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Credit Constraints and Innovation Activities: Empirical Evidence on Russian Enterprises

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Abstract. This article studies the relationship between the credit constraints on Russian enterprises and their decision to introduce product innovation, process innovation, and to spend on research and development (R&D). The evidence regarding the relationship between R&D spending remains somewhat ambiguous and could differ between countries. A cross-sectional macro dataset of the World Bank Enterprises Survey in Russia in 2019 is used in a system of seemingly unrelated regressions. The results show that the existence of credit constraints is associated with a lower probability of introducing product innovations and spending on R&D activities. Nevertheless, there is no significant relationship between being credit constrained and the enterprise decision to introduce process innovations. The importance of this article stems from the fact that previous works showed that these relationships differ by country and that these relationships are considered simultaneously, while other works concentrate mainly on one of these relationships.

Keywords: Credit constraints; Financial constraints; Innovation activities; Research and development; World Bank Enterprises Survey

1. Introduction

Innovation activity is considered to be one of the main drivers of economic growth on the national level (Aghion et al., 2009; Solow, 1957). Innovations are of great importance for company growth and competitiveness. Companies develop new products and processes or improve old ones to maintain and increase their productivity and market share (Berawi, 2016, 2017; Dabla-Norris et al., 2012; Leland & Pyle, 1977). However, many factors could hinder investment in innovation activities, particularly in R&D activities. Innovation projects require high sunk costs, especially projects containing R&D activities that could require large investments in their initial stages (Alderson & Betker, 1996). In addition to research activities, numerous other activities are necessary to develop new products and release them to the market, which creates a large time lag between investing in these projects and starting to get a return on such investments. This time lag discourages banks from giving companies credit to finance their innovative projects (Bakker, 2013).

Other factors that hamper investing in innovation activities include the inherent high level of uncertainty in such projects. Many technological, strategic, and market factors lead

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to uncertainty. Innovative companies do not have enough information about the activities of their rival companies or about the readiness of the market to accept their new products (Spielkamp & Rammer, 2009). Innovation projects usually result in intangible assets, for instance, patents, utility models, or even the new knowledge and experience of the company personnel. Such assets cannot be used as collateral to obtain credit from banks (Hall, 1992). Additionally, different participants in the innovation activities have a different level of information about the innovation itself, which leads to the problem of asymmetric information. The company management or innovators have more information about their new products than investors. Innovators also tend not to reveal many details about their innovation because of the appropriability problem whereby other rival companies could benefit from this information (Leland & Pyle, 1977). As a result, the problem of asymmetric information discourages investors from participating in innovative projects (West, 2004).

The aforementioned factors lead to constraining the access of innovative companies to external financial resources. Thus, constrained companies tend to reduce or stop their investment in innovation activities, which influences their competitiveness and productivity. It is worth mentioning that the boom in R&D spending in the USA in the 1990s can be attributed to a shift in the supply of finance (Brown et al., 2009). Therefore, the underinvestment of a huge number of companies in innovation activities could influence the innovation development of the country and its economic growth (Brown et al., 2012).

This paper aims to analyze the mutual relationships between credit constraints and the enterprise decision to introduce product innovation, process innovation, and to spend on R&D internally or externally. The relevant scientific literature concentrates on the relationship between financial constraints and R&D spending or between financial constraints and product innovation in particular. The importance of this work stems from two facts. First, the considered relationships are significantly different by country, and it is important to study these relationships in the context of an emerging economy like Russia, where credit financing is considered to be the main external financial resource for Russian enterprises (Guriev et al., 2004). Second, this paper considers the relationship between credit constraints and the enterprise decision to introduce product innovation and process innovation and to spend on R&D simultaneously. Thus, it will be possible to compare the significance and magnitude of these three relationships.

