Asia-Pacific Journal of Accounting & Economics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/raae20

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To cite this article: Dengjun Zhang (2021): Impacts of credit constraints on innovation propensity and innovation performance: evidence from China and India, Asia-Pacific Journal of Accounting & Economics, DOI: 10.1080/16081625.2021.1872033

To link to this article: https://doi.org/10.1080/16081625.2021.1872033

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Published online: 07 Jan 2021.

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ASIA-PACIFIC JOURNAL OF ACCOUNTING & ECONOMICS
https://doi.org/10.1080/16081625.2021.1872033

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Impacts of credit constraints on innovation propensity and innovation performance: evidence from China and India

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ABSTRACT

In the literature, researchers generally focus on the impact of credit constraints on innovation activities as a whole. In this study, we investigated how a firm's financial status affects its adoption of product, process, or organizational innovations and the contribution of the individual innovation activities to innovation performance. Our empirical results indicate that financial constraints restrain Chinese firms' engagement in all types of innovation, reduce Indian firms' motivation to engage in product innovation, and force Indian firms to undertake organizational innovation. Consistency between the impacts of financial status on innovation propensity and innovation performance is further discussed.

ARTICLE HISTORY
Received 4 March 2020
Accepted 26 November 2020

KEYWORDS
Credit constraints; innovation; China; India; manufacturing

1. Introduction

According to UNIDO (United Nations Industrial Development Organization) (2017), global manufacturing value added (MVA) more than doubled between 1990 and 2016. During this period, the share of developing countries in global MVA increased from 21.7% to 44.6%, due to manufacturing-led development strategies adopted by many developing countries. The manufacturing sector directly contributes to economic growth and further fuels productivity gains in other economic sectors (Hong et al. 2016; Hallward-Driemeier and Nayyar 2017). As the global economy saw fundamental changes during the last decades, there are no standard national or regional developing models. However, one essential element for manufacturing-led development is capacity, which needs to be upgraded to enhance value-added products and processes. In terms of manufacturing subsectors, the upgrading process leads to a sound industry structure, which is crucial for economic growth and development in developing countries. The updating process depends on firms' innovative activities such as product, process, and organizational innovations, which correspond to the types of upgrading singled out along the value chain, namely process, product, functional, and intersectoral upgrading (Giuliani, Pietrobelli, and Rabellotti 2005).

Firms in developing and emerging countries are typically constrained by limited financial resources, which prevents them from undertaking innovative activities to upgrade their existing facilities (Almeida, Campello, and Weisbach 2004; Bellone et al. 2010; Chen, Hua, and Boateng 2017). In financing hierarchy models, the availability of internal funds and external capital determines firms' capability to undertake desirable investment (Fazzari and Petersen 1988), for the reasons of the information asymmetry between management and investors (Myers and Majluf 1984) and the lack of collateral value (Arrow 1972). Limited access to finance hampers all kinds of investment projects. Of these, innovative activities are more sensitive to financial frictions because

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of asymmetric information and lack of collateral value (Brown, Martinsson, and Petersen 2012; Gorodnichenko and Schnitzer 2013).

Researchers generally focus on the impact of credit constraints on innovative activities as a whole (Savignac 2008; Crisóstomo, López-Iturriaga, and Vallelado 2011). The effect of credit constraint conditions on the propensity to innovate may vary by the type of innovation. This is further related to the different roles that various innovative activities play in firms' operations and management (Damanpour, Walker, and Avellaneda 2009; Camisón and Villar-López 2014). Moreover, firms' motivation to invest in innovative activities is probably subject to the possible outcomes of these activities. Credit constraints further affect the intensity of innovation investment and innovative performance (Savignac 2008; Crisóstomo, López-Iturriaga, and Vallelado 2011; Gorodnichenko and Schnitzer 2013). Financial status may affect innovation propensity and innovative performance in different ways, since the merchandising of innovative products relies on the level of innovativeness and market demand for innovative products.

The purpose of this paper is to investigate the impact of manufacturing firms' access to credit on their adoption of innovative activities and on innovation success. We hypothesize that innovation activities (new products, new processes, and organizational innovation) are linked to a firm's financial constraint condition and that limited access to financing reduces the economic performance of innovation. Following the literature (Laursen and Salter 2006; Fu, Hou, and Liu 2018; Haus-Reve, Fitjar, and Rodríguez-Pose 2019), innovation success is measured as a firm's share of new product sales over its total sales.[1] Additionally, we also examine the impact of innovative activities on total turnover, which likely reflects the general impact of innovation on firms' overall performance. The sample is composed of manufacturing firms in China and India. China and India are neighboring countries and have experienced remarkable growth in recent decades; however, they differ in their level of development, manufacturing industry composition, and particularly innovative activities (see Section 3). For example, China and India utilize different processes of innovation and differ in their levels of integration into global innovation networks (Kennedy 2016). Thus, our empirical results from the two countries reveal the probability of generalizing the empirical findings to other institutional setups or national contexts.

This study contributes to the literature in several ways. First, instead of focusing on innovative activities as a whole, we test the impact of credit constraints on individual innovation activities. Researchers have examined complementarities between different types of innovation and the effectiveness of combinatorial strategies (Guan and Ma 2003; Hagedoorn and Wang 2012; Ballot et al. 2015). Credit-constrained firms may allocate their limited financial resources to innovative activities, according to the complementary relationships between them. Second, we investigate how credit constraints affect innovation propensity and innovative performance and how they correlate with each other. Few studies have explored the consistencies between the impacts of credit constraints on the propensity and the outcomes of innovation activities. This is relevant to policy implications. Government support programs may seek to encourage firms to engage in innovations typically constrained by financial status, as far as their contributions to firms' innovative performance and the overall financial performance go. Third, the cases studied are manufacturing firms in China and India, which account for a substantial share of products and MVA generated by all developing countries (Lema and Lema 2012; UNIDO (United Nations Industrial Development Organization) 2017). Although China and India are neighboring countries, they differ in their level of development, manufacturing industry composition, the liberality of internal and external financing, and innovative activities. The empirical findings based on the two sample countries reveal the robustness of the hypothesis tests, from which policy implications are then derived.

Our empirical and analytical results suggest that credit constraints lead to low engagement in all types of innovation for Chinese firms and low engagement in product innovation for Indian firms. In India, the odds of undertaking organizational are higher when firms have poor financial status. Limited access to financing reduces the contribution of organizational innovation to innovative performance in Chinese firms. For Indian firms, only process innovation is positively associated

with new product sales, irrespective of financial status. The empirical findings indicate the consistency between the impacts of credit constraints on innovation propensity and on firm performance.

The paper is structured as follows. In Section 2, we discuss the literature on credit constraints and innovation, from which the hypotheses are presented. This is followed in Section 3 with some notes on the national context as it pertains to financial markets and innovations. Section 4 describes the data and provides measures of innovation and credit constraints. In Section 5, the empirical models are outlined. The econometric results are then presented in Section 6. Finally, we summarize the main findings and implications of this study in Section 7.

2. Credit constraints and innovation

Investment spending depends on financial factors such as the availability of internal funds and external capital, as well as the functioning of credit markets. In financing hierarchy models, the availability of internal funds and external capital determines firms' capability to undertake desirable investment (Fazzari and Petersen 1988). The impact of financial constraints on investment decisions is further attributed to the information asymmetries between management and investors, since new investment is generally underpriced by investors who are aware of their relative 'ignorance' (Myers and Majluf 1984). Motivated by the fundamental theory about the relationship between financing and investment, researchers have provided theoretical contributions to the relationship between financing constraints and innovation activities. The lack of external financing sources may drain internal funds, which are an important determinant of innovation, such as R&D (Himmelberg and Petersen 1994). Although financial constraints limit all kinds of desirable investment projects, innovation is generally more susceptible to liquidity because of asymmetric information and a lack of collateral value (Arrow 1972; Brown, Martinsson, and Petersen 2012). The impact of financial constraints on innovative outcomes is further explored by Gorodnichenko and Schnitzer (2013), who assumed a two-stage innovation financing. While in stage one, firms rely on internal funds, they turn to external finance in stage two, in the case of a drain of liquidity. Therefore, the limited access to external finance may mainly constrain the success in commercializing innovative activities.

