareholder	First_Stake	The proportion of the largest shareholder's shareholding in the companies.
	Nature of the controlling owner	Property	A dummy variable equal to 1 for a state-owned listed company and 0 otherwise.
	Venture capital	VC	If the firm is venture capital backed, the value is 1; otherwise, the value is 0.
	Firm life cycle	Age	The survival time of the firm from the beginning to this year.
	Stock knowledge of firm	Patents_past_total	The number of patents the firm accumulated in past years.
	Firm size	Size	Size = Natural logarithm of total assets at year-end.
	Industry effects	Industry	First-level industry classification according to the CSRC industry standard. We define eight dummy variables for which the benchmark is L, representing the communication and culture industry.
	Year effects	Year	We define three dummy variables, for which the benchmark year is 2009.

3. Research design

3.1. Sample selection and data sources

We use Chinese ChiNext companies from 2009 to 2012 as research samples and financial data from the China Stock Market and Accounting Research (CSMAR) Database. Using the annual reports of listed companies, we hand collect the R&D data, overseas income structures and overseas institutions. The patent data of listed companies are from the *China Patent Database* published by China Intellectual Property Office Intellectual Property Press. We classify and arrange the patents owned by listed companies according to year. After excluding the missing data, we obtain a final sample of 825 firm-year observations. Of these observations, 36, 153, 281 and 355 correspond to 2009, 2010, 2011 and 2012, respectively.

3.2. Model specifications and variable definitions

To test [Hypothesis 1](#), we build the following regression models, Models (1)–(4), according to the relevant literature ([Himmelberg and Petersen, 1994](#); [Hubbard, 1998](#)). The model variables are defined in [Table 2](#). All of the behaviors related to cross-border expansion can be regarded as companies' internationalization; the sales, manufacturing or R&D in different areas or overseas markets embody internationalization ([Hitt et al., 1994, 1997](#)). Therefore, according to the relevant literature ([Hitt et al., 1997](#); [Lu and Beamish, 2004](#); [Altomonte et al., 2013](#)), we adopt overseas sales intensity (Overseas_Sales), the proportion of overseas revenue (Export_Rate) and overseas institutions (Overseas_Agency) to measure the degree of internationalization. Due to the different institutions in Hong Kong, Macao, Taiwan and mainland China, the sales revenues in these three areas are included in the overseas sales revenue.

$$RD_intensity_t = \beta_0 + \beta_1 Total_Sales_t + \beta_2 Tobins'Q_t + \beta_3 Lev_t + \beta_4 CEO_Gender_t + \beta_5 CEO_Age_t + \beta_6 CEO_Education_t + \beta_7 CEO_Experience_t + \beta_8 Dual_t + \beta_9 First_Stake_t + \beta_{10} Property_t + \beta_{11} VC_t + \beta_{12} Size_t + \beta_{13} Industry + \beta_{14} Year + \zeta \quad (1)$$

$$RD_intensity_t = \beta_0 + \beta_1 Overseas_Sales_t + \beta_2 Domes_Sales_t + \beta_3 Tobins'Q_t + \beta_4 Lev_t + \beta_5 CEO_Gender_t + \beta_6 CEO_Age_t + \beta_7 CEO_Education_t + \beta_8 CEO_Experience_t + \beta_9 Dual_t + \beta_{10} First_Stake_t + \beta_{11} Property_t + \beta_{12} VC_t + \beta_{13} Size_t + \beta_{14} Industry + \beta_{15} Year + \zeta \quad (2)$$

$$RD_intensity_t = \beta_0 + \beta_1 Export_Rate_t + \beta_2 Tobins'Q_t + \beta_3 Lev_t + \beta_4 CEO_Gender_t + \beta_5 CEO_Age_t + \beta_6 CEO_Education_t + \beta_7 CEO_Experience_t + \beta_8 Dual_t + \beta_9 First_Stake_t + \beta_{10} Property_t + \beta_{11} VC_t + \beta_{12} Size_t + \beta_{13} Industry + \beta_{14} Year + \zeta \quad (3)$$

$$RD_intensity_t = \beta_0 + \beta_1 Overseas_Agency_t + \beta_2 Total_Sales_t + \beta_3 Tobins'Q_t + \beta_4 Lev_t + \beta_5 CEO_Gender_t + \beta_6 CEO_Age_t + \beta_7 CEO_Education_t + \beta_8 CEO_Experience_t + \beta_9 Dual_t + \beta_{10} First_Stake_t + \beta_{11} Property_t + \beta_{12} VC_t + \beta_{13} Size_t + \beta_{14} Industry + \beta_{15} Year + \zeta \quad (4)$$

To alleviate the impact of endogeneity, we build Models (5), (6) and (7) to further investigate the influence of companies' internationalization on R&D input according to Models (1), (2) and (3). The definitions of the main variables are presented in [Table 2](#).

$$\Delta RD_intensity = \beta_0 + \beta_1 \Delta Total_Sales + \beta_2 \Delta Tobins'Q + \beta_3 \Delta Lev + \beta_4 Industry + \beta_5 Year + \zeta \quad (5)$$

$$\Delta RD_intensity = \beta_0 + \beta_1 \Delta Overseas_Sales + \beta_2 \Delta Domes_Sales + \beta_3 \Delta Tobins'Q + \beta_4 \Delta Lev + \beta_5 Industry + \beta_6 Year + \zeta \quad (6)$$

$$\Delta RD_intensity = \beta_0 + \beta_1 \Delta Export_Rate + \beta_2 \Delta Tobins'Q + \beta_3 \Delta Lev + \beta_4 Industry + \beta_5 Year + \zeta \quad (7)$$

To better alleviate the impact of endogeneity, we also use the two-stage least squares (TSLS) method to test the influence of companies' internationalization on R&D. We follow the literature (Lileeva and Treffer, 2010; Bustos, 2011; Bratti and Felice, 2012) and choose the proportion of assets of foreign-funded firms in ChiNext companies with output values of over 5 million yuan (Foreign_ratio) as an instrumental variable for internationalization. The data are from the *Industrial Statistics Data* of the National Bureau of Statistics. The proportion of foreign assets in ChiNext companies with output values over 5 million yuan is a good indicator of the degree of internationalization. It also has no direct interaction with corporate independent innovation and is irrelevant to the regression residuals of Models (2), (3) and (4). That is, it meets the instrumental variables' exogeneity requirements. The TSLS regression process is as follows. During the first stage, Overseas_Sales, Export_Rate and Overseas_Agency are adopted to conduct the regression of Foreign_ratio and all control variables except for Overseas_Sales, Export_Rate and Overseas_Agency from Models (2), (3) and (4), including Domes_Sales (only in Overseas_Sales), Tobin's Q, Lev, Ceo_Gender, Ceo_Age, Ceo_Education, Ceo_Experience, Dual, First_Stake, Property, VC, Size, Year and Industry. The following induction model is used:

$$\begin{aligned} \text{Overseas_Sales}_i / \text{Export_Rate}_i / \text{Overseas_Agency}_i = & \varphi_0 + \varphi_1 \text{Foreign_ratio}_i \\ & + \sum_{j=1}^m \varphi_{1+m} \text{Other-exogenous-variable}_{ji} + \varepsilon \end{aligned} \quad (8)$$

where other exogenous variables include Domes_Sales (only in Overseas_Sales), Tobin's Q, Lev, Ceo_Gender, Ceo_Age, Ceo_Education, Ceo_Experience, Dual, First_Stake, Property, VC, Size, Year and Industry. The fitted values of Overseas_Sales, Export_Rate and Overseas_Agency are extracted using the preceding equation. During the second stage, the fitted values of Overseas_Sales, Export_Rate and Overseas_Agency replace Overseas_Sales, Export_Rate and Overseas_Agency in Models (2), (3) and (4) to conduct the regression analysis. To test Hypothesis 2, we construct the Poisson regression in Models (9), (10) and (11) according to related studies (Pakes and Griliches, 1980; Bound et al., 1984; Hausman et al., 1984). The variables are defined in Table 2. Patent output has strong lagged effects and results from current and lagged R&D expenditures. We control the lagged one period and lagged two period of companies' R&D inputs (RD_intensity_{t-1} and RD_intensity_{t-2}).