2. Literature Review

Exploring the impact of financial constraints on investment begins with testing the sensitivity of companies' investments to cash flow (Fazzari et al., 1988). Many articles have followed this approach to test the sensitivity of R&D spending to cash flow (Bond et al., 2005; Brown et al., 2012; Borisova & Brown, 2013; Cincera et al., 2016; Lööf & Nabavi, 2016). The evidence regarding the relationship between R&D spending and financial constraints remains somewhat ambiguous (Altomonte et al., 2016). However, several weaknesses could be identified in this methodology. First, this approach does not consider the existence of external financial resources (Kaplan & Zingales, 1997; Moyen, 2004). Second, regarding the fact that the majority of R&D spending is on wages for researchers, companies tend to smooth their R&D spending over time (Hottenrott & Peters, 2012). Thus, it is difficult to identify the real impact of cash flow changes on R&D spending (Hottenrott & Peters, 2012). Finally, this approach focuses on the impact of financial constraints on R&D activities, which is one of many types of innovation activities.

Other works take an experimental approach, where companies are asked to decide whether to initiate additional innovation projects or to pay dividends with a hypothetical amount of money. Thus, the companies choosing to initiate new projects are financially

constrained. Another literature stream attempts to study the financial constraints on innovation activities by analyzing standardized credit ratings or credit requests. However, a selectivity problem arises when analyzing credit requests since constrained companies may not ask for credits because they know they will not receive them (Czarnitzki, 2006; Piga & Atzeni, 2007; Czarnitzki & Hottenrott, 2011; Bottazzi et al., 2014).

The widespread innovation surveys at the micro level present an opportunity to investigate the impact of financial constraints on companies' innovation activities. Surveys such as the European Community Innovation Survey (CIS) ask directly about the financial constraints on the company rather than using proxies, such as cash flow or credit ratings (Hall et al., 2016; Gorodnichenko & Schnitzer, 2013; Savignac, 2008; Canepa & Stoneman, 2008). Some contributions consider a company to be constrained when it declares in the survey that a lack of finances is hampering its innovation projects (Tiwari et al., 2008; Spielkamp & Rammer, 2009). One of the drawbacks of this approach to defining a constrained company is the endogeneity of the survey indicator, as companies may tend to answer that they are constrained (Czarnitzki & Hottenrott, 2010). Nevertheless, while most of these contributions concentrate on R&D, the results are not even by country.

3. Methods

Our data source is the Enterprises Survey in the Russian Federation conducted by the World Bank, European Bank for Reconstruction and Development and European Investment Bank in the period January–July 2019 (World Bank, 2019). The survey covers 1323 Russian enterprises distributed across six manufacturing industries and two service industries. The sample selection method is stratified random sampling by industry, region, and size. Enterprises are distributed by size as follows: small (5 to 19 employees), medium (20 to 99 employees), and large (100 or more employees). After cleaning the data in order to build our model, a sample of 1248 observations was obtained for the analysis.

To study the mutual relationships among the four dependent variables (introducing a product innovation, introducing a process innovation, spending on R&D, and the existence of credit constraints on the enterprises), four single probit regressions have been run in order to explore the signs and magnitude among the four dependent variables. Further, a system of simultaneous equations has been built to consider the mutual relationship among the variables. This methodology has been used in a relevant article by Altomonte et al. (2016) to study the relationship among financial constraints, R&D decision, export ,and total factor productivity. Dependent variables of the four regressions are dummy variables for product innovation, process innovation, and spending on R&D internally or externally as well as a dummy variable to identify whether or not the enterprise is credit constrained.

The variable (prod_inno) takes the value 1 if the company has introduced a product innovation in the last three years and takes the value 0 otherwise. The second variable (proc_inno) takes the value 1 if the company has introduced a process innovation in the last three years and takes the value 0 otherwise. Based on the recommendation in the Oslo Manual and its guidelines for collecting, reporting, and using data on innovation, three years is the recommended period to monitor a company's innovative products and processes (OECD/Eurostat, 2018). A third dummy variable (rd) takes the value 1 if the company has spent on R&D internally or externally in its last fiscal year and takes the value 0 otherwise. Internal expenditures are an in-house R&D process, while external expenditures refer those contracted with other companies. The enterprises answered this question depending on their expenditures in their last fiscal year. The credit applications and their results are used to identify the existence of financial constraints on the enterprise. An enterprise is considered to be constrained in two cases. The first case is when the enterprise has applied