In tandem with the theoretical literature, researchers have attempted to empirically explore how credit constraints affect innovation investment (Bigsten et al. 2003; Savignac 2008; Crisóstomo, López-Iturriaga, and Vallelado 2011; Altomonte et al. 2016), but with different innovation classifications and different modeling techniques. In general, researchers have explored the impact of credit constraints on innovation activities as a whole. Additionally, innovation studies typically examine the impacts of credit constraints on the propensity to innovate and innovation performance separately.

2.1. Credit constraints and the propensity to innovate

Researchers generally focus on the impact of credit constraints on the likelihood of undertaking innovative activities as a whole. For example, Savignac (2008) used French firm-level data to explore how financial status affects the propensity to innovate. In his study, the financial constraint condition was identified according to survey questions about financing resources, processes of financing establishment, and interest rates. Unlike Savignac (2008), Crisóstomo, López-Iturriaga, and Vallelado (2011) defined innovation as innovation stock used in innovative activities and R&D and tested how firms' credit conditions influence innovation stock. Although Savignac (2008) and Crisóstomo, López-Iturriaga, and Vallelado (2011) used different measures of innovation, they provided evidence of the negative impact of financial status on innovative activities as a whole.

The effect of credit constraint conditions on the propensity to innovate may vary by innovation activity. This is further related to the different roles that various innovative activities play in firms'

operations and management. For example, unlike new products and new processes, which influence a firm's technological and operational systems, organizational innovation refers mainly to management systems (Damanpour, Walker, and Avellaneda 2009; Camisón and Villar-López 2014). Moreover, due to their different features, innovation activities respond differently to organizational factors (Damanpour, Walker, and Avellaneda 2009). Firms' financial status is probably a factor with various influences on innovation activities. Credit-constrained firms may invest in new products to improve liquidity. On the other hand, firms may be required by financial institutions to undertake organizational innovation for better corporate governance.

Some studies confirmed that innovation activities respond differently to financial status. For Eastern and Central European countries, an increase of one standard deviation in the severity of financial constraints lowers the probability of successful new product innovation by 16% and the probability of adopting new technology by 22% (Gorodnichenko and Schnitzer 2013). Companies in Chile and Peru tend to invest in marketing innovation to enhance production performance when they face binding financial constraints and tend to increase innovation sources and process innovation when they perceive fewer financial barriers (Pérez et al. 2019).

The relationship between different types of innovation is probably another reason explaining why the impacts of financial status on the propensity to innovate (and innovative performance) are likely dependent on innovation type. A large number of studies have investigated the complementarities between different types of innovation (Guan and Ma 2003; Hagedoorn and Wang 2012; Ballot et al. 2015; Zhang and Xie 2020). The presence of complementarities between different innovations and firms' various allocation strategies for innovation resources indicate that the impacts of credit constraints on innovation propensity may depend on the type of innovation.

Based on the above discussion, we first establish the following hypothesis.

Hypothesis 1 **(H1)**. Limited access to financing reduces the likelihood of undertaking innovation activities, and the impacts vary across different types of innovation.

2.2. Credit constraints and innovative performance

Credit constraints affect productivity through their influence on innovation investment (Jin, Zhao, and Kumbhakar 2019). Gorodnichenko and Schnitzer (2013) documented the negative impact of financial constraints on the propensity to innovate and on total factor productivity (TFP). A similar relationship was found by Altomonte et al. (2016), who revealed a mutual causal-relationship between financing constraints and TFP. However, Gorodnichenko and Schnitzer (2013) and Altomonte et al. (2016) did not reveal how financial status affects innovation, subsequently affecting TFP. Different from the above citations, Coad, Pellegrino, and Savona (2016) tested the impact on the productivity of financial barriers to innovation. They divided financial barriers into financing costs and the availability of financing and documented a negative effect of financial/cost obstacles to innovation on firms' productivity.

Aside from productivity, new product sales are widely used as a proxy for innovation performance in the literature (Cassiman and Veugelers 2006; Liu and Buck 2007; Girma, Gong, and Görg 2008; Guariglia and Liu 2014; Haus-Reve, Fitjar, and Rodríguez-Pose 2019). New product sales are directly related to the outcome of product innovation and reveal firms' success in commercializing innovative activities (Laursen and Salter 2006). Product innovation is the most used measure of firms' innovative performance (Guariglia and Liu 2014). New product sales explicitly reflect the market acceptance of innovation outcomes (Liu and Buck 2007). After new products are launched on the market, customers become the crucial factor affecting the success of new products (Dziallas and Blind 2019). Selling new products requires sufficient liquidity to enter into new markets, build up/update the supply chain, and undertake marketing programs. We therefore make the following hypothesis.

Hypothesis 2 **(H2)**. Limited access to financing reduces new product sales, a measure of innovation performance.

The innovation performance of new products depends on other innovative activities and complementarities between them (Pérez et al. 2019). Organizational innovation is a necessary precondition for a firm to profit from innovative products and processes. Changes in a firm's technological system require organizational innovation to meet the requirements of the new technological system, in line with the socio-technical system theory (Azar and Ciabuschi 2017). The use of new products requires changes in production processes. Complementarities between innovative products, processes, and organizational innovations are tested directly in the literature (Ballot et al. 2015) or are investigated regarding their impacts on firm performance (Guan and Ma 2003). In particular, organizational innovation, as a non-technological innovation, generally affects firm performance through its interaction with other technological innovations (Ballot et al. 2015). The existence of complementarities between l innovation activities indicates a positive impact of processes and organizational innovations on new product sales, which may be affected by firms' financial status.

When assessing the credit constraints–innovation performance relationship, the interactions between financial status and each of the process and organizational innovations reveal how financial status affects the contribution of these types of innovation to innovation performance. In cases where other innovations are positively associated with new product sales, a lower level of credit access may negatively affect this relationship. This expectation is expressed in the third hypothesis:

Hypothesis 3 **(H3)**. Limited access to financing reduces the contribution of process and organizational innovations to new product sales.

Hypotheses 1, 2, and 3 are of primary concern in this study. In addition, innovative activities may affect sales of the normal products through a spillover effect from innovative products. Cassiman and Veugelers (2006) focused on innovative performance rather than overall firm performance and argued that overall performance is likely subject to other sources of firm heterogeneity. The survey data used in this study provide a large number of firm characteristics that control well for firm heterogeneity. We therefore also test how credit constraints affect the contribution of innovation to overall performance.

3. Some notes on China and India

China and India account for a substantial share of manufacturing products and MVA generated by all developing countries (Lema and Lema 2012; UNIDO (United Nations Industrial Development Organization) 2017). In 2015, China's share of the global MVA was 23.46%, while India's was 3.25%. The share of medium-high-tech and high-tech MVA of the country's total MVA is close for China (41.4%) and India (37.9%). Between 2000 and 2016, the average annual growth rate of MVA was 10.3% for China and 7.9% for India. China and India's rapid economic growth is attributed to manufacturing-led development strategies and innovation initiatives (Altenburg, Schmitz, and Stamm 2008; Hong et al. 2016). The intensive development of private firms through a deepening of internal innovation capabilities fuels economic growth in China and other developing countries (Wang et al. 2018). However, development strategies and innovation types differ between these two countries, as do financial markets and firms' operation decisions (Bruche 2009; Quazi and Tandon 2011).

In China, household savings are mainly allocated to State-Owned Enterprises (SOEs) rather than private firms, which results in an increasing number of credit-constrained private firms (Cubizol 2018). Chinese banks are primarily state-owned or partially state-owned and adopt a restrictive credit policy toward private firms (Jin, Zhao, and Kumbhakar 2019). Additionally, the rapid development of bond and stock markets in China provides financial resources for SOEs and large firms. Howell's (2016) empirical results demonstrate that lower access to liquidity reduces the intensity of private firms' innovative activities in China and negatively affects their innovation success. Aside from external finance, internal financing can represent a barrier to innovation, especially for small Chinese firms with sole proprietorship (Guariglia and Liu 2014). However,

Chinese firms with foreign ownership are less likely constrained by access to financing and more likely to engage in innovation activities (Girma, Gong, and Görg 2008).

Since the 1990s, India has undergone market-oriented reforms aimed at liberalizing internal and external financing and allowing firms greater flexibility to make investment decisions and choose their capital structure (Ganesh–Kumar, Sen, and Vaidya 2001). This implies that bank loans have become less available to innovative young firms and that firms more efficiently reallocate financial resources into innovative activities and other investments. Sundaram (2015) used data on small Indian firms and found that the presence of bank branches spurs economic activity and innovation. In India, the ratio of the gross expenditure of innovative inputs such as R&D to GDP has been stagnant since the nineties due to insufficient access to financing (Sasidharan, Lukose, and Komera 2015), which further negatively affects the innovation–performance relationship.