$$\begin{aligned} \Delta \text{Patents}_t = & \beta_0 + \beta_1 \text{RD_intensity}_t + \beta_2 \text{RD_intensity}_{t-1} + \beta_3 \text{RD_intensity}_{t-2} + \beta_4 \text{Overseas_Sales}_t \\ & + \beta_5 \text{Domes_Sales}_t + \beta_6 \text{Patent_past_total}_t + \beta_7 \text{Ceo_Gender}_t + \beta_8 \text{Ceo_Age}_t \\ & + \beta_9 \text{Ceo_Education}_t + \beta_{10} \text{Ceo_Experience}_t + \beta_{11} \text{Dual}_t + \beta_{12} \text{Age}_t + \beta_{13} \text{First_Stake}_t \\ & + \beta_{14} \text{Property}_t + \beta_{15} \text{VC}_t + \beta_{16} \text{Size}_t + \beta_{17} \text{Lev}_t + \beta_{18} \text{Industry}_t + \beta_{19} \text{Year}_t + \zeta \end{aligned} \quad (9)$$

$$\begin{aligned} \Delta \text{Patents}_t = & \beta_0 + \beta_1 \text{RD_intensity}_t + \beta_2 \text{RD_intensity}_{t-1} + \beta_3 \text{RD_intensity}_{t-2} + \beta_4 \text{Export_Rate}_t \\ & + \beta_5 \text{Patent_past_total}_t + \beta_6 \text{Ceo_Gender}_t + \beta_7 \text{Ceo_Age}_t + \beta_8 \text{Ceo_Education}_t \\ & + \beta_9 \text{Ceo_Experience}_t + \beta_{10} \text{Dual}_t + \beta_{11} \text{Age}_t + \beta_{12} \text{First_Stake}_t + \beta_{13} \text{Property}_t + \beta_{14} \text{VC}_t \\ & + \beta_{15} \text{Size}_t + \beta_{16} \text{Lev}_t + \beta_{17} \text{Industry}_t + \beta_{18} \text{Year}_t + \zeta \end{aligned} \quad (10)$$

$$\begin{aligned} \Delta \text{Patents}_t = & \beta_0 + \beta_1 \text{RD_intensity}_t + \beta_2 \text{RD_intensity}_{t-1} + \beta_3 \text{RD_intensity}_{t-2} + \beta_4 \text{Overseas_Agency}_t \\ & + \beta_5 \text{Patent_past_total}_t + \beta_6 \text{Ceo_Gender}_t + \beta_7 \text{Ceo_Age}_t + \beta_8 \text{Ceo_Education}_t \\ & + \beta_9 \text{Ceo_Experience}_t + \beta_{10} \text{Dual}_t + \beta_{11} \text{Age}_t + \beta_{12} \text{First_Stake}_t + \beta_{13} \text{Property}_t + \beta_{14} \text{VC}_t \\ & + \beta_{15} \text{Size}_t + \beta_{16} \text{Lev}_t + \beta_{17} \text{Industry}_t + \beta_{18} \text{Year}_t + \zeta \end{aligned} \quad (11)$$

The empirical literature indicates that dependent variables (RD_intensity and $\Delta \text{Patents}$) and independent variables (Overseas_Sales, Export_Rate and Overseas_Agency) may be influenced by company characteristics (Bernard and Jensen, 1999; Melitz, 2003; Greenaway et al., 2005) and manager characteristics² (Faleye, 2011;

² The authors are grateful for the referees' suggestions.

Table 3
Industry affiliation of ChiNext companies.

Industry	2009		2010		2011		2012	
	Number	Percentage (%)	Number	Percentage (%)	Number	Percentage (%)	Number	Percentage (%)
<i>Panel A Industry affiliations of the full sample</i>								
A (Agriculture, Forestry, Animal Husbandry and Fishery)	0	0	4	2.61	6	2.14	7	1.97
B (Mining)	0	0	1	0.65	4	1.42	5	1.4
C (Manufacturing)	21	58.33	101	66.01	187	66.55	229	64.51
E (Construction)	0	0	1	0.65	2	0.71	3	0.85
F (Transportation and Storage)	1	2.78	1	0.65	2	0.71	3	0.85
G (Information Technology)	8	22.22	30	19.61	55	19.57	77	21.69
H (Wholesale and Retail)	2	5.56	2	1.31	2	0.71	2	0.56
K (Social Service)	3	8.33	7	4.58	14	4.98	18	5.07
L (Communication and Culture)	1	2.78	6	3.93	9	3.21	11	3.1
Total	36	100	153	100	281	100	355	100
Strategic emerging industries								
<i>Panel B Strategic emerging industries affiliations of sample firms</i>								
Energy saving and environmental protection industry	1	4	6	5.83	9	4.92	11	4.8
New generation of information technology	8	32	27	26.21	50	27.32	73	31.88
Biomedicine	6	24	15	14.56	31	16.94	37	16.16
High-end equipment manufacturing	6	24	25	24.27	49	26.78	56	24.45
New energy	2	8	13	12.62	16	8.74	17	7.42
New materials	1	4	15	14.56	23	12.57	29	12.66
New energy automobile	1	4	2	1.95	5	2.73	6	2.63
Total	25	100	103	100	183	100	229	100

Table 4
Overseas income of ChiNext companies.

Industry	Non-exporters	Exporters	Entrants	Quitters	Switchers
A (Agriculture, Forestry, Animal Husbandry and Fishery)	5	2	0	0	0
B (Mining)	3	2	0	0	0
C (Manufacturing)	22	143	62	0	2
E (Construction)	0	2	1	0	0
F (Transportation and Storage)	1	2	0	0	0
G (Information Technology)	50	24	2	1	0
H (Wholesale and Retail)	0	2	0	0	0
K (Social Service)	0	8	10	0	0
L (Communication and Culture)	0	5	5	0	1
Total	81	190	80	1	3

Note: Switchers refer to two situations: there is no overseas income in one year, but there is overseas income before and after that year; there is overseas income in one year, but there is no overseas income before or after that year.

Debrulle and Maes, 2015; Naldi et al., 2015; Sala and Yalcin, 2015). For example, venture companies or adventurous managers tend to choose the internationalization strategy. These kinds of companies or managers are more inclined to invest in innovative high-risk projects. Therefore, we select firm size (Size), firm investment opportunities (Tobin's Q), financial risk (Lev), CEO duality (Dual), proportion of the largest shareholder (First_Stake), nature of the controlling owner (Property), venture capital (VC), firm life cycle (Age), CEO gender (Ceo_Gender), CEO age (Ceo_Age), educational background of CEO (Ceo_Education) and overseas experience of CEO (Ceo_Experience) as our control variables.

4. Empirical results

4.1. Descriptive statistics

Table 3 shows the industry affiliations of ChiNext companies. Panel A shows 229 and 77 companies in the manufacturing and information technology industries, respectively. Panel B presents the sample by strategic emerging industries, with 73 companies in new generation of information technology and 56 companies in high-end equipment manufacturing. The number of companies in energy saving and environmental protection and new energy automotive is relatively small.

Table 4 presents the descriptive statistics of overseas income for ChiNext companies. Of the 355 ChiNext companies, 81 (22.82%) are non-exporters that never export, 190 (53.52%) are exporters that always export, 80 are entrants (22.82%) that begin exporting and 1 is a quitter that no longer exports. This shows that the degree of internationalization of ChiNext companies is higher and that most companies actively explore the international market to earn overseas income.

Table 5 presents the descriptive statistics of export region distribution for ChiNext companies. It shows that ChiNext companies have expanded their businesses in five continents, with a considerable number of companies selling their products and services to Europe, North America and South America. From the dynamic trend, the export region of ChiNext companies is mainly in Asia (excluding Hong Kong, Macao and Taiwan) and Hong Kong, and Macao and Taiwan. Asia is the area with the largest overseas export of ChiNext companies in China. In 2012, 182 companies exported their products to Asia (excluding Hong Kong, Macao and Taiwan) and 62 companies exported their products to Hong Kong, and Macao and Taiwan. Moreover, under the guidance of the “going out” strategy, ChiNext companies have actively explored markets in Europe and North America. The companies that export to Europe and North America have maintained increasing trends.

Table 6 presents the descriptive statistics for the sample of ChiNext companies. The mean value of RD_intensity_t, RD_intensity_{t-1} and RD_intensity_{t-2} of the sample companies are 2.32%, 2.23% and 2.36%, respectively, which are higher than 2%, the basic survival line recognized by the OECD. This indicates that under the guidance of the national strategy for building an innovative nation, great value has been attached to independent innovation by Chinese enterprises. Investment in technological innovation has also greatly increased.

Table 5
Export region distribution of ChiNext companies.

Year	Europe	Asia (except Hong Kong, Macao and Taiwan)	North America	South America	Africa	Oceania	HongKong, Macao and Taiwan province ^a
2009	9 ^b	17 ^b	6	4	3	2	8
2010	29	170	33	14	11	6	35
2011	30	163	35	14	14	9	40
2012	43	182	46	15	10	5	62

Note: As the data disclosure of ChiNext companies in terms of their income details and regional segment reports is not clear or complete, the values in Table 5 are repeatedly calculated.

^a Hong Kong, Macao and Taiwan are listed individually due to the different institutions between the mainland, Hong Kong, Macao and Taiwan. We find that the vast majority of ChiNext companies disclose information for Hong Kong, Macao and Taiwan separately.

^b Nine ChiNext companies had overseas income from Europe and seventeen ChiNext companies had overseas income from Asia (excluding Hong Kong, Macao and Taiwan) in 2009. The other values in Table 5 can be deduced from this.

Table 6
Descriptive statistics.