to get a loan and its application has been rejected. The second case is if the enterprise has answered the question "What was the main reason why this establishment did not apply for any line of credit or loan?" with one of the following answers: "Application procedures were complex," "Collateral requirements were too high," or "Size of loan and maturity were insufficient." Following this approach, financially constrained enterprises can be identified without further calculations. This method has been used in many related scientific works to identify financially constrained companies (Bigsten et al., 2003; Hansen & Rand, 2014; Wellalage & Locke, 2016; Zhang, 2020). A dummy variable (constrained) takes the value 1 if the enterprise is constrained in accordance with the aforementioned methodology and takes the value 0 otherwise.

Other control variables that are included in the four regressions are a dummy variable for enterprise age, a dummy variable for the enterprise size, and a dummy variable for the industry type of the enterprise. Additional control variables are added to particular regression equations. The percentage of the enterprise's high-qualified personnel is considered in equation 3. Acquisition of external knowledge in the last three years is considered in equation 1 on product innovation, while the use of foreign-licensed technology is considered in equation 2 on process innovation. Other variables that are used for predicting financial constraints include being a part of multi-establishment-firm, using overdrafts, and the existence of state- or foreign-owned shares in the enterprise.

4. Results and Discussion

4.1. Descriptive Statistics

Table 1 reports the descriptive statistics of the sample by size classes. Large enterprises tend to introduce product and process innovations and spend on R&D more than small and medium enterprises. However, small enterprises appear to be more constrained than other enterprises. Regarding the existence of two large heterogenous groups (other manufacturing and other services) in the industry classification, which makes the identification of the industry sector very difficult, a dummy variable (manu) has been identified, which takes the value 1 if the enterprise is a manufacturing enterprise and the value 0 if it is a service enterprise.

Table 1 Percentage of enterprises introducing product and process innovation, enterprises spending on R&D, and credit-constrained enterprises by size classes

Size classes	Observations	prod_inno=1 (%)	proc_inno=1 (%)	rd=1 (%)	constrained=1 (%)
Small	500	11.6	11.2	11.8	19.2
Medium	388	13.4	10.3	17.5	18.8
Large	360	18.9	11.7	28.6	16.9
Total	1248	14.3	11.1	18.4	18.4

Table 2 shows the percentage of our four main variables by industry type. Manufacturing enterprises introduce more product and process innovations and spend more on R&D than service enterprises. Nevertheless, there is no large difference between the percentage of constrained enterprises in both groups. Some research shows that service firms tend to engage more in training and organizational changes than in R&D investment. Therefore, there are more product and process innovations in the manufacturing sector than in the service sector (Evangelista, 2006).

Table 2 Percentage of enterprises introducing product and process innovations, enterprises spending on R&D, and credit-constrained enterprises by industry type

	Observations	prod_inno=1 (%)	proc_inno=1 (%)	rd=1 (%)	constrained=1 (%)
Manufacturing	847	17.5	11.7	22.0	18.3
Services	401	7.5	9.7%	11.0	18.7
Total	1248	14.3	11.1	18.4	18.4

4.2. Single Probit Regressions

The results of the single probit regressions are presented in Table 3. The dependent variables are a dummy variable for introducing a product innovation in the last three years, a dummy variable for introducing a process innovation in the last three years, a dummy variable for spending on R&D in the last year, and a dummy variable for the existence of credit constraints on the enterprise. It is worth noting that the observations' weights mentioned in the dataset are not taken into account in the regression equations regarding that considering it has led to a robust standard error (Solon et al., 2013). To cope with the heteroscedasticity problem, robust standard errors are used.