Although China and India are neighboring countries and have experienced remarkable growth in recent decades, they differ in their level of development, manufacturing industry composition, the liberality of internal and external financing, and innovative activities. In general, China has been focusing on industry sectors with competitive advantages in the global market and has stepped up efforts toward foreign direct investment inflows; India, however, has emphasized service-producing industries rather than low-wage manufacturing (Bosworth and Collins 2008). As pointed out by Altenburg, Schmitz, and Stamm (2008), China has been more integrated into the global market and has had a higher level of industrial development; India, on the other hand, has ranked highly on the Global Competitiveness Index, indicating an advanced private business sector. Aside from innovative inputs by domestic firms in China and India, multinational companies (MNCs) are transferring business R&D into these two countries. Technology spillovers from MNCs to local firms may enhance their innovation performance (Liu and Buck 2007). While the MNC R&D is more market-seeking in China in line with China's growing market scale, it is more resource-seeking in India for the purpose of using talents and technologies to support the global value chain (Bruche 2009). This generates differences in innovation types between MNCs in the two countries. For example, the market-oriented R&D inputs of MNCs in China are associated with new product development targeting the local markets.

Compared to China, the equity market in India is relatively thin, and the corporate bond market is substantially underdeveloped. In the process of liberalizing the financial market, China is more attractive to foreign investors than India (Quazi and Tandon 2011), which reflects a perceived difference in firms' access to financing in the two countries.

4. Data and measurement

The World Bank Enterprise Surveys (Enterprise Surveys 2019) provide the firm-level data for China (the 2012 wave) and India (the 2014 wave).[2] The surveys employ a stratified sampling methodology (by firm size, sector, and geographic region within a country) to collect representative data on business environments as well as performance measures for private firms in developing countries. The survey data have been widely used in the literature to explore firms' innovative activities and their credit constraint condition (Deininger and Mpuga 2005; Krkoska and Robeck 2008; Kenny 2009; Gorodnichenko and Schnitzer 2013; Hansen and Rand 2014a, 2014b; Zhang and Xie 2020).

The sample consists of 1,693 manufacturing firms for China, with an eligibility rate at the value of 64.0% under strict assumptions and 90.1% under weak assumptions.[3] For India, the eligibility rate of the wave is 76.5% under strict assumptions and 90.6% under weak assumptions. For India, a separate innovation follow-up survey was conducted with a target share of 75% of the originally surveyed firms, resulting in an estimation sample of about 2,691 manufacturing firms. The share of small, medium-sized, and large firms is respectively 12.8%, 40.5%, and 46.7% for China, and 27.2%, 45.9%, and 26.9% for India (see Table 2 for sample disposition by firm characteristics).[4]

4.1. Innovation

For manufacturing firms, Giuliani, Pietrobelli, and Rabellotti (2005, p. 550) defined upgrading as 'the capacity of a firm to innovate to increase the value added of its products and processes.' They further summarized four types of upgrading along the value chain: product upgrading, process upgrading, function upgrading, and intersectoral upgrading. Product and process upgrading are related to product innovation and process innovation, which are further consistent with the conceptual typologies of innovation such as radical versus incremental innovations and product versus process innovations (Damanpour, Walker, and Avellaneda 2009; Cassiman, Golovko, and Martínez-Ros 2010; Azar and Ciabuschi 2017). Functional upgrading denotes the acquisition of new and superior functions in an internal organization and along the supply chain. Intersectional upgrading refers to product structure. Organizational innovation contributes, at least partly, to manufacturing firms' functional and intersectional upgrading. As with integrated elements of firm updating, innovative products and processes require changes in internal organization for a successful implementation of technological innovations (Azar and Ciabuschi 2017).

The survey question about new product innovation is, 'In the last three years, has this establishment introduced new products or services?' The survey question on whether a firm has introduced new or significantly improved methods of manufacturing or not over the last three years is an indicator of new process innovation. Organizational innovation is assessed by the survey question 'During the last three years, has this establishment introduced any new or significantly improved organizational structures or management practices?' in the Indian survey, with a similarly worded version in the Chinese survey.[5] The measure of cumulative adoption of innovations is widely used in the literature, as it allows firms with the required competencies to improve their financial performance (Damanpour, Walker, and Avellaneda 2009). For example, Cassiman and Veugelers (2006) defined innovation performance as sales of new products introduced in the past two years. Another advantage of this measure is that we can avoid the problem of endogeneity between innovative activities and financial performance when estimating the model.

4.2. Measuring credit constraints

Since credit constraints are not directly observable, researchers reply on various indirect measures (Savignac 2008; Crisóstomo, López-Iturriaga, and Vallelado 2011; Gorodnichenko and Schnitzer 2013; Wagner 2014; Farre-Mensa and Ljungqvist 2016). Taking the data features into account and following previous studies (Bigsten et al. 2003; Hansen and Rand 2014b; Zhang 2020), we measure firms' financial status according to whether they have applied for a bank loan and the results of the loan application.[6] Loan applications indicate a demand for external financing, and the rejection of an application implies credit constraints faced by firms.

The measure of credit constraints is based on two survey questions: 'Referring only to this most recent application for a line of credit or loans, what was the outcome of that application?' and 'What were the main reasons why this establishment did not apply for any line for credit or loan?' Thus, firms were divided into two groups: one group that had applied for loans and another that had not. Firms were considered credit constrained if (1) they were in the first group but their most recent loan application had been rejected or (2) they belonged to the second group and they had not applied for a loan for the reasons of 'application procedures were complex,' 'collateral requirements were too high,' or 'size of loan and maturity were insufficient.' Firms were not treated as credit constrained if they had not applied for a loan for the reason of 'interest rates were not favorable' or 'did not think it would be approved,' which reflect a low return of investment relative to interest rates and hence no demand for external funds (Bigsten et al. 2003).

Hansen and Rand (2014b) criticized the view that different measures of credit constraint condition may affect empirical findings. They argued that whether a firm used informal financial services or not is another indicator of financial status. The use of informal financial resources

indicates the unavailability of internal and external funds, which likely affects firms' investment in innovation and other operational activities. Accordingly, firms that are not classified as constrained by credit access but have used informal financial services for the purchase of fixed assets or working capital are considered credit-constrained.

(Table 1) shows that 999 out of 1,693 Chinese sample firms are constrained by access to financing and that 2,255 out of 2,691 Indian firms are credit-constrained, i.e., 59.0% for China versus 83.8% for India. Regarding firm size measured by annual sales in local currency units (LCU), the unconstrained Indian firms are much larger than the constrained firms, .i.e., 1,134 million versus 559 million LCU for China and 259 million versus 169 million LCU for India.

4.3. Innovation and credit constraints

(Table 1) also summarizes the forms of innovative activities undertaken by credit-constrained and credit-unconstrained firms, as well as the average annual sales and sales share of new products. In terms of the number of firms (the second column in Table 1), Chinese unconstrained- and constrained-firms are more likely to undertake process innovation. In India, product innovation is the most frequently adopted innovation for credit-unconstrained firms; for credit-constrained firms, it is process innovation. We further calculated the share of firms with various innovative activities for the constrained and unconstrained firm groups. For each of the three innovations with the exception of organizational innovation in India, the share of unconstrained firms is higher than the corresponding share for constrained firms.

For each firm group classified by the type of innovation undertaken, total sales for credit-unconstrained firms are larger than those for credit-constrained firms, with a much larger gap for Indian firms. The sales share of new products directly measures the outcome of innovative activities and explicitly accounts for firm size proxied by sales. Of firms with new products, Chinese credit-constrained firms have a greater sales share of new products than Chinese credit-unconstrained firms (25.9% versus 21.4%); the opposite is true for India (9.48% versus 12.7%). Of firms with process innovation, credit-constrained firms have a smaller sales share of new products than credit-unconstrained firms for both China and India. Regarding firms with organizational innovation, while Chinese credit-constrained firms have a smaller sales share of new products than Chinese credit-unconstrained firms (14.5% versus 16.0%), Indian credit-constrained firms have

Table 1. Sample distribution, firm sales, and new product sales.