Variables	N	Mean	Max	Min	Median	SD
RD_intensity _t	825	0.0232	0.1400	0.0000	0.0200	0.0171
ΔRD_intensity	470	0.0043	0.0698	−0.0216	0.0022	0.0087
ΔPatents _t	825	10.7624	349.0000	0.0000	4.0000	21.0348
Overseas_Sales _t	825	0.0584	0.7783	0.0000	0.0050	0.1083
ΔOverseas_Sales	470	0.0002	0.2256	−0.3015	0.0000	0.0443
Export_Rate _t	825	0.1272	0.9930	0.0000	0.0145	0.2135
ΔExport_Rate	470	0.0014	0.3965	−0.3964	0.0017	0.0700
Overseas_Agency _t	825	0.6424	1.0000	0.0000	1.0000	0.4796
Total_Sales _t	825	0.4179	1.8800	0.0800	0.3801	0.2154
ΔTotal_Sales	470	0.0339	0.8788	−0.3390	0.0306	0.1055
Domes_Sales _t	825	0.3596	1.8800	0.0100	0.3300	0.2134
ΔDomes_Sales	470	0.0337	0.8788	−0.3300	0.0251	0.0995
Tobin's Q _t	825	2.6290	4.6293	0.9737	1.4799	0.4659
ΔTobin's Q	470	0.0678	2.2879	−2.0606	0.0862	0.4469
Lev _t	825	0.1741	0.7670	0.0110	0.1417	0.1264
ΔLev	470	0.0783	1.3677	−0.1681	0.0406	0.1301
Ceo_Gender _t	825	0.9358	1.0000	0.0000	1.0000	0.2453
Ceo_Age _t	825	46.5467	66.0000	27.0000	47.0000	5.8692
Ceo_Education _t	825	0.7648	1.0000	0.0000	1.0000	0.4244
Ceo_Experience _t	825	0.1018	1.0000	0.0000	0.0000	0.3026
Dual _t	825	0.4836	1.0000	0.0000	0.0000	0.5000
First_Stake _t	825	0.3380	0.6887	0.0877	0.3125	12.7597
Property _t	825	0.0400	1.0000	0.0000	0.0000	0.1961
VC _t	825	0.6206	1.0000	0.0000	1.0000	0.4855
Age _t	825	9.1952	26.0000	1.0000	9.0000	4.4421
RD_intensity _{t−1}	825	0.0223	0.2015	0.0000	0.0223	0.0244
RD_intensity _{t−2}	825	0.0236	0.1990	0.0000	0.0235	0.0295
Patents_past_total _t	825	16.9285	859.0000	0.0000	6.0000	46.7520
Size _t	825	2.1974	2.2824	2.1353	2.1939	0.0259

This phenomenon reflects the clear positioning of the ChiNext market, which is committed to supporting the growth and strength of high-tech and high-growth enterprises. The mean value of ΔRD_intensity is 0.43%, representing the increase in momentum of R&D in ChiNext companies. The mean value of ΔPatent is 10.7624, which shows that ChiNext companies have strong capabilities for innovation. However, new patents are distributed unevenly with a great standard deviation of 21.0348, which reflects significant differences in the innovation capabilities of the sample companies.

In terms of internationalization, the mean value of Export_Rate is 12.72%, indicating that on average 12.72% of ChiNext companies' incomes come from overseas markets. The means of ΔExport_Rate and

Table 7
Regression results for the internationalization and R&D input of ChiNext companies (Level model).

Variables	Predicted sign	RD_intensity Full sample	RD_intensity Full sample	RD_intensity Companies with non-overseas income	RD_intensity Companies with overseas income	RD_intensity Full sample	RD_intensity Full sample
		Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Total_Sales	+	0.046 ^{***} (3.24)					0.014 ^{***} (5.22)
Overseas_Sales	+		0.017 ^{***} (3.36)		0.017 ^{***} (3.33)		
Domes_Sales	+		0.015 ^{***} (5.28)	0.005 [*] (1.68)	0.027 ^{***} (6.72)		
Export_Rate	+					0.001 [*] (1.77)	
Overseas_Agency	+						0.006 ^{***} (5.17)
Ceo_Gender	+	0.002 (0.99)	0.002 (0.74)	−0.002 (−0.59)	0.002 (0.74)	0.003 (1.27)	0.001 (0.68)
Ceo_Age	−	−1.06E−04 (−1.17)	−8.5E−05 (−0.95)	−1.53E−04 (−0.93)	−5.05E−05 (−0.50)	−1.01E−04 (−1.11)	−0.15E−05 (−0.47)
Ceo_Education	+	0.004 ^{***} (3.56)	0.004 ^{***} (3.53)	0.004 (1.46)	0.006 ^{***} (4.33)	0.004 ^{***} (3.41)	0.005 ^{***} (3.99)
Ceo_Experience	+	−0.004 ^{**} (−2.14)	−0.003 [*] (−1.94)	−0.004 (−1.02)	−0.004 ^{**} (−2.24)	−0.004 ^{**} 88 (−2.19)	−0.004 ^{***} (−2.63)
Dual	+/−	0.002 (1.53)	0.002 (1.39)	0.003 [*] (1.77)	0.001 (1.11)	0.001 (1.30)	0.002 (1.46)
First_Stake	+/−	−9.84E−05 ^{**} (−2.42)	−1.17E−04 ^{***} (−2.91)	−5.56E−05 (−0.77)	−1.83E−04 ^{***} (−3.94)	−1.07E−04 ^{***} (−2.63)	−1.00E−04 ^{**} (−2.54)
Property	+/−	0.006 ^{**} (2.04)	0.004 (1.53)	0.001 (0.31)	0.006 ^{**} (2.05)	0.005 [*] (1.74)	0.004 [*] (1.87)
VC	+	8.31E−04 (0.78)	0.001 (0.95)	0.001 (0.71)	3.13E−04 (0.26)	0.001 (0.54)	7.90E−04 (0.76)
Tobin's Q	+	0.005 ^{***} (3.67)	0.006 ^{***} (5.04)	0.008 ^{***} (4.15)	0.003 ^{**} (2.14)	0.006 ^{***} (4.50)	0.006 ^{***} (5.25)
Lev	−	−0.005 (−1.18)	−0.014 ^{***} (−3.05)	−0.008 (−1.03)	−0.015 ^{***} (−2.83)	−0.006 (−1.24)	−0.014 ^{***} (−2.98)

Size	+	−5.41E−04 (−0.23)	0.001 (0.41)	0.002 (0.42)	0.004 (1.41)	−0.001 (−0.36)	0.001 (0.06)
Constant	?	0.015 (0.70)	−0.006 (−0.27)	0.002 (0.05)	−0.043 (−1.64)	0.019 (0.84)	−0.016 (−0.36)
Industry		Yes	Yes	Yes	Yes	Yes	Yes
Year		Yes	Yes	Yes	Yes	Yes	Yes
F-statistics		15.27 ^{***}	15.88 ^{***}	7.77 ^{**}	13.85 ^{***}	14.63 ^{***}	17.52 ^{***}
Prob > F		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R^2		0.2848	0.3024	0.3168	0.3706	0.2756	0.3248
N		825	825	322	503	825	825

T-statistics in parentheses are robust.

* Statistical significance at the 10% level for two-tailed tests.

** Statistical significance at the 5% level for two-tailed tests.

*** Statistical significance at the 1% level for two-tailed tests.

Table 8

Regression results for the internationalization and R&D input of ChiNext companies (Change model).

Variables	Predicted sign	Δ RD_intensity Full sample	Δ RD_intensity Full sample	Δ RD_intensity Companies with non- overseas income	Δ RD_intensity Companies with overseas income	Δ RD_intensity Full sample
		Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Δ Total_Sales	+	0.014*** (3.75)				
Δ Overseas_Sales	+		0.022** (2.41)		0.023*** (2.74)	
Δ Domes_Sales	+		0.013*** (3.21)	0.013** (2.10)	0.013** (2.41)	
Δ Export_Rate	+					0.001* (1.77)
Δ Tobin's Q	+	0.002** (2.15)	0.002** (2.11)	0.003* (1.80)	0.001 (0.58)	0.003** (2.33)
Δ Lev	–	–0.008*** (–2.58)	–0.008*** (–2.60)	–0.009* (–1.87)	–0.012*** (–2.79)	–0.008** (–2.09)
Constant	?	0.002 (0.57)	0.002 (0.64)	0.003 (0.90)	–0.004 (–0.44)	0.001 (0.05)
Industry		Yes	Yes	Yes	Yes	Yes
Year		Yes	Yes	Yes	Yes	Yes
F-statistics		2.83***	2.68***	2.84**	2.44***	1.85**
Prob > F		0.0006	0.0009	0.0172	0.0030	0.0402
Adj. R^2		0.0482	0.0478	0.0494	0.0647	0.0331
N		470	470	178	292	300

T-statistics in parentheses are robust.

* Statistical significance at the 10% level for two-tailed tests.

** Statistical significance at the 5% level for two-tailed tests.

*** Statistical significance at the 1% level for two-tailed tests.

Δ Overseas_Sales are 0.14% and 0.02%, respectively, showing the increase in momentum of the proportion of overseas incomes of ChiNext companies. In addition, the mean value of Overseas_Agency is 0.6424, which suggests that 64.24% of the companies have set up branches abroad.

As for the control variables, the mean value of Ceo_Gender is 0.9358, indicating that 93.58% of the sample companies have male CEOs. The mean value of Ceo_Education is 0.7648, implying that the vast majority of ChiNext companies' CEOs are highly educated. The mean and median of Ceo_Experience are 0.1018 and 0.0000, respectively, showing that CEOs with overseas experience are rarely seen in ChiNext companies. Only 10.18% of the sample companies have CEOs with overseas experience. Moreover, the mean and median of Lev are 0.1741 and 0.1417, respectively, meaning that the financial risks of ChiNext companies are generally low. The mean, median and standard deviation of First_Stake are 0.3380, 0.3125 and 12.7597, respectively. Thus, large shareholders are commonly seen in ChiNext companies and the proportions of the largest shareholders vary drastically. The mean and median of Property are 0.0400 and 0.0000, respectively, denoting that the vast majority of ChiNext companies are non-state-owned companies. The mean of VC is 0.6206, which suggests that the vast majority of ChiNext companies are associated with the equity support of venture capital.