The results presented in Table 3 show that the probability of being credit constrained is negatively associated with introducing new product innovations and with the decision to spend on R&D in equations 1 and 3, respectively. However, there is no significant correlation between credit constraints and the R&D decision in equation 4. Furthermore, there is no significant correlation between credit constraints and process innovation in equations 2 and 4. The coefficients of the negative relationship between credit constraints and introducing product innovation and spending on R&D in equations 1 and 3 are of similar size. Furthermore, a positive significant correlation can be observed among introducing product innovation, introducing process innovation, and spending on R&D. The magnitude of the positive correlation between the decision to introduce product innovation and process innovation is larger than that between introducing product innovation and spending on R&D activities. Considering the control variables, the probability to introduce a product innovation and spend on R&D is larger for manufacturing enterprises than for service enterprises, but such a positive relationship has not been observed for introducing process innovations. The acquisition of external knowledge has a positive effect on the probability to introduce product innovation, while using foreign-licensed technologies is positively correlated with introducing a process innovation. The only significant control variable for credit constraints in equation 4 is the use of overdraft facilities.

4.3. Simultaneous Equation System

To identify the simultaneous mutual relationships among the enterprise decision to introduce product innovation, process innovation, to spend on R&D, and to be credit constrained, we use a seemingly unrelated regression model. This approach is built on the works of Zellner (1962, 1963). This method assumes an unstructured variance-covariance matrix of the error terms.

$$\begin{cases} Prod\_inno_i = \alpha_{11} Proc\_inno_i + \alpha_{12} RD_i + \alpha_{13} Constrained_i + \beta_1 X_i + u_{1i} \\ Proc\_inno_i = \alpha_{21} Prod\_inno_i + \alpha_{22} RD_i + \alpha_{23} Constrained_i + \beta_2 X_i + u_{2i} \\ RD_i = \alpha_{31} Prod\_inno_i + \alpha_{32} Proc\_inno_i + \alpha_{33} Constrained_i + \beta_3 X_i + u_{3i} \\ Constrained_i = \alpha_{41} Prod\_inno_i + \alpha_{42} Proc\_inno_i + \alpha_{43} RD_i + \beta_4 X_i + u_{4i} \end{cases}$$

The results of the seemingly unrelated regressions are presented in Table 4, and they confirm our previous results. Considering the simultaneous relationship among the four studied variables led to a more significant negative correlation between being credit

constrained and both introducing product innovation and deciding to spend on R&D. The coefficients of these correlations are of the same size. Credit constraints are negatively correlated with introducing innovative products and spending on R&D. However, there is no significant relationship between being credit constrained and introducing a process innovation. This could be explained by the fact that developing new products and R&D activities need more financing than introducing process innovations.

The magnitude of the positive correlation between deciding to spend on R&D and introducing process innovation is larger than that between spending on R&D and introducing product innovation. Furthermore, introducing product innovation is more associated with introducing a process innovation rather than with spending on R&D activities. Regarding the control variables, manufacturing enterprises are more inclined to introduce product innovation and less inclined to introduce process innovation in comparison to service enterprises. A positive correlation is observed between introducing product innovation and acquisition of new knowledge. Additionally, there is a positive correlation between being credit constrained and overdraft use. The results of this paper are consistent with the results of other papers that used surveys to study the relationship between financial constraints and innovation activities. For instance, Álvarez and Crespi (2015) found that credit constraints influence the propensity of enterprises to innovate in Chile. The same conclusion was reached by Sun (2020) in China regarding product innovation. However, Lööf and Nabavi (2016) found that credit constraints could influence innovation activities only in high-tech enterprises in Sweden.