Firm type	Firm number	Average sales (mil. LCU)	Average sales share of new products (%)
	China		
Credit unconstrained firms	694	259	12.6
with product innovation	408	352	21.4
with process innovation	544	280	14.9
with organizational innovation	417	379	16.0
Credit constrained firms	999	169	9.45
with product innovation	364	178	25.9
with process innovation	535	223	14.2
with organizational innovation	365	225	14.5
Whole sample	1693	206	10.7
	India		
Credit unconstrained firms	436	1134	10.3
with product innovation	299	1446	12.7
with process innovation	275	1206	11.9
with organizational innovation	212	896	8.71
Credit constrained firms	2255	559	
with product innovation	1340	695	9.48
with process innovation	1394	670	9.86
with organizational innovation	1278	625	9.84
Whole sample	2691	653	9.61

Notes: LCU means local currency units, i.e., Yuan for China and Rupee for India.

Table 2. Variable definitions and descriptive statistics.

		China		India	
Variable	Definition	Mean	SD	Mean	SD
New-Product	Dummy variable (= 1 for firms with new products, and 0 otherwise)	0.456	0.498	0.609	0.488
New-Process	Dummy variable (= 1 for firms with new products, and 0 otherwise)	0.637	0.481	0.620	0.485
Organizational	Dummy variable (= 1 for firms with new products, and 0 otherwise)	0.462	0.499	0.554	0.497
Sales (in logarithm)	The value of sales in Yuan for China and Rupee for India	16.91	1.674	18.068	1.953
Share (in %)	Sales share of new products over total turnover	10.73	17.57	9.614	21.39
Credit-Constraints	Dummy variable (= 1 for constrained firms, and 0 otherwise)	0.590	0.492	0.838	0.369
Size-Medium	Dummy variable (=1 for firms with employee numbers: ≥20 and ≤99, and 0 otherwise)	0.405	0.491	0.459	0.498
Size-Large	Dummy variable (=1 for Employee numbers: ≥100, and 0 otherwise)	0.467	0.499	0.269	0.444
High-tech	Dummy variable (= 1 for firms under the Standard Industrial Classification (SIC): 23–35), and 0 otherwise)	0.696	0.460	0.709	0.455
Firm-Age	Firms age in number of years	14.07	8.257	20.09	14.74
Foreign-Ownership	Dummy variable (=1 Firms with foreign investors, and 0 otherwise)	0.074	0.262	0.010	0.102
Group	Dummy variable (= 1 for firms that are part of a larger establishment, and 0 otherwise)	0.112	0.315	0.768	0.422
Export-Experience	Years since this establishment started exports	3.171	5.211	2.953	6.907
Manager-Experience	Manager experience in years	16.94	7.564	14.68	9.583
Worker-Skilled (in %)	Percentage of skilled production workers	44.18	24.87	64.03	21.53
Worker-Education (in %)	Percentage of workers who completed secondary school	50.45	27.81	49.33	29.05
Over-Competition	Dummy variable (= 1 for firms with competitors: 'too many to count', and 0 otherwise))	0.654	0.476	0.380	0.486
Location: Big-City	Dummy variable (= 1 for city with population over 1 million, and 0 otherwise)	0.982	0.132	0.326	0.469

a greater sales share of new products than Indian credit-unconstrained firms (9.61% versus 10.7%). Above all, there exists heterogeneity between Chinese and Indian manufacturing firms regarding the correlation between credit constraints and the adoption of innovative activities and between credit constraints and the economic performance of these activities.

5. Econometric methods

5.1. Model A: innovation propensity (H1)

When testing the impact of credit constraints on firms' decision to invest in innovation or not, a binary logit model is an appropriate approach. The logit model is represented by the following equation:

$$Innovation_i = \begin{cases} 1 \ \text{iff} Innovation_i^* > 0 \\ 0 \ \text{iff} Innovation_i^* \leq 0 \end{cases} \quad (1)$$

$$\Pr(Innovation_i = 1 | \mathbf{X}_i) = \varphi(Z_i) \quad (2)$$

where $Innovation_i^*$ is a latent variable for *New-Product, New-Process*, and *Organizational* innovation, one at a time; $Innovation_i$ is a dummy variable that equals one (and hence $Innovation_i^* > 0$) for firm i with a kind of innovation and zero otherwise; X represents a vector of control variables. $\Pr(Innovation_i = 1)$, conditional on the vector of the explanatory variables X being $\varphi(Z_i)$, is

a logistical distribution function with a range between zero and one. The specification of Z_i is a linear function of a dummy variable for credit constraints and other control variables. This gives:

$$Z_i = \delta' X_i + a_1 Credit\_Constraints_i + u_i \tag{3}$$

where the dummy variable, *Credit-Constraints*$_i$, equals one for firms constrained by access to financing and zero otherwise, and u_i is the error term.

The logistical distribution probability is:

$$\varphi(Z_i) = \frac{e^{Z_i}}{1 + e^{Z_i}} \tag{4}$$

Using the definition of the logistic distribution, we obtain log (odds ratio) = Z_i. Thus, the natural exponent of the coefficient is explained as changes in the odds ratio in response to a one-unit change in the explanatory variable, *ceteris paribus*. When explaining the estimated parameters of the logit model, we follow the common practice in the literature and compute the marginal effect of the determinants. The marginal effect directly represents changes in probability when the covariate increases by one unit (from zero to one for dummy variables).

5.2. Model B: new product sales (H2 and H3)

Using the ordinary least squares (OLS) approach to estimate the model for the share of new products (*Share*, in percentage points) may generate a biased estimate, since the dependent variable, *Share*, is censored at 0 and 100, resulting in a violation of the normality assumption. Accordingly, this tobit model is applied to estimate the impact of innovative activities on *Share*. This is:

$$Share_i = \begin{cases} 0 & \min \\ Share_i^* & \text{if } 0 < Share_i^* < 100 \\ 100 & \max \end{cases} \tag{5}$$

$$Share_i = \eta' X_i + b_1 New\_Process_i + b_2 Organizational_i + b_3 Credit\_Constraints_i + v_i \tag{6}$$

where $Share_i^*$ is a latent variable; $Share_i$ denotes the share of new products out of total sales, in percentage points; v_i is the error term. The innovation variables are dummies taking one for firms with a particular innovation and zero otherwise.

We further investigated the impacts of new processes and organizational innovation on *Share*. The basic specification of Model B is modified by adding *New-Process* and *Credit-Constraints* for one regression and *Organization* and *Credit-Constraints* for the other.

5.3. Model C: total sales

Next, we examine how a credit constraint condition affects the impact of innovation on firms' total turnover, which measures overall firm performance. We used the OLS regression to estimate the model with the following basic specification:

$$\begin{aligned} \log(Sales_i) = {} & \theta' X_i + c_1 New\_Product_i + c_2 New\_Process_i + c_3 Organizational_i \\ & + c_4 Credit\_Constraints_i + o_i \end{aligned} \tag{7}$$

where log represents the logarithm function; the variable, *Sales*, represents total turnover in local currency unit; o_i is the error term.

In order to test the interaction effect between innovation and credit constraints, we add interaction terms to the basic model, one at a time. This leads to three regressions responding to the three types of innovations.

Table 3. Correlation matrix.

Variable	Credit-Constraints	New-Product	New-Process	Organizational	Share	Sales
			China			
Credit-Constraints	1					
New-Product	−0.221	1				
New-Process	−0.254	0.424	1			
Organizational	−0.232	0.327	0.322	1		
Share	−0.088	0.667	0.289	0.242	1	
Sales	−0.204	0.184	0.135	0.255	0.091	1
			India			
Credit-Constraints	1					
New-Product	−0.069	1				
New-Process	−0.010	0.283	1			
Organizational	0.060	0.227	0.423	1		
Share	−0.014	0.125	0.034	0.003	1	
Sales	−0.103	0.152	0.125	0.059	0.086	1

5.4. Control variables

To examine the nexus between financial constraints and innovation, we need to controls for firm heterogeneity, which may affect both the propensity to undertake innovative activities and innovative performance. The survey data include a large number of firm characteristics and other factors, which affect both firms' financial performance and investment behavior (Gorodnichenko and Schnitzer 2013).