4.2. Multivariate regression analysis

Table 7 examines the impacts of the internationalization of ChiNext companies on R&D investments. According to the regression results, the F-statistics of all of the models are significant at the 1% level, indicating high-fitting precision. All of the values of adjusted R^2 are greater than 27%, signifying that the explanation is reliable. With all other related factors controlled, there is a significant positive relationship between

Table 9

Two-stage regression results for the internationalization and R&D input of ChiNext companies (Foreign_ratio).

Variables	Predicted sign	Full sample RD_intensity Model (1)	Full sample RD_intensity Model (2)	Full sample RD_intensity Model (3)
Overseas_Sales	+	0.201 ^{***} (4.67)		
Domes_Sales	+	0.044 ^{***} (6.06)		
Export_Rate	+		0.114 ^{***} (4.61)	
Overseas_Agency	+			0.031 ^{***} (4.61)
Ceo_Gender	+	−0.004 [*] (−1.69)	−0.003 (−1.24)	0.001 (0.62)
Ceo_Age	−	2.19E−04 [*] (1.92)	3.60E−04 ^{***} (2.67)	1.58E−04 (1.49)
Ceo_Education	+	0.003 ^{***} (2.65)	0.002 (1.54)	0.007 ^{***} (5.13)
Ceo_Experience	+	−0.004 ^{**} (−2.31)	−0.008 ^{***} (−4.18)	−0.010 ^{***} (−4.58)
Dual	+/−	5.09E−04 (0.46)	−8.33E−04 (−0.69)	0.002 (1.50)
First_Stake	+/−	−2.26E−04 ^{***} (−4.78)	−2.21E−04 (−4.67)	−2.52E−05 (−0.57)
Property	+/−	0.005 [*] (1.85)	0.011 ^{***} (3.76)	0.009 ^{***} (3.20)
VC	+	0.002 [*] (1.79)	−0.002 (−1.39)	−4.18E−04 (−0.39)
Tobin's Q	+	0.011 ^{***} (6.64)	0.011 ^{***} (6.47)	0.007 ^{***} (5.43)
Lev	−	−0.046 ^{***} (−5.27)	−0.014 ^{***} (−2.86)	−0.007 (−1.50)
Size	+	0.010 ^{***} (3.15)	0.009 ^{***} (2.83)	−0.004 [*] (−1.82)
Constant	?	−0.109 ^{***} (−3.37)	−0.089 ^{***} (−2.78)	0.015 (0.71)
Industry		Yes	Yes	Yes
Year		Yes	Yes	Yes
F-statistics		16.51 ^{***}	15.93 ^{***}	15.93 ^{***}
Prob > F		0.0000	0.0000	0.0000
Adj. R2		0.3112	0.2942	0.2942
N		825	825	825

T-statistics in parentheses are robust.

^{*} Statistical significance at the 10% level for two-tailed tests.^{**} Statistical significance at the 5% level for two-tailed tests.^{***} Statistical significance at the 1% level for two-tailed tests.

Total_Sales and RD_intensity in Model (1). The regression coefficient is 0.046, which is significant at the 1% level. This indicates that R&D intensity is stronger when the sales income of a company is higher. We conduct further tests in Model (2), dividing the sales revenues of companies into Overseas_Sales and Domes_Sales

Table 10

Regression results for the internationalization and patent output of ChiNext companies.

Variables	Predicted sign	Δ Patents Full sample Model (1)	Δ Patents Companies with non-overseas income Model (2)	Δ Patents Companies with overseas income Model (3)	Δ Patents Full sample Model (4)	Δ Patents Full sample Model (5)
RD_intensity	+	17.134 ^{***} (24.09)	12.307 ^{**} (3.87)	7.693 ^{**} (9.92)	16.392 ^{**} (23.43)	12.967 ^{**} (18.03)
RD_intensity _{t-1}	+	2.631 ^{***} (6.03)	4.672 ^{**} (3.30)	3.018 ^{**} (5.14)	2.341 ^{***} (5.29)	2.687 ^{**} (6.11)
RD_intensity _{t-2}	+	3.277 ^{***} (6.42)	7.457 ^{**} (5.44)	6.681 ^{**} (10.29)	3.456 ^{**} (6.72)	3.023 ^{***} (5.81)
Overseas_Sales	+	0.280 ^{***} (5.03)		3.561 ^{***} (15.88)		
Domes_Sales	+	0.191 ^{***} (2.76)	0.583 ^{***} (3.31)	0.331 ^{***} (3.00)		
Export_Rate	+				0.288 ^{**} (6.35)	
Overseas_Agency	+					0.722 ^{***} (22.99)
Patents_past_total	+	0.004 ^{***} (36.43)	0.021 ^{***} (26.61)	0.004 ^{***} (29.99)	0.004 ^{***} (39.12)	0.003 ^{***} (35.40)
Ceo_Gender	+	0.240 ^{***} (4.51)	1.103 ^{***} (5.32)	0.373 ^{***} (5.25)	0.213 ^{***} (4.01)	0.217 ^{**} (4.07)
Ceo_Age	–	–0.015 ^{***} (7.20)	0.019 ^{**} (3.38)	0.018 ^{***} (6.57)	0.014 ^{***} (6.73)	0.011 ^{***} (5.08)
Ceo_Education	+	0.110 ^{***} (3.88)	0.059 (0.73)	0.189 ^{***} (4.96)	0.108 ^{***} (3.81)	0.175 ^{***} (6.17)
Ceo_Experience	+	0.027 (0.70)	0.585 ^{***} (6.92)	0.140 ^{***} (2.87)	0.025 (0.65)	0.139 ^{***} (3.53)
Dual	+/–	–0.004 (–0.16)	0.282 ^{**} (4.45)	–0.154 ^{***} (–4.71)	–0.009 (–0.38)	0.018 (0.73)
Age	–	–0.014 ^{***} (–5.15)	–0.058 ^{***} (–7.97)	–0.012 ^{***} (–3.30)	–0.013 ^{***} (–4.72)	0.012 ^{***} (4.63)
First_Stake	+/–	0.009 ^{***} (9.82)	0.003 (1.33)	0.006 ^{***} (5.04)	0.008 ^{***} (9.60)	0.009 ^{***} (9.96)

Property	+/-	0.188 ^{***} (4.03)	0.333 ^{**} (2.50)	0.701 ^{***} (12.83)	0.198 ^{***} (4.24)	0.271 ^{***} (5.79)
VC	+	0.351 ^{***} (13.99)	0.333 ^{***} (5.27)	0.508 ^{***} (14.96)	0.352 ^{***} (14.08)	0.328 ^{***} (13.15)
Size	+	10.816 ^{***} (24.86)	7.496 ^{***} (5.88)	8.142 ^{***} (12.86)	11.196 ^{***} (25.80)	10.474 ^{***} (24.31)
Lev	-	0.180 [*] (1.82)	1.399 ^{***} (6.00)	-1.083 ^{***} (-7.17)	0.024 (0.26)	-0.025 (-0.26)
Constant	?	-24.247 ^{***} (-25.24)	-17.077 ^{***} (-6.09)	-16.495 ^{***} (-11.46)	-25.083 ^{***} (-26.21)	-24.073 ^{***} (-25.28)
Industry		Yes	Yes	Yes	Yes	Yes
Year		Yes	Yes	Yes	Yes	Yes
LR χ^2		5,003.97 ^{***}	1,416.41 ^{***}	2,900.44 ^{***}	5,035.52 ^{***}	5,586.99 ^{***}
Prob > χ^2		0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R^2		0.2630	0.3618	0.2372	0.2647	0.2937
N		825	322	503	825	825

We use the Poisson model.

T-statistics in parentheses are robust.

* Statistical significance at the 10% level for two-tailed tests.

** Statistical significance at the 5% level for two-tailed tests.

*** Statistical significance at the 1% level for two-tailed tests.

Table 11
Regression results for the internationalization and patent output of ChiNext companies (robustness tests).

Variables	Predicted sign	Ln(Δ Patents + 1) Full sample Model (1)	Ln(Δ Patents + 1) Companies with non-overseas income Model (2)	Ln(Δ Patents + 1) Companies with overseas income Model (3)	Ln(Δ Patents + 1) Full sample Model (4)	Ln(Δ Patents + 1) Full sample Model (5)
RD_intensity	+	12.900 ^{***} (4.27)	4.162 [*] (1.81)	3.708 ^{**} (3.14)	11.934 ^{***} (4.05)	8.092 ^{***} (2.79)
RD_intensity _{t-1}	+	2.295 (1.09)	2.411 (0.92)	3.377 (1.16)	2.503 (1.19)	2.259 (1.11)
RD_intensity _{t-2}	+	2.259 (1.22)	0.216 (0.08)	3.081 (1.30)	2.110 (1.14)	2.213 (1.23)
Overseas_Sales	+	0.234 [*] (1.83)		0.702 [*] (1.71)		
Domes_Sales	+	0.405 [*] (1.70)	0.799 ^{***} (2.87)	0.029 [*] (1.82)		
Export_Rate	+				0.437 ^{**} (2.19)	
Overseas_Agency	+					0.679 ^{***} (7.58)
Patents_past_total	+	0.008 ^{***} (9.33)	0.027 ^{***} (8.67)	0.006 ^{***} (6.82)	0.008 ^{***} (9.39)	0.007 ^{***} (8.83)
Ceo_Gender	+	0.226 (1.33)	0.439 [*] (1.78)	0.051 (0.24)	0.191 (1.33)	0.198 (1.21)
Ceo_Age	–	–0.002 (–0.30)	–0.005 (–0.44)	0.001 (0.07)	–0.001 (–0.16)	0.002 (0.30)
Ceo_Education	+	0.157 (1.57)	0.058 (0.37)	0.255 ^{**} (2.07)	0.159 (1.59)	0.232 ^{**} (2.39)
Ceo_Experience	+	–0.118 (–0.85)	0.067 (0.31)	0.376 ^{**} (2.26)	–0.118 (–0.86)	0.252 [*] (1.87)
Dual	+/–	0.062 (0.71)	0.199 (1.58)	0.067 (0.60)	0.061 (0.69)	0.088 (1.04)
Age	–	–0.004 (–0.41)	–0.058 ^{***} (–7.97)	0.001 (0.09)	–0.004 (–0.40)	–0.005 (–0.58)
First_Stake	+/–	0.329 (1.01)	0.197 (1.59)	0.847 ^{**} (2.00)	0.306 (0.94)	0.428 (1.36)