Regarding innovation investment, a firm's basic features, such as its number of employees (*Firm-Medium* and *Firm-Large*) and the age of the firm (*Firm-Age*) directly affect the need for innovative activities. High-tech firms (*High-Tech*) are more likely to invest in innovations. Firms with foreign shareholders (*Foreign-Ownership*) are probably less risk-averse and are more motivated to undertake value-enhancing investments than firms with solely domestic ownership. The control variable *Export-Experience* is measured in years of exporting, which influences both innovation and financial performance. Firms that belong to a larger establishment (*Group*) may have internal financial resources for investment. While managers' experience levels (*Manager-Experience*) affect their choices of innovative types, the ability to implement innovative activities depends on the capability and education of employees (*Worker-Skilled* and *Worker-Education*). A firm's location (*Big-City*) affects the demand for innovation and the supply of innovative inputs. The demand for innovation is further strengthened when the firm competes with many market competitors (*Over-Competition*).

A list of the variables used in the analyses and descriptive statistics is presented in (Table 2). For dummy variables, the mean is the share of firms with the characteristics out of the total number of firms. For example, 45.6% of Chinese firms invested in new product innovation; for India, the counterpart is 60.9%. (Table 3) presents the pairwise correlation between *Credit-Constraints* and the dependent variables. For both China and India, the variable *Credit-Constraints* is negatively correlated with the three innovative activities, innovation performance, and total sales. The pairwise relationships between *New-Product* and *New-Process* and between *New-Product* and *Organizational* are stronger for China than for India; the opposite is true for the relationship between *New-Process* and *Organizational*.

6. Estimation results

6.1. Univariate t-test results

Before presenting the estimation results, we report test results of the mean difference of all variables classified by credit-constrained and credit-unconstrained firm groups. (Table 4) also presents the summary statistics of all variables.

Table 4. Mean difference test of variables for unconstrained and constrained firms.

	India					
	Mean of			Mean of		
Variable	Unconstrained firms	Constrained firms	Mean difference	Unconstrained firms	Constrained firms	Mean difference
New-Product	0.588	0.364	0.224	0.686	0.594	0.092
New-Process	0.784	0.536	0.248	0.631	0.618	0.013
Organizational	0.601	0.365	0.235	0.486	0.567	−0.081
Sales	17.32	16.63	0.695	18.53	17.98	0.546
Share	12.59	9.438	3.147	10.31	9.478	0.836
Size-Medium	0.375	0.426	−0.052	0.459	0.459	0.000
Size-Large	0.559	0.402	0.157	0.183	0.286	−0.102
High-tech	0.719	0.681	0.038	0.693	0.712	−0.019
Firm-Age (years)	14.98	13.44	1.543	20.42	20.03	0.388
Foreign-Ownership	0.098	0.057	0.041	0.025	0.008	0.018
Group	0.112	0.111	0.001	0.734	0.774	−0.040
Export-Experience	4.465	2.271	2.194	3.842	2.781	1.061
Manager-Experience	17.95	16.25	1.706	15.18	14.58	0.606
Worker-Skilled	42.82	45.13	−2.312	61.70	64.48	−2.785
Worker-Education	52.43	49.07	3.360	52.97	48.63	4.346
Over-Competition	0.575	0.709	−0.134	0.390	0.378	0.012
Location: Big-City	0.994	0.974	0.020	0.319	0.328	−0.009

Notes: ***, **, and * indicate significant at the 0.01, 0.05 and 0.10 level, respectively.

Between the two firm groups, the share of firms with innovative activities out of the number of firms in the respective group is significantly different for all three innovation types for China. For India, the share of unconstrained firms with innovative products is larger than its counterpart for constrained firms. In contrast, Indian credit-unconstrained firms are less likely to invest in organizational innovation, compared to Indian credit-constrained firms. The difference in the share of firms with innovative processes is insignificant for both constrained and unconstrained Indian firms. Credit-constrained firms have greater sales and a larger sales share of new products than credit-unconstrained firms in both China and India. The empirical question is whether differences in firms' engagement in innovation types and economic outcomes are related to differences in firm characteristics and other explanatory variables. As one sees in (Table 4), except for one explanatory variable in the Chinese model, the mean differences are all significant; for India, the mean difference for 7 out of 13 control variables is statistically significant. This indicates the need to incorporate these control variables in the models when testing the impact of credit constraints on firms' choices of innovative activities and the economic outcomes of these innovations.

6.2. Results of Model A

(Table 5) presents the estimation results (marginal effects) of Model A for China and (Table 6) for India. For China, *Credit-Constraints* is significant and negative in the three regressions, indicating that the likelihood of investing in the three types of innovation is lower for credit-constrained firms. Compared to credit-unconstrained firms, credit-constrained firms have a 20.0% lower probability of adopting product innovation; this is 23.1% for new processes and 18.8% for organizational innovation. In all, for Chinese manufacturing firms, all three innovative activities are negatively affected by credit constraints, with a tight reduction in probability.

The impact of credit constraints on Indian firms depends heavily on innovation type. A credit constraint condition negatively affects the adoption of new product innovation, does not affect new processes, and positively affects the engagement in organizational innovation. This indicates

Table 5. Estimation results of Model A for China.

Variable	Regression 1	Regression 2	Regression 3
Dependent variable	New-Product	New-Process	Organizational
Size-Medium	0.055	0.123 ***	0.1504***
	[0.0425]	[0.0358]	[0.0449]
Size-Large	0.1027**	0.1252***	0.2435***
	[0.0427]	[0.0374]	[0.0435]
High-tech	0.0508*	0.0255	0.0721**
	[0.0278]	[0.0267]	[0.0281]
Firm-Age	-0.003*	-0.0053***	0.0019
	[0.0017]	[0.0016]	[0.0018]
Foreign-Ownership	-0.009	0.0549	0.0828*
	[0.0501]	[0.0477]	[0.0513]
Group	0.2246***	0.0914**	0.1725***
	[0.0397]	[0.0370]	[0.0413]
Export-Experience	0.0107***	0.0046	0.007***
	[0.0027]	[0.0026]	[0.0027]
Manager-Experience	0.0016	0.006***	-0.0025
	[0.0018]	[0.0018]	[0.0018]
Worker-Skilled	0.0005	0.0012**	-0.0014***
	[0.0005]	[0.0005]	[0.0005]
Worker-Education	0.0008*	0.0005	0.0008
	[0.0005]	[0.0004]	[0.0005]
Over-Competition	0.0205	-0.0508**	-0.0381
	[0.0276]	[0.0261]	[0.0280]
Location: Big-City	-0.0352	-0.3086***	0.2461***
	[0.0986]	[0.0333]	[0.0879]
Credit-Constraints (CC)	-0.2003***	-0.2305***	-0.1883***
	[0.0259]	[0.0234]	[0.0262]
AIC	2198	2217	2149
Observations	1693	1693	1693

Notes: ***, **, and * indicate significant at the 0.01, 0.05 and 0.10 level, respectively. Standard errors are in parenthesis.

substitutability between new products and organizational innovations when an Indian firm faces barriers in obtaining loans.[7]

For the two countries, the *Credit-Constraints* variable has a negative and significant coefficient in the regression for product innovation; however, the reduction in the probability of undertaking new product innovation is much lower for Indian firms than for Chinese firms (8.06% versus 20.0%). The less prevalent impact of credit constraints on innovation in India may relate to firms' access to informal financial resources, which are widely used in less-developed financial markets.

The estimation results for the control variables further reveal differences between Chinese and Indian firms regarding firms' choices of innovation investment. For example, only in China are firms of medium and large size more likely to invest in innovative activities. High-tech firms in China prefer product innovation and organizational innovation, while high-tech firms in India are more interested in new processes and organizational innovation. This may reflect Indian firms' awareness about improving production efficiency.

6.3. Results of Model B

The estimated impacts of innovation and credit constraints on the sales share of new products (Model B) are reported in (Table 7) for China and (Table 8) for India.

For Chinese firms, as we see in the second column (Regression 1) of (Table 7), both *New-Process* and *Organizational* are significant and positive. This confirms a synergistic effect between new products and the other two innovations. The coefficient of *New-Process* is more than twice as large as that of *Organizational* (29.0 versus 12.1), indicating a high interaction effect between new products and new processes. The importance of process innovation is not subject to firms' credit

Table 6. Estimation results of Model A for India.

Variable	Regression 3		
Variable	Regression 1	Regression 2	Regression 3
Dependent variable	New-Product	New-Process	Organizational
Size-Medium	-0.0609**	0.0096	0.0658**
	[0.0264]	[0.0260]	[0.0268]
Size-Large	-0.1676***	-0.0863***	-0.0076
	[0.0308]	[0.0305]	[0.0311]
High-tech	0.0148	0.0354*	0.0408*
	[0.0217]	[0.0217]	[0.0226]
Firm-Age	-0.0001	0.0002	-0.0016**
	[0.0008]	[0.0008]	[0.0008]
Foreign-Ownership	0.2582***	0.2423***	0.1731**
	[0.0694]	[0.0709]	[0.0899]
Group	0.0069	-0.0871***	-0.203***
	[0.0250]	[0.0237]	[0.0234]
Export-Experience	0.0015	0.0055***	0.0036**
	[0.0016]	[0.0017]	[0.0017]
Manager-Experience	0.0025**	0.0041***	-0.0016
	[0.0011]	[0.0012]	[0.0012]
Worker-Skilled	0.0042***	0.0018***	0.0041***
	[0.0005]	[0.0005]	[0.0005]
Worker-Education	0.0009***	0.0009**	0.0016***
	[0.0004]	[0.0004]	[0.0004]
Over-Competition	-0.0494**	-0.1312***	-0.1354***
	[0.0208]	[0.0206]	[0.0214]
Location: Big-City	-0.1528***	-0.1928***	-0.1376***
	[0.0220]	[0.0219]	[0.0226]
Credit-Constraints (CC)	-0.0806***	0.0119	0.1024***
	[0.0257]	[0.0269]	[0.0281]
AIC	3380	3325	3386
Observations	2691	2691	2691

Notes: ***, **, and * indicate significant at the 0.01, 0.05 and 0.10 level, respectively. Standard errors are in parenthesis.

constraint condition, since its interaction with *Credit-Constraints* is insignificant, as shown in Regression 2. However, Regression 3 reveals that the impact of organizational innovation varies between firm groups regarding access to financing. The significant interaction term in Regression 3 implies that organizational innovation raises the sales share of new products much higher for credit-unconstrained firms than for credit-constrained firms.

For Indian firms, the estimation results in (Table 8) indicate that firms with new process innovation amplify the success of new product innovation, as the coefficient of *New-Process* is significant, with a value of 0.083. Credit constraint condition, as a stand-alone factor, does not affect the sales share of new products for Indian firms, in contrast to the findings for China. Financial status further does not affect the impact of new processes on the sales share of new products since the interaction term is insignificant in Regression 2. The individual *Organizational* in Regression 1 and its interaction with *Credit-Constraints* in Regression 3 are insignificant. Organizational innovation has no impact on new product sales for both credit-constrained and credit-unconstrained firms. A plausible reason for the results may be attributed to the lower radicalness of product innovation in India than in China. As we discussed above, China is more integrated into the global market and focuses on market-oriented R&D inputs, which implies a high radicalness of product innovation.

For control variables, we primarily focus on those that are significant in the three regressions. Compared to its small firms, India's large firms have a small sales share of new products. For China, large firms have a better innovation outcome in terms of new product sales than small firms when we control for the different impacts of process (and organizational) innovation on the innovation success of credit-constrained and credit-unconstrained firms (Regressions 2 and 3). For both China and India, foreign-owned firms do not have a higher sales share of new products than domestically

Table 7. Estimation results of Model B for China.

Variable	Regression 1	Regression 2	Regression 3
Dependent variable		Share	
Intercept	−36.2263***	−39.3886***	−17.2927**
	[8.2370]	[8.0603]	[7.9576]
Size-Medium	2.9449	4.2843	5.7693*
	[3.0603]	[3.0856]	[3.0723]
Size-Large	3.0182	5.6112*	5.4017*
	[3.1113]	[3.1205]	[3.1219]
High-tech	2.4519	3.2637*	2.3962
	[1.9473]	[1.9645]	[1.9848]
Firm-Age	−0.1734	−0.1266	−0.3346***
	[0.1205]	[0.1204]	[0.1239]
Foreign-Ownership	0.5788	1.1942	1.552
	[3.2535]	[3.2966]	[3.3461]
Group	6.6851**	8.0736***	7.7526***
	[2.6745]	[2.6983]	[2.7557]
Export-Experience	0.4807***	0.5468***	0.5768***
	[0.1730]	[0.1745]	[0.1780]
Manager-Experience	0.0206	−0.0093	0.1553
	[0.1236]	[0.1246]	[0.1259]
Worker-Skilled	−0.052	−0.0781**	−0.0051
	[0.0356]	[0.0357]	[0.0362]
Worker-Education	0.0674**	0.0762**	0.0712**
	[0.0322]	[0.0325]	[0.0329]
Over-Competition	0.3938	0.0227	−0.8774
	[1.8721]	[1.8881]	[1.9166]
Location: Big-City	−0.3009	3.2741	−7.9899
	[6.5729]	[6.6260]	[6.8213]
New-Process	28.9819***	34.074***	
	[2.2724]	[2.4718]	
Organizational	12.0864***		
	[1.8998]		21.9376***
Credit-Constraints (CC)	−1.5782		[2.2535]
	[1.8695]		
New-Process: CC		−2.3994	
		[2.0816]	
Organizational: CC			−5.5664**
			[2.5184]
Log-likelihood	−3251	−4095	−4000
Observations	1693	1693	1693

Notes: ***, **, and * indicate significant at the 0.01, 0.05 and 0.10 level, respectively. Standard errors are in parenthesis.

owned firms. Thus, our empirical findings do not support Gorodnichenko and Schnitzer (2013) proposition that foreign-owned firms innovate more intensively and hence have more significant innovation outcomes than domestically owned firms. For both countries, firms with long exporting histories have a higher sales share of new products. The share of skilled workers positively affects the sales share of new products for Indian firms, yet its impact in China is negative or null. The level of employee education is positively associated with new product sales for Chinese firms; however, it does not affect Indian firms. This reflects heterogeneity between the workers–innovation outcome relationships in the two countries.

6.4. Results of Model C

The estimated impacts of innovative activities and financial status on firm sales are presented in (Table 9) for China and in (Table 10) for India. The value of the adjusted R-squared ranges between 0.448 and 0.454 for China and between 0.461 and 0.465 for India, indicating a similar goodness-of-fit of the three regressions. Since the dependent variable is in a logarithmic scale, the estimated

Table 8. Estimation results of Model B for India.

Variable	Regression 1	Regression 2	Regression 3
Dependent variable		Share	
Intercept	−67.0585***	−65.68***	−62.992***
	[10.0554]	[9.3780]	[9.2731]
Size-Medium	0.5701	0.7821	0.5618
	[4.3300]	[4.3187]	[4.3224]
Size-Large	−13.5745**	−13.4249**	−14.2042***
	[5.3001]	[5.2843]	[5.2761]
High-tech	−1.2983	−1.2284	−1.2488
	[3.7287]	[3.7235]	[3.7235]
Firm-Age	−0.0981	−0.1023	−0.0941
	[0.1287]	[0.1286]	[0.1287]
Foreign-Ownership	12.4725	11.3117	14.1186
	[15.3728]	[15.4247]	[15.3388]
Group	−1.8027	−2.1175	−1.9693
	[4.1984]	[4.1561]	[4.1925]
Export-Experience	0.5941**	0.5889**	0.6267**
	[0.2559]	[0.2559]	[0.2555]
Manager-Experience	0.5717***	0.5601***	0.6063***
	[0.1928]	[0.1923]	[0.1921]
Worker-Skilled	0.2044**	0.2179***	0.2081**
	[0.0845]	[0.0835]	[0.0844]
Worker-Education	−0.0113	−0.0115	−0.0092
	[0.0634]	[0.0633]	[0.0634]
Over-Competition	1.075	0.9136	0.4639
	[3.6187]	[3.6045]	[3.6078]
Location: Big-City	−8.7382**	−9.1895**	−9.6516**
	[3.8988]	[3.8820]	[3.8686]
New-Process	8.3465**	12.4452**	
	[4.0650]	[5.9999]	
Organizational	2.6895		2.1784
	[3.9760]		[6.5836]
Credit-Constraints (CC)	0.9419		
	[4.6590]		
New-Process: CC		−3.6363	
		[5.6019]	
Organizational: CC			4.3239
			[6.3348]
Log-likelihood	−4359	−4359	−4361
Observations	2691	2691	2691

Notes: ***, **, and * indicate significant at the 0.01, 0.05 and 0.10 level, respectively. Standard errors are in parenthesis.

coefficient for a dummy variable represents percentage changes of the dependent variable for a one-unit change (from zero to one).