Property	+/-	0.352 (1.62)	0.480 (1.60)	0.546 [*] (1.91)	0.354 (1.63)	0.457 ^{**} (2.17)
VC	+	0.154 [*] (1.80)	0.081 (0.66)	0.150 (1.37)	0.156 [*] (1.83)	0.142 [*] (1.72)
Size	+	4.173 ^{**} (2.47)	3.837 (1.54)	3.829 [*] (1.71)	4.728 ^{***} (2.82)	3.732 ^{**} (2.31)
Lev	-	0.362 (0.96)	1.268 ^{**} (2.46)	-0.062 (-0.13)	0.177 (0.50)	0.161 (0.47)
Constant	?	-8.690 ^{**} (-2.31)	-7.357 (-1.34)	-8.514 [*] (-1.70)	-10.130 ^{***} (-2.73)	-8.527 ^{**} (-2.38)
Industry		Yes	Yes	Yes	Yes	Yes
Year		Yes	Yes	Yes	Yes	Yes
F-statistics		9.63 ^{***}	6.62 ^{***}	5.46 ^{***}	10.02 ^{***}	12.57 ^{***}
Prob > F		0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R2		0.2385	0.3292	0.2036	0.2402	0.2884
N		825	322	503	825	825

We use the OLS model.

T-statistics in parentheses are robust.

^{*} Statistical significance at the 10% level for two-tailed tests.

^{**} Statistical significance at the 5% level for two-tailed tests.

^{***} Statistical significance at the 1% level for two-tailed tests.

Table 12

Univariate analysis of the influence of internationalization on R&D input and patent output (exporters vs. non-exporters).

Variable	Mean (<i>N</i>)		Mean difference test	Median (<i>N</i>)		Median difference test
	Exporters	Non-exporters		Exporters	Non-exporters	
RD_intensity	0.0326 (190)	0.0237 (81)	1.6792*	0.0198 (190)	0.0121 (81)	3.573***
Variable	Mean (<i>N</i>)		Mean difference test	Median (<i>N</i>)		Median difference test
	Exporters	Non-exporters		Exporters	Non-exporters	
△Patents	14.2017 (190)	4.71080 (81)	6.1218***	7.0000 (190)	1.0000 (81)	10.616****

** Statistical significance at the 5% level for two-tailed tests.

* Statistical significance at the 10% level for two-tailed tests.

*** Statistical significance at the 1% level for two-tailed tests.

according to the source of sales revenue. A significant positive relationship is discovered between Overseas_Sales, Domes_Sales and RD_intensity. The regression coefficients are 0.017 and 0.015, respectively, which are significant at the 1% level. This shows that more overseas and domestic incomes lead to stronger R&D intensity. Furthermore, overseas income, which measures a company's degree of internationalization, contributes more to R&D investments than domestic income ($0.017 > 0.015$). The results demonstrate that an internationalization strategy has a significant incentive effect on R&D inputs. The entrepreneurial companies with higher degrees of internationalization have higher R&D inputs.

To obtain robust results, we conduct further tests grouped by the existence of overseas income. One group consists of ChiNext companies without internationalization, which means that all of their revenues are domestic. The other group is made up of ChiNext companies that have overseas revenues. The results are displayed in Models (3) and (4). Overseas_Sales is significantly positively related to RD_intensity in Model (4). The regression coefficient is 0.017, which is significant at the 1% level. Thus, an internationalization strategy has a significant incentive effect on R&D input. The entrepreneurial companies with higher degrees of internationalization have higher R&D inputs.

Using Export_Rate and Overseas_Agency as proxy variables of internationalization, further tests are conducted in Models (5) and (6). Export_Rate is significantly positively related to RD_intensity in Model (5). The regression coefficient is 0.001, which is significant at the 10% level. This illustrates that companies with higher degrees of internationalization have higher R&D inputs. Additionally, Overseas_Agency is significantly positively related to RD_intensity in Model (6). The regression coefficient is 0.006, which is significant at the 1% level. This implies that setting up branches overseas has a significant positive effect on domestic R&D. Overall, these results provide support for [Hypothesis 1](#). An internationalization strategy has a significant incentive effect on R&D input. The entrepreneurial companies with higher degrees of internationalization have higher R&D inputs.

In terms of the control variables, Tobin's Q is significantly positively related to RD_intensity. This shows that better investment opportunities increase R&D intensity investments.

To obtain more robust results, the Change model is used to further investigate the impacts of ChiNext companies' internationalization on R&D. The results are shown in [Table 8](#). A significant positive relationship between △Total_Sales and △RD_intensity is shown in Model (1). The regression coefficient is 0.014, which is significant at the 1% level. This shows that changes in sales revenues cause changes in R&D investments in the same direction. △Overseas_Sales and △Domes_Sales are significantly positively related to △RD_intensity in Model (2). The regression coefficients are 0.022 and 0.013, respectively, which are significant at the 5% and 1% levels, respectively. This shows that greater changes in overseas and domestic income lead to greater changes in R&D intensity. Furthermore, overseas income, which measures a company's degree of internationalization, contributes more to changes in R&D investments than domestic income ($0.022 > 0.013$). This supports the conclusion that an internationalization strategy has an incentive effect on R&D. Changes in the degree of internationalization beget changes in RD_intensity in the same direction.

To make our test results more robust, we conduct further tests grouped by the existence of overseas income. One group consists of ChiNext companies without internationalization, which means that all of their revenues

Table 13

Regression results for the internationalization and R&D input of ChiNext companies (subsample test by strategic emerging industries).

Variables	Strategic emerging industries	Non-strategic emerging industries	Strategic emerging industries	Non-strategic emerging industries	Strategic emerging industries	Non-strategic emerging industries	Strategic emerging industries	Non-strategic emerging industries
	RD_intensity Full sample	RD_intensity Full sample	RD_intensity Full sample	RD_intensity Full sample	RD_intensity Full sample	RD_intensity Full sample	RD_intensity Companies with overseas income	RD_intensity Companies with overseas income
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
Overseas_Sales	0.023*** (4.03)	0.007 (0.68)					0.017** (2.57)	0.011 (1.30)
Domes_Sales	0.024*** (6.36)	0.009* (1.88)					0.024*** (4.39)	0.031*** (5.14)
Export_Rate			0.004** (2.25)	−0.006 (−1.16)				
Overseas_Agency					0.005*** (3.48)	0.013*** (5.57)		
Total_Sales					0.002 (0.57)	0.009** (2.15)		
Ceo_Gender	−0.004 (−1.57)	0.008** (2.16)	−0.003 (−1.25)	0.010** (2.47)	−0.003 (−1.35)	0.010*** (2.61)	−0.002 (−0.68)	0.008** (2.39)
Ceo_Age	−1.63E−04 (−1.58)	−7.56E−05 (−0.45)	−1.43E−04 (−1.33)	−1.12E−04 (−0.66)	−1.20E−04 (−1.13)	−5.49E−05 (−0.34)	−1.80E−04 (−1.30)	2.66E−04* (1.80)
Ceo_Education	0.004*** (2.89)	0.004 (1.45)	0.003** (2.53)	0.004 (1.62)	0.004 (2.88)	0.004* (1.66)	0.007*** (3.98)	0.004* (1.83)
Ceo_Experience	−0.004** (−1.97)	0.001 (0.35)	−0.004* (−1.95)	0.001 (0.31)	−0.005** (−2.38)	−0.001 (−0.37)	−0.006** (−2.41)	0.002 (0.55)
Dual	0.003** (2.31)	−6.23E−04 (−0.27)	0.002** (2.03)	−4.69E−04 (−0.21)	0.003** (2.06)	4.24E−04 (0.19)	0.004*** (2.81)	−0.005** (−2.39)
First_Stake	−1.75E−04*** (−3.94)	−1.11E−04 (−1.35)	−1.61E−04 (−3.49)	−1.08E−04 (−1.30)	−1.51E−04*** (−3.32)	−2.16E−05 (−0.27)	−2.49E−04*** (−4.21)	−1.18E−04 (−1.62)
Property	−8.57E−05 (−0.03)	0.009* (1.84)	−6.08E−04 (−0.18)	0.009* (1.87)	−7.05E−04 (−0.21)	0.014*** (3.07)	0.002 (0.36)	0.012*** (2.65)
VC	−2.51E−04 (−0.21)	0.003 (1.15)	−0.001 (−1.09)	0.002 (1.05)	−0.002 (−1.27)	0.002 (1.10)	−6.98E−04 (−0.45)	0.003* (1.68)

continued on next page

Table 13 (continued)