For China, the estimates from the basic specification (Regression 1) show that the sales of firms with product innovation are 11.8% greater than those of firms without this kind of innovation, indicating a spillover effect from new products to other products. Organizational innovation enhances firm sales by 22.7%. In contrast, new process innovation is not significantly associated with changes in firm sales. As expected, credit-constrained firms have 15.7% lower sales than credit-unconstrained firms. This is the average reduction for all firms, regardless of innovation adoption. Regressions 2–4 reveal the interaction effect of innovation and credit constraint conditions on firm sales. Both *New-Product* and its interaction with *Credit-Constraints* in Regression 2 are significant. The positive sign of *New-Product* and the negative sign of the interaction term indicate that new product innovation contributes at a higher rate to sales of credit-constrained firms than to sales of credit-unconstrained firms (24.9% versus 2.98%). This conclusion further applies to both new process innovation and organizational innovation. Although the coefficient of *New-Process* is not

Table 9. Estimation results of Model C for China.

Variable	Regression 1	Regression 2	Regression 3	Regression 4
Dependent variable		Sales		
Intercept	14.1295***	13.9943***	13.9803***	13.9947***
	[0.2999]	[0.2933]	[0.3009]	[0.2919]
Size-Medium	1.1336***	1.168***	1.159***	1.147***
	[0.0943]	[0.0948]	[0.0951]	[0.094]
Size-Large	2.4685***	2.5261***	2.519***	2.4855***
	[0.1016]	[0.1021]	[0.1025]	[0.101]
High-tech	0.2616***	0.2768***	0.2807***	0.2706***
	[0.0649]	[0.0652]	[0.0652]	[0.0649]
Firm-Age	0.012***	0.0123***	0.0125***	0.0111**
	[0.0046]	[0.0046]	[0.0048]	[0.0047]
Foreign-Ownership	−0.0209	5.00E-04	−0.002	−0.0182
	[0.114]	[0.1146]	[0.1144]	[0.1136]
Group	0.8519***	0.8694***	0.903***	0.8737***
	[0.1337]	[0.1329]	[0.1322]	[0.1334]
Export-Experience	0.0188***	0.0199***	0.0216***	0.02***
	[0.0068]	[0.0068]	[0.0068]	[0.0067]
Manager-Experience	0.021***	0.0208***	0.0205***	0.0213***
	[0.0044]	[0.0044]	[0.0044]	[0.0044]
Worker-Skilled	−0.0029**	−0.0034***	−0.0034***	−0.003**
	[0.0013]	[0.0013]	[0.0013]	[0.0013]
Worker-Education	−0.0007	−0.0007	−0.0006	−0.0007
	[0.0012]	[0.0012]	[0.0012]	[0.0012]
Over-Competition	−0.1073	−0.1257*	−0.1131*	−0.1051
	[0.069]	[0.0684]	[0.069]	[0.0685]
Location: Big-City	0.5037**	0.568**	0.576**	0.54**
	[0.2424]	[0.2466]	[0.2504]	[0.2446]
New-Product	0.1176*	0.323***		
	[0.0707]	[0.0786]		
New-Process	−0.0188		0.2486***	
	[0.0726]		[0.0773]	
Organizational	0.2272***			0.4117***
	[0.0638]			[0.0783]
Credit-Constraints (CC)	−0.1573**			
	[0.064]			
New-Product: CC		−0.2461***		
		[0.0921]		
New-Process: CC			−0.2188***	
			[0.0769]	
Organizational: CC				−0.2639***
				[0.0928]
Adj.R^2	0.4533	0.45	0.4483	0.4535
Observations	1693	1693	1693	1693

Notes: ***, **, and * indicate significant at the 0.01, 0.05 and 0.10 level, respectively. Standard errors are in parenthesis.

significant in Regression 1, it becomes significant in Regression 3, implying that the impact of process innovation depends on firms' credit constraint condition.

For India, the estimation results of Regression 1 in (Table 10) show that credit-constrained firms have 12.5% lower sales than credit-unconstrained firms. For innovation activities, *New-Product* is significant and positive, *New-Process* is insignificant, and *Organizational* is significant and negative. The average sales of firms that invested in new products are 14.2% greater than those of firms without new products. However, firms with organizational innovation saw 23.2% smaller annual sales than firms without this type of innovation. When Indian firms face credit constraints, they likely substitute product innovation for organizational innovation (Model A), which coincides with the positive impact of product innovation on sales and the negative impact of organizational innovation on sales. This is further verified by the estimation results of Regression 2 of Model C. The interaction term is significant and negative. For the credit-unconstrained firm group, the annual sales of firms with product innovation are 26.2% higher than those of firms without this kind

Table 10. Estimation results of Model C for India.

Variable	Regression 1	Regression 2	Regression 3	Regression 4
Dependent variable		Sales		
Intercept	19.9348***	19.7782***	19.8215***	19.9242***
	[0.1538]	[0.1421]	[0.1449]	[0.1417]
Size-Medium	−1.803***	−1.8173***	−1.8283***	−1.8176***
	[0.0735]	[0.0731]	[0.0735]	[0.0738]
Size-Large	−3.0181***	−3.0301***	−3.0541***	−3.0572***
	[0.0848]	[0.0849]	[0.0842]	[0.0845]
High-tech	0.2069***	0.1999***	0.2001***	0.2078***
	[0.0611]	[0.061]	[0.0611]	[0.0611]
Firm-Age	−5.00E-04	−1.00E-04	−2.00E-04	−4.00E-04
	[0.0023]	[0.0023]	[0.0023]	[0.0023]
Foreign-Ownership	0.6723**	0.6528**	0.6897**	0.726**
	[0.3348]	[0.336]	[0.337]	[0.3393]
Group	−0.5704***	−0.5353***	−0.5316***	−0.5671***
	[0.0716]	[0.0708]	[0.0713]	[0.0718]
Export-Experience	0.0279***	0.0278***	0.0277***	0.0283***
	[0.0045]	[0.0045]	[0.0046]	[0.0046]
Manager-Experience	−0.003	−0.0022	−0.0021	−0.0022
	[0.0035]	[0.0035]	[0.0035]	[0.0035]
Worker-Skilled	−0.0016	−0.0023	−0.0019	−0.0013
	[0.0014]	[0.0014]	[0.0013]	[0.0014]
Worker-Education	0.0038 ***	0.0037 ***	0.0037 ***	0.0040 ***
	[0.0011]	[0.0011]	[0.0011]	[0.0011]
Over-Competition	0.0513	0.067	0.0706	0.0444
	[0.0585]	[0.0578]	[0.0588]	[0.0581]
Location: Big-City	0.032	0.0436	0.0277	0.0015
	[0.064]	[0.064]	[0.064]	[0.0632]
New-Product	0.1424**	0.2619***		
	[0.0607]	[0.094]		
New-Process	0.0946		0.1275	
	[0.0653]		[0.0991]	
Organizational	−0.2321***			−0.0826
	[0.0647]			[0.1101]
Credit-Constraints (CC)	−0.1251*			
	[0.0748]			
New-Product: CC		−0.1605*		
		[0.0899]		
New-Process: CC			−0.1064	
			[0.0943]	
Organizational: CC				−0.1124
				[0.105]
Adj.R^2	0.4649	0.4626	0.4613	0.4631
Observations	2691	2691	2691	2691

Notes: ***, **, and * indicate significant at the 0.01, 0.05 and 0.10 level, respectively. Standard errors are in parenthesis.

of innovation; the counterpart is 10.1% for the credit-constrained firm group. However, the impact of organizational innovation on sales does not depend upon the financial constraint condition since both *Organizational* and its interaction with *Credit-Constraints* are not significant in Regression 3.

Among control variables, the estimates of firm size are opposite for China and India. While large and medium-sized Chinese firms have greater sales than small firms, the inverse is generally true for India. As firm size is measured according to the number of employees, the empirical findings indicate that the labor productivity of large firms is relatively lower in India than in China. (Tables 9 and Tables 10) further show that high-tech firms in China and India have higher sales than low-tech firms and that having a large share of educated workers contributes to total sales only in India. However, employee education levels are not associated with the new product sales of Indian firms (Model B). The rationale behind this is that the increase in total sales may overwhelm the moderate increase in new product sales. Chinese firms with more-educated employees do not have higher total sales than other firms, yet they do have a higher sales share of new products (Model B).

6.5. Robustness checks

As pointed out by Savignac (2008), endogeneity is a typical issue affecting the estimation results of the impact of financing constraints on the probability that a firm has innovative activities. In this study, the innovative activities are measured as the cumulative adoption in the last three years. The measure of the credit constraint condition is based on the outcome of the latest loan application and the use of informal financial resources to purchase fixed assets or as a source of working capital. Since both firms' engagement in innovative activities and their financial status are based on the historical data, they determine the new product sales and total turnover, rather than the reverse.[8]

However, firms' financial status is likely affected by innovation investment, indicating the existence of endogeneity caused by selection bias. Following Minetti and Zhu (2011) and using the variable *Audit* (whether a firm used audit assurance or not) as an instrument variable (Hasan and Sheldon 2016; Zhang 2020),[9] we applied a bivariate probit model to test endogeneity in Model A. For the six pairs (one for *Credit-Constraints* and the other for *Innovation*) of regressions of Model A (three for China and three for India), only for the regression for Chinese firms' organizational innovation could we not reject endogeneity. However, the estimation results (available upon request) indicate a negative impact of credit constraints on the likelihood of undertaking organizational innovation, in line with the results of the original regression.

7. Conclusion

In this study, we examined how the presence of financial constraints affects firms' innovation investment behavior and the economic benefits of innovative activities. The cases studied are manufacturing firms in China and India, two developing countries. The question becomes particularly important because the manufacturing-led development strategies adopted by developing countries depend on innovative activities. The innovation literature generally focuses on innovative activities as a whole and investigates the impact of credit shortages on innovation (Savignac 2008; Crisóstomo, López-Iturriaga, and Vallelado 2011; Gorodnichenko and Schnitzer 2013; Altomonte et al. 2016; Coad, Pellegrino, and Savona 2016). The existence of different liquidity requirements between innovative activities in various stages (Gorodnichenko and Schnitzer 2013) and the complementarities between innovative activities (Guan and Ma 2003; Hagedoorn and Wang 2012; Ballot et al. 2015) indicate that firms facing a credit shortage may allocate funds to innovations according to their interrelationship. This study therefore represents a contribution to the innovation literature since we focused on individual innovations and explored the consistency between the impacts of credit constraints on innovation propensity and on innovation performance.

Following Ballot et al. (2015), we divided innovative activities into new products, new processes, and organizational innovation. The empirical results show that restricted access to financing reduces Chinese firms' engagement in all types of innovation and Indian firms' product innovation. Furthermore, the probability of undertaking organizational innovation is higher when Indian firms have poor financial status. Both new processes and organizational innovation enhance the innovative performance of Chinese firms. Limited access to financing reduces the contribution of organizational innovation to innovative performance for Chinese manufacturers. In India, only process innovation is positively associated with new product sales, regardless of firms' credit constraint conditions.

There are a number of possible explanations for the different empirical findings for China and India. In general, the impact of financial status on innovation depends on the institutional context and industry characteristics (Ballot et al. 2015). China is more integrated into the global supply chain, focusing on market-oriented innovation, which leads to strong complementarities between product innovation and the other two types of innovations, resulting in their similar responses to financial status. In contrast, India emphasizes service-producing industries, indicating Indian firms may focus on one or two types of innovations rather than the whole innovation system. This may

cause different responses of innovation activities to financial status and the lack of complementarities between those activities. According to Gorodnichenko and Schnitzer (2013), in the process of innovation, firms first rely on internal funds and then turn to external finance at a later stage. Since we measured financial status according to the outcome of firms' loan application (external finance), the strong correlation between financial status and Chinese firms' innovations may indicate a high radicalness of innovation for these firms. For India, the lack of pervasive impacts of financial status on innovation may indicate a low level of innovation, in line with the stagnant innovative inputs at the country level (Sundaram 2015). The less developed financial market in India may force firms to seek informal finance resources, which further disconnects the relationship between innovations and firms' access to bank loans. On the other hand, Indian financial institutions may adopt a restrictive credit policy and require firms to involve in organizational innovation before they make lending decisions.

The consistency between the probability of undertaking innovation activities and firm performance under credit constraints further provides an explanation of firm innovation behavior. Our empirical results suggest that limited credit access reduces all types of innovative activities for Chinese firms, which coincides with the contribution of new processes and organizational innovation to financial performance. When facing credit constraints, Indian firms replace product innovation with organizational innovation, in line with the null (negative) impact of organizational innovation on new product sales (overall financial performance).

A poorly developed financial market fails to allocate capital to firms with high-value projects. Government-implemented credit programs improve the efficiency of financial markets and promote the potential availability of external financing, which leads to higher economic activity and growth (Bigsten et al. 2003; Fisman and Love 2003; Fauceglia 2015). This study provides support for decisionmakers in designing credit programs in order to strengthen manufacturing-led development strategies. The importance of government subsidies and incentives to firms' innovative activities has been widely emphasized in the literature (Hall et al. 2016). However, the market demand for new products is not guaranteed (Pellegrino and Savona 2017). When policymakers design government programs to alleviate credit constraints and stimulate investment in innovation, the types of innovation need to be specified based on the extent to which firms' innovation is restricted by financial constraints and the extent to which innovative performance can be improved. Credit support programs may be used to encourage firms to invest financial resources in the innovation activities that most strongly affect innovation performance and overall financial performance.

In this study, we used the World Bank survey data of self-reported responses from manufacturing firms. Although the surveys employed a stratified sampling methodology to collect representative data, the sampling weights for the probability of selection may affect the true representativeness of the sample. We used cross-sectional data and included many firm characteristics as variables in the models; however, there are probably other factors (e.g., market share, own financing ratio, and the cost of finance) that need to be controlled. Furthermore, we discussed the implications of this study regarding innovation financing. It is important to bear in mind that financial markets vary across countries. How to study financial markets and recommend financial supports for innovation is an issue left to future studies.

Notes

1. In addition to new product sales, productivity is another commonly used indicator of innovative performance (Hall et al. 2016). In a recent study, Pérez et al. (2019) tested the impact of various innovative activities on firms' financial, production, and market performance. Brenner and Broekel (2011) suggested using a multitude of different approaches to measure innovation performance.
2. For the World Bank Enterprise Surveys, see https://www.enterprisesurveys.org. Chinese and Indian firm-level data are available after submitting an application or from the author upon request.

3. Under the strict assumption, eligible firms are those that can be directly contacted. Under the weak assumption, eligible firms include those under the strict assumption and those that rejected the screener questionnaire or were not able to finalize a contact.
4. The test results of the Pearson chi-squared test indicate that we fail to reject the hypothesis that the firm-size distributions of the sample and population are different (p-value is 0.242 for China and 0.237 for India).
5. For China, the question asked whether in the last three years a firm had engaged in the introduction of 'new managerial/administrative processes.'
6. In the survey, firms were asked, 'to what degree is Access to Finance an obstacle to the current operations of the establishment?' The answers are ordinal, from 'No Obstacle,' 'Minor Obstacle,' 'Moderate Obstacle,' and 'Major Obstacle' to 'Very Severe.' As criticized by Gorodnichenko and Schnitzer (2013), the self-reported measures of financial constraints are likely distorted due to subjective and cultural biases and measurement errors.
7. The positive impact of credit constraints on organizational innovation is consistent with the estimation results from Models B and C, see subsectors below. It may also relate to firms' incentives to ease credit constraints by getting involved in organizational innovation, which signals an effective and well-governed firm. As pointed out by one of the referees, the different measures of organizational innovation for China and India may also partly explain the different estimates of this variable for China and India.
8. This was confirmed by the test results. We followed Tucker (2010) and used the Heckman model to test endogeneity in Models B and C. The estimation results indicate that the inverse Mills ratios are not significant in the three regressions of each model, for both China and India.
9. The audited financial statement reduces the information asymmetry between managers and financial institutions and hence influences lending decisions and financial status.

Acknowledgments

The author wishes to thank the editor and two anonymous reviewers for their valuable and constructive comments. Appreciation is also expressed to Joshua Wimpey from the World Bank for patiently answering all my queries regarding the data and the survey methods, as well as Tom Brökel for his insightful comments on an early draft of this study.

Disclosure statement

No potential conflict of interest was reported by the author.

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