Tobin's Q	0.005 ^{***} (3.31)	0.008 ^{***} (3.50)	0.005 ^{***} (3.48)	0.007 ^{***} (3.12)	0.005 ^{***} (3.63)	0.006 ^{***} (3.00)	0.004 ^{**} (2.21)	0.005 [*] (1.68)
Lev	−0.017 ^{***} (−3.31)	−0.006 (−0.65)	−0.006 (−1.15)	−0.001 (−0.07)	−0.006 (−1.24)	−2.65E−04 (−0.03)	−0.009 (−1.24)	−0.026 ^{***} (−2.84)
Size	0.005 ^{**} (2.01)	−0.007 (−1.41)	0.003 (1.32)	−0.008 [*] (−1.73)	0.003 (1.07)	−0.009 ^{**} (−1.97)	0.005 (1.40)	0.004 (0.83)
Constant	−0.008 (−0.36)	0.059 (1.26)	0.012 (0.50)	0.079 [*] (1.72)	0.015 (0.61)	0.073 [*] (1.68)	1.21E−04 (0.01)	−0.069 (−1.38)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics	17.36 ^{***}	6.19 ^{***}	14.58 ^{***}	6.33 ^{***}	14.92 ^{***}	8.00 ^{***}	13.19 ^{***}	6.35 ^{***}
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R2	0.3403	0.3050	0.2874	0.3016	0.3051	0.3716	0.3901	0.4101
N	540	285	540	285	540	285	325	178

T-statistics in parentheses are robust.

* Statistical significance at the 10% level for two-tailed tests.

** Statistical significance at the 5% level for two-tailed tests.

*** Statistical significance at the 1% level for two-tailed tests.

Table 14

Regression results for the internationalization and R&D input of ChiNext companies (Change model, subsample test by strategic emerging industries).

Variables	Strategic emerging industries Full sample	Non-strategic emerging industries Full sample	Strategic emerging industries Full sample	Non-strategic emerging industries Full sample	Strategic emerging industries Companies with overseas income Δ RD_intensity Model (5)	Non-strategic emerging industries Companies with overseas income Δ RD_intensity Model (6)	Strategic emerging industries Companies with non-overseas income Δ RD_intensity Model (7)
	Δ RD_intensity Model (1)	Δ RD_intensity Model (2)	Δ RD_intensity Model (3)	Δ RD_intensity Model (4)			
Δ Overseas_Sales	0.030*** (3.11)	0.008 (0.41)			0.022** (1.97)	0.010 (0.75)	
Δ Domes_Sales	0.022*** (4.02)	0.004 (0.59)			0.010 (1.22)	0.017** (2.47)	0.011* (1.84)
Δ Export_Rate			0.005** (2.46)	−0.006 (−0.49)			
Δ Tobin's Q	0.001 (0.45)	0.003* (1.97)	0.006** (2.45)	0.003* (1.85)	0.001 (0.01)	0.001 (0.88)	0.001*** (2.97)
Δ Lev	−0.009** (−2.11)	−0.007 (−1.45)	−0.005 (−0.85)	−0.008** (−2.14)	−0.010** (−2.16)	−0.010* (−1.93)	−0.017*** (−4.46)
Constant	0.002 (0.56)	0.002 (0.47)	−0.006 (−1.45)	0.003 (0.49)	0.001 (0.07)	−0.003 (−0.79)	0.003 (0.90)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics	2.61***	1.87**	1.94**	2.07**	2.63**	2.84***	2.42***
Prob > F	0.0019	0.0378	0.0372	0.0255	0.018	0.0025	0.0100
Adj. R^2	0.0634	0.067	0.0521	0.1048	0.0487	0.1823	0.1167
N	311	159	189	111	192	100	119

T-statistics in parentheses are robust.

* Statistical significance at the 10% level for two-tailed tests.

** Statistical significance at the 5% level for two-tailed tests.

*** Statistical significance at the 1% level for two-tailed tests.

Table 15

Regression results for the internationalization and patent output of ChiNext companies (subsample test by strategic emerging industries).

Variables	Strategic emerging industries			Non-strategic emerging industries			Strategic emerging industries	
	Full sample			Full sample			Companies with overseas income	Companies with non-overseas income
	Δ Patents Model (1)	Δ Patents Model (2)	Δ Patents Model (3)	Δ Patents Model (4)	Δ Patents Model (5)	Δ Patents Model (6)	Δ Patents Model (7)	Δ Patents Model (8)
RD_intensity	16.289 ^{***} (18.71)	15.143 ^{***} (18.32)	8.877 ^{***} (14.64)	19.169 ^{***} (12.30)	17.996 ^{***} (11.76)	14.713 ^{***} (6.44)	18.043 ^{***} (14.37)	18.564 ^{***} (7.40)
RD_intensity _{t-1}	4.147 ^{***} (5.12)	4.420 ^{***} (5.45)	4.687 ^{***} (5.68)	3.752 ^{***} (4.64)	4.252 ^{**} (5.24)	3.662 ^{***} (4.48)	2.012 [*] (1.98)	6.783 ^{***} (4.49)
RD_intensity _{t-2}	4.914 ^{***} (6.92)	4.967 ^{***} (6.96)	5.161 ^{***} (7.24)	−0.097 (−0.15)	−0.318 (−0.50)	−0.244 (−0.39)	5.967 ^{***} (7.20)	2.888 [*] (1.78)
Overseas_Sales	0.756 ^{***} (5.45)			0.212 [*] (1.86)			1.037 ^{***} (6.54)	
Domes_Sales	0.260 ^{***} (2.88)			0.571 ^{***} (4.12)			0.101 [*] (1.81)	1.167 ^{***} (5.70)
Export_Rate		0.182 ^{***} (2.89)			0.521 ^{***} (5.38)			
Overseas_Agency			0.506 ^{***} (14.45)			1.062 ^{***} (13.54)		
Patents_past_total	0.003 ^{***} (28.08)	0.003 ^{***} (28.42)	0.003 ^{***} (26.15)	0.022 ^{***} (37.45)	0.022 ^{***} (37.45)	0.021 ^{***} (34.38)	0.003 ^{***} (23.30)	0.017 ^{***} (20.68)
Ceo_Gender	0.117 [*] (1.82)	0.113 [*] (1.76)	0.072 (1.12)	0.153 (1.49)	0.086 (0.84)	0.181 [*] (1.77)	0.060 (0.87)	0.322 [*] (1.78)
Ceo_Age	−0.023 ^{***} (−8.77)	−0.022 ^{***} (−8.63)	−0.017 ^{***} (−6.59)	0.008 ^{**} (2.14)	0.007 ^{**} (2.03)	0.010 ^{***} (2.79)	−0.017 ^{***} (−5.43)	−0.054 ^{***} (−9.59)
Ceo_Education	0.085 ^{***} (2.56)	0.096 ^{***} (2.92)	0.144 ^{***} (4.36)	0.246 ^{***} (4.25)	0.236 ^{***} (4.08)	0.320 ^{***} (5.69)	−0.027 (−0.74)	0.342 ^{***} (3.67)
Ceo_Experience	−0.062 (−1.29)	−0.060 (−1.25)	−0.117 ^{**} (−2.42)	0.107 (1.33)	0.092 (1.14)	−0.083 (−1.01)	−0.355 ^{***} (−6.05)	0.447 ^{***} (5.07)
Dual	0.138 ^{***} (4.61)	0.137 ^{***} (4.61)	0.151 ^{***} (5.08)	−0.268 ^{***} (−5.57)	−0.253 ^{***} (−5.29)	−0.195 ^{***} (−4.06)	−0.040 (−1.11)	0.581 ^{***} (8.98)
First_Stake	1.034 ^{***} (9.61)	0.960 ^{***} (9.07)	0.953 ^{***} (8.91)	0.248 (1.39)	0.065 (0.38)	0.168 (0.97)	0.708 ^{***} (13.28)	0.277 (1.12)
Property	0.475 ^{***} (7.06)	0.479 ^{***} (7.12)	0.454 ^{***} (6.71)	−0.725 ^{***} (−8.49)	−0.632 ^{***} (−7.63)	−0.466 ^{***} (−5.45)	0.487 ^{***} (6.44)	0.250 (1.32)

VC	0.344*** (11.10)	0.360*** (11.66)	0.319*** (10.41)	0.088* (1.85)	0.081* (1.70)	0.131*** (2.70)	0.297*** (8.26)	0.434*** (6.45)
Tobin's Q	0.224*** (5.66)	0.218*** (5.52)	0.160*** (4.07)	0.190*** (3.14)	0.229*** (4.12)	0.298*** (5.13)	0.269*** (5.55)	0.079 (1.00)
Lev	−0.290** (−2.49)	0.161 (1.43)	0.072 (0.63)	−0.312 (−1.43)	−0.692*** (−3.69)	−0.958*** (−5.05)	−0.955*** (−6.37)	−2.499*** (−10.99)
Size	12.249*** (23.89)	12.421*** (24.32)	11.940*** (23.50)	4.428*** (4.90)	5.605*** (6.12)	5.380*** (5.89)	12.998*** (21.75)	7.145*** (5.64)
Constant	−24.813*** (−21.91)	−25.288*** (−22.46)	−24.662*** (−22.05)	−9.314*** (−4.71)	−11.906*** (−5.94)	−12.879*** (−6.35)	−26.568*** (−20.20)	−14.148*** (−5.08)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LR χ^2	3,192.39***	3,169.24***	3,385.06***	2,916.10***	2,922.18***	3,103.89***	2,152.64***	1,415.67***
Prob > χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R^2	0.2500	0.2482	0.2651	0.5018	0.5028	0.5341	0.2568	0.3766
N	540	540	540	285	285	285	325	215

We use the Poisson model.

T-statistics in parentheses are robust.

* Statistical significance at the 10% level for two-tailed tests.

** Statistical significance at the 5% level for two-tailed tests.

*** Statistical significance at the 1% level for two-tailed tests.

Table 16

Regression results for the internationalization and patent output of ChiNext companies (subsample test by strategic emerging industries, robustness tests).

Variables	Strategic emerging industries			Non-strategic emerging industries			Strategic emerging industries	
	Full sample			Full sample			Companies with overseas income	Companies with non-overseas income
	Ln(Δ Patents + 1) Model (1)	Ln(Δ Patents + 1) Model (2)	Ln(Δ Patents + 1) Model (3)	Ln(Δ Patents + 1) Model (4)	Ln(Δ Patents + 1) Model (5)	Ln(Δ Patents + 1) Model (6)	Ln(Δ Patents + 1) Model (7)	Ln(Δ Patents + 1) Model (8)
RD_intensity	10.264** (2.47)	9.383** (2.35)	5.746* (1.84)	12.878** (3.24)	12.643*** (3.26)	8.983** (2.26)	6.697* (1.82)	6.833* (1.76)
RD_intensity _{t-1}	3.311 (1.15)	3.356 (1.17)	3.467 (1.24)	3.030 (1.14)	3.536 (1.34)	2.647 (1.02)	4.110 (1.04)	3.376 (0.89)
RD_intensity _{t-2}	4.613* (1.81)	4.584* (1.80)	4.821* (1.95)	1.247 (0.53)	1.752 (0.75)	1.194 (0.52)	5.512 (1.65)	0.869 (0.23)
Overseas_Sales	0.104* (1.72)			0.738* (1.80)			0.734* (1.87)	
Domes_Sales	0.246* (1.82)			0.357* (1.81)			0.384* (1.77)	0.984** (2.08)
Export_Rate		0.111* (1.75)			0.782*** (2.66)			
Overseas_Agency			0.596*** (5.50)			0.533*** (3.50)		
Patents_past_total	0.006*** (6.93)	0.006*** (6.97)	0.006*** (6.50)	0.030*** (10.96)	0.030*** (10.99)	0.029*** (10.50)	0.005*** (5.36)	0.024*** (6.24)
Ceo_Gender	0.029 (0.13)	0.014 (0.06)	−0.041 (−0.19)	0.275 (1.20)	0.222 (0.99)	0.273 (1.23)	−0.162 (−0.57)	0.308 (0.90)
Ceo_Age	−0.008 (−0.87)	−0.008 (−0.87)	−0.005 (−0.56)	0.011 (1.12)	0.014 (1.37)	0.013 (1.34)	0.004 (0.28)	−0.020 (−1.55)
Ceo_Education	0.277** (2.28)	0.283** (2.34)	0.353*** (2.98)	0.048 (0.31)	0.021 (0.14)	0.078 (0.52)	0.325** (2.12)	0.292 (1.48)
Ceo_Experience	−0.308* (−1.76)	−0.310* (−1.77)	−0.434** (−2.53)	0.107 (0.53)	0.098 (0.49)	0.075 (0.38)	−0.468** (−2.12)	−0.051 (−0.19)
Dual	0.123 (1.12)	0.127 (1.16)	0.151 (1.42)	−0.018 (−0.14)	−0.036 (−0.27)	0.024 (0.18)	0.083 (0.58)	0.228 (1.38)
First_Stake	0.518 (1.24)	0.484 (1.16)	0.472 (1.17)	−0.090 (−0.19)	−0.060 (−0.13)	0.137 (0.29)	1.209** (2.18)	0.029 (0.05)

Property	0.961 ^{***} (3.19)	0.970 ^{***} (3.22)	0.974 ^{***} (3.33)	−0.522 [*] (−1.84)	−0.496 [*] (−1.76)	−0.308 (−1.08)	0.961 ^{**} (2.46)	0.840 [*] (1.85)
VC	0.194 [*] (1.81)	0.199 [*] (1.86)	0.159 (1.53)	0.050 (0.38)	0.058 (0.45)	0.070 (0.55)	0.200 (1.43)	0.076 (0.48)
Tobin's Q	0.247 [*] (1.84)	0.243 [*] (1.81)	0.190 (1.46)	0.128 (0.93)	0.164 (1.23)	0.140 (1.07)	−0.163 (−0.89)	0.250 (1.34)
Lev	0.130 (0.27)	0.013 (0.03)	−0.055 (−0.13)	0.075 (0.13)	−0.068 (−0.13)	−0.017 (−0.03)	0.017 (0.03)	0.526 (0.76)
Size	6.012 ^{***} (2.84)	6.254 ^{***} (2.97)	5.848 ^{***} (2.87)	2.687 (1.03)	3.562 (1.37)	1.978 (0.77)	5.323 ^{**} (2.01)	4.084 (1.24)
Constant	−12.170 ^{***} (−2.61)	−12.743 ^{***} (−2.75)	−12.023 ^{***} (−2.69)	−5.406 (−0.94)	−7.518 (−1.32)	−4.709 (−0.84)	−10.948 [*] (−1.87)	−7.340 (−1.01)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics	7.15 ^{***}	7.50 ^{***}	9.45 ^{***}	10.95 ^{***}	11.67 ^{***}	12.10 ^{***}	3.82 ^{***}	5.08 ^{***}
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R ²	0.1983	0.1994	0.2446	0.5022	0.5108	0.5205	0.1586	0.2827
N	540	540	540	285	285	285	325	215

We use the OLS model.

T-statistics in parentheses are robust.

^{*} Statistical significance at the 10% level for two-tailed tests.

^{**} Statistical significance at the 5% level for two-tailed tests.

^{***} Statistical significance at the 1% level for two-tailed tests.

are domestic. The other group consists of ChiNext companies that have overseas revenues. The results are displayed in Models (3) and (4). $\Delta\text{Overseas_Sales}$ and $\Delta\text{Domes_Sales}$ are significantly positively related to $\Delta\text{RD_intensity}$ in Model (4). The regression coefficients are 0.023 and 0.013, respectively, which are significant at the 1% and 5% levels, respectively. Thus, an internationalization strategy has a significant incentive effect on R&D input for internationalized ChiNext companies. Overseas income, which measures a company's degree of internationalization, contributes more to changes in R&D investments than domestic income ($0.023 > 0.013$).

$\Delta\text{Export_Rate}$ is significantly positively related to $\Delta\text{RD_intensity}$ in Model (5). The regression coefficient is 0.001, which is significant at the 10% level. This indicates that a higher $\Delta\text{Export_Rate}$, which measures the degree of internationalization, strengthens RD_intensity. The empirical evidence reported in Table 8 thus supports Hypothesis 1. An internationalization strategy has an incentive effect on R&D. In addition, the control variables in the model are consistent with the previous regression results.

Based on previous studies (Lileeva and Treffer, 2010; Bustos, 2011; Bratti and Felice, 2012), we use TSLS to test the effects of internationalization on independent innovation while considering the endogeneity of internationalization. The corresponding results are shown in Table 9.

As shown in Table 9, an internationalization strategy still has an incentive effect on R&D input after controlling for endogeneity. Companies with higher degrees of internationalization have higher R&D inputs. The empirical evidence reported in Table 9 provides additional support for Hypothesis 1.

To completely investigate the influence of an internationalization strategy on entrepreneurial companies' independent innovation, an empirical analysis of the influences of internationalization on the efficiency of patent output is displayed in the remaining part. In light of the related literature (Pakes and Griliches, 1980; Hausman et al., 1984), we adopt the Poisson model to explore the relationship between internationalization, R&D input and patent output. The results are shown in Table 10.

According to Models (1) to (5) in Table 10, when other variables such as $\text{RD_intensity}_{t-1}$ and $\text{RD_intensity}_{t-2}$ are controlled, RD_intensity , $\text{Patents_past_total}$ and $\Delta\text{Patents}$ are significantly positively related. The corresponding regression coefficients are significant at the 1% level. This shows that companies with higher R&D inputs and more knowledge stock have more patent outputs.

In Models (1), (3), (4) and (5), the proxy variables of internationalization strategy, such as Overseas_Sales , Export_Rate and Overseas_Agency , are significantly positively related to $\Delta\text{Patents}$. The corresponding regression coefficients are 0.280, 3.561, 0.288 and 0.722, respectively, which are all significant at the 1% level. Thus, internationalization can significantly increase entrepreneurial companies' patent outputs. Moreover, Overseas_Sales has greater effects on patent output than Domes_Sales in Model (3) ($3.561 > 0.331$). Therefore, an internationalization strategy can improve the efficiency of patent output. The empirical evidence reported in Table 10 thus supports Hypothesis 2.

In Table 11, the ordinary least squares (OLS) model is adopted to replace the Poisson model for further robustness testing. Models (1), (3), (4) and (5) show that when other variables such as $\text{RD_intensity}_{t-1}$ and $\text{RD_intensity}_{t-2}$ are controlled, proxy variables of internationalization strategy such as Overseas_Sales , Export_Rate and Overseas_Agency are significantly positively related to $\Delta\text{Patents}$. The corresponding regression coefficients are 0.234, 0.702, 0.437 and 0.679, respectively, which are significant. This shows that internationalization can significantly increase the number of entrepreneurial companies' patent outputs. In Model (3), Overseas_Sales has a greater effect on patent output ($0.702 > 0.029$) than Domes_Sales . This result is essentially the same as that in Table 10, further demonstrating that our results are robust. The internationalization strategies of companies have obvious efficiency improvement effects on patent output. The higher the degree of internationalization, the higher companies' patent outputs. This further supports Hypothesis 2.

To make the results more robust, the differences between export and non-export companies in R&D inputs and patent outputs are compared. The results are shown in Table 12.

Table 12 shows that export companies have higher R&D intensities and more patent outputs than non-export companies regardless of the mean and median. An internationalization strategy has an incentive effect on R&D and R&D output. Thus, Hypotheses 1 and 2 are supported.

5. Influence of internationalization on strategic emerging industries: An expanding analysis

Decision of the State Council on Accelerating the Fostering and Development of Strategic Emerging Industries (2010, No. 32), promulgated by the State Council in October 2010, determines the focus on the development of energy saving, new generation of IT and seven other strategic emerging industries, requiring the relevant departments to promptly formulate plans and implement specific supporting measures. Moreover, *Guiding Opinions on Promoting the Internationalization of Strategic Emerging Industries* (2011, No. 310), jointly promulgated by the Ministry of Commerce, the National Development and Reform Committee and nine other ministries and commissions in September 2011, explicitly state that global innovation resources are to be used to enhance the ability of industrial innovation. To this end, the ChiNext market attaches more importance to the development of strategic emerging industries. We believe that the ChiNext market is perfect for researching the impacts of internationalization strategy on R&D in strategic emerging industries, as a large sum of high-quality companies in strategic emerging industries are listed in the ChiNext market.

Conforming with the *Strategic Emerging Industry Classification (2012) (Trial)* compiled by the National Statistics Bureau in December 2012, the samples are subdivided into strategic emerging industries to further explore the effects of internationalization strategy on R&D in strategic emerging industries.

More specifically, in correspondence with the main business and prime products disclosed in the prospectuses, 540 observations defined in strategic emerging industries include 27 observations in the energy saving and environmental protection industry, 158 observations in the new generation of IT industry, 89 observations in the pharmaceutical industry, 136 observations in the high-end equipment manufacturing industry, 48 observations in the new energy industry, 68 observations in the new materials industry and 14 observations in the new energy vehicles industry. Table 13 reports the results.

In Table 13, a comparison of Models (1) and (2) shows a significant positive relationship between Overseas_Sales and RD_intensity in strategic emerging industries. The regression coefficient is 0.023, which is significant at the 1% level. However, in non-strategic industries, there is no significant relationship between overseas sales and R&D input. This shows that the internationalization strategies in strategic emerging industries positively promote R&D. Companies with higher degrees of internationalization have higher R&D inputs.

A comparison of Models (3) and (4) shows that Export_Rate, which measures internationalization, is significantly positively related to RD_intensity. The regression coefficient is 0.004, which is significant at the 5% level. However, no significant relation is found between overseas sales and R&D input in non-strategic industries. This shows that the internationalization strategies in strategic emerging industries have incentive effects on R&D. Companies with higher proportions of overseas sales have higher R&D inputs.

In Models (5) and (6), Overseas_Agency has significant positive impacts on RD_intensity in either strategic or non-strategic industries. The regression coefficients are 0.005 and 0.013, respectively, which are significant at the 1% level. Thus, the establishment of overseas institutions positively promotes R&D for companies in both strategic and non-strategic industries. In addition, a comparison of Models (7) and (8) shows that the different natures of strategic emerging industries cause overseas sales to have different influences on RD_intensity from those of other internationalization companies. In strategic emerging industries, both the regression coefficients and significance levels are higher than those of non-strategic companies (coefficient $0.017 > 0.011$, T value $2.57 > 1.3$). This further shows that an internationalization strategy has more pronounced incentive effects on R&D inputs in strategic emerging industries. An internationalization strategy has a more positive role in promoting the R&D of companies in strategic emerging industries.

To enhance the robustness of the results, as shown in Table 8, the Change model is used to further examine the impacts of internationalization on R&D in strategic emerging industries. The results are shown in Table 14.

A comparison of Models (1) and (2) in Table 14 shows that Δ Overseas_Sales and Δ Domes_Sales are significantly positively related to Δ RD_intensity. The regression coefficients are 0.030 and 0.022, respectively, which are significant at the 1% level. In non-strategic industries, changes in overseas and domestic sales have no significant impacts on changes in R&D inputs. This shows that the internationalization strategy mainly exerts positive impacts on R&D in companies in strategic emerging industries. More changes in overseas and domestic sales cause greater changes in R&D input. In addition, compared with domestic revenues,

changes in overseas revenues, which measure companies' internationalization, cause greater changes in R&D inputs ($0.030 > 0.022$). This further proves that in strategic emerging industries an internationalization strategy has an incentive effect on R&D input, and that changes in the degree of internationalization lead to changes in R&D input in the same direction.

In Models (3) and (4), the $\Delta\text{Export_Rate}$ of strategic industrial companies is positively related to the change in R&D input. The regression coefficient is 0.005, which is significant at the 5% level. In non-strategic industrial companies, changes in the proportion of overseas sales have no significant impacts on R&D input. This shows that in strategic industrial companies, greater changes in the proportion of overseas sales, which measure the degree of internationalization, cause greater changes in R&D input. Therefore, implementing internationalization strategies in strategic industrial companies have an incentive effect on R&D.

Compared with Models (5) and (6), changes in overseas sales have significant effects on strategic industrial companies' R&D. The regression coefficient of $\Delta\text{Overseas_Sales}$ is 0.022, which is significant at the 5% level. No significant impact is found in non-strategic industries. In addition, comparing Models (5) and (7) shows that an internationalization strategy has a more significant influence on R&D input in strategic emerging industries than in non-strategic emerging industries.

To comprehensively study the impact of an internationalization strategy on the independent innovation of strategic emerging industries, we further examine the impact of internationalization on patent output in strategic emerging industries. The results are shown in Tables 15 and 16.

Models (1) to (6) in Table 15 show that after controlling other variables such as $\text{RD_intensity}_{t-1}$ and $\text{RD_intensity}_{t-2}$, proxy variables of internationalization strategy such as Overseas_Sales , Export_rate and Overseas_Agency are significantly positively related to $\Delta\text{Patents}$ in both strategic emerging and non-strategic industries. The regression coefficients are 0.756, 0.182, 0.506 and 0.212, 0.521 and 1.062, respectively. This proves that internationalization can significantly improve entrepreneurial companies' patent outputs in both strategic and non-strategic emerging industries.

Comparing Models (1) and (4) shows that in strategic emerging industries, Overseas_Sales has a greater impact on patent output than domestic sales ($0.756 > 0.260$). In non-strategic industrial companies, Dome_Sales has a greater impact than Overseas_Sales on patent output ($0.571 > 0.212$). The results of Model (7) show that in strategic industrial companies, Overseas_Sales has a greater impact than Dome_Sales on patent output ($1.037 > 0.101$). The results illustrate that in strategic emerging industries, companies with higher degrees of internationalization have higher patent outputs. Thus, an internationalization strategy can enhance companies' patent outputs in strategic emerging industries.

In Table 16, the OLS model substitutes the Poisson model for further robustness testing. The regression results are substantially the same as those in Table 15, which further demonstrates that our results are robust. In summary, an internationalization strategy has more pronounced effects on the independent innovation input and efficiency of strategic emerging industries.

6. Conclusions and implications

Guided by the “going-out” strategy, Chinese enterprises have accelerated their pace of internationalization in recent years. We study how an internationalization strategy affects the independent innovation of Chinese entrepreneurial companies from two dimensions: R&D input and patent output. The main findings are outlined as follows.

First, a large number of ChiNext companies have implemented internationalization strategies and have actively expanded into overseas markets to earn foreign revenues.

Second, an internationalization strategy has a significant incentive effect on R&D input. Companies with higher degrees of internationalization have higher R&D inputs. After controlling for endogeneity, the incentive effect still exists.

Third, an internationalization strategy has significantly improved the efficiency of patent outputs. Companies with higher degrees of internationalization have higher patent output efficiencies.

Fourth, an internationalization strategy has more pronounced effects on independent innovation in strategic emerging industries.

Improving independent innovation capability and building a long-term competitive advantage are not only vital to the survival and development of China's companies, but also important to China's long-term economic development. An internationalization strategy is conducive to enhancing Chinese companies' independent innovation, regardless of R&D input or patent output. Therefore, Chinese entrepreneurial companies should clearly understand that an internationalization strategy is an important way to enhance independent innovation capacity. They must adhere to the going-out strategy, actively expand overseas markets, integrate global resources through various approaches such as exports and overseas investment and establish foreign institutions to enhance their independent innovation capacities. However, aside from encouraging and guiding companies to open up to the world, the government should vigorously promote the internationalization of strategic emerging industries to achieve industrial transformation and improvement.

From the two dimensions of R&D input and patent output, we provide empirical evidence that Chinese entrepreneurial companies' internationalization strategies influence their independent innovation. This study has two limitations. First, the ChiNext companies' sales data are not reported clearly or completely with respect to detail or regional division, making it difficult to confirm overseas sales in certain regions. Thus, we fail to study the influences of internationalization on innovation under the distribution of export regions. Second, the sample period used covers 2009 to 2012. Future studies should choose longer sample periods.

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