Table 3 Single equation probit regression

	Prod_inno (1)	Proc_inno (2)	Rd (3)	Constrained (4)
Product innovation		1.21 ***	0.62 ***	-0.30 **
		(0.12)	(0.12)	(0.15)
Process innovation	1.23 ***		0.84 ***	-0.01
	(0.13)		(0.13)	(0.16)
R&D	0.43 ***	0.68 ***		-0.20
	(0.12)	(0.13)		(0.13)
Financially constrained	-0.30 **	0.02	-0.26 **	
	(0.14)	(0.15)	(0.13)	
Age: 1–5 years	-0.09	0.01	0.12	-0.01
	(0.13)	(0.15)	(0.12)	(0.11)
6–10 years	-0.25*	0.33 **	-0.08	-0.12
	(0.13)	(0.13)	(0.12)	(0.11)
Size: Medium	-0.08	-0.21	0.20*	0.00
	(0.12)	(0.13)	(0.11)	(0.10)
Large	0.03	-0.33 **	0.54 ***	0.03
	(0.13)	(0.15)	(0.12)	(0.11)
Industry Manufacturing	0.47 ***	-0.13	0.32 ***	0.05
	(0.12)	(0.12)	(0.12)	(0.09)
Percentage of highly qualified personnel: 34–67%			0.00	
			(0.11)	
67–100%			-0.72 ***	
			(0.24)	
Acquisition of external knowledge	0.58 ***			
	(0.16)			
Licensed foreign technology		0.29*		
		(0.16)		
Part of financial group				-0.21
				(0.27)
Overdraft facility				0.22 **
				(0.10)
State-owned				-4.14
				(68.82)
Foreign owned				-0.18

				(0.26)
Constant	-1.68 *** (0.13)	-1.63 *** (0.13)	-1.55 *** (0.16)	-0.99 *** (0.13)
Pseudo R2	0.29	0.30	0.22	0.03
Robust standard errors in parenthesis	*** p < 0.01; ** p < 0.05; * p < 0.1			

In contrast to our results about Russian enterprises, Altomonte et al. (2016) concluded that there is no mutual relationship between credit constraints and R&D investments for enterprises in France, Italy, Germany, and Spain. Finally, regarding process innovation, while this paper did not find a significant correlation between this type of innovation and credit constraints, Álvarez and Crespi (2015) found that credit constraints have an impact on the probability of introducing process innovation. However, the magnitude of this impact is less than that for product innovation. These comparisons lead to a clear conclusion that the relationship between credit constraints and different innovation activities differs significantly by country.

Table 4 Simultaneous equation regressions model

	Prod_inno (1a)	Proc_inno (2a)	Rd (3a)	Constrained (4a)
Product innovation		0.51 *** (0.02)	0.27 *** (0.03)	-0.12 *** (0.04)
Process innovation	0.61 *** (0.03)		0.41 *** (0.03)	0.04 (0.04)
R&D	0.18 *** (0.03)	0.24 *** (0.02)		-0.10 *** (0.03)
Financially constrained	-0.08 *** (0.02)	0.03 (0.02)	-0.10 *** (0.03)	
Age	-0.03 ** (0.01)	0.03 *** (0.01)	-0.01 (0.01)	-0.02 (0.01)
Size	0.00 (0.01)	-0.03 *** (0.01)	0.06 *** (0.01)	0.01 (0.01)
Industry Manufacturing	0.06 *** (0.02)	-0.05 ** (0.02)	0.03 (0.02)	0.02 (0.02)
Percentage of high qualified personnel			-0.03* (0.02)	
Acquisition of external knowledge	0.12 *** (0.03)			
Licensed foreign technology		0.04 (0.03)		
Part of financial group				-0.04 (0.06)
Overdraft facility				0.05 ** (0.03)
State-owned				-0.17 (0.12)
Foreign owned				-0.04 (0.06)
Constant	0.16 ** (0.06)	0.25 *** (0.06)	0.43 *** (0.08)	1.48 *** (0.17)
R^2	0.16	0.13	0.12	0.01
Robust standard errors in parenthesis	*** p < 0.01; ** p < 0.05; * p < 0.1			

5. Conclusions

Applying a system of simultaneous seemingly unrelated regressions led to the conclusion that credit constraints are negatively correlated with the decision of the company to introduce new products or to spend on R&D internally or externally. Such a relationship has not been observed between credit constrained and introducing process innovation. The development of new products and spending on R&D activities require large

investments from enterprises. Financially constrained enterprises may not have enough resources to invest in such activities. Meanwhile, the enterprise decision to introduce process innovation, which needs less investment, is not correlated with credit constraints. It is worth noting that the correlations between credit constraints and both product innovation and R&D spending are of the same size, while not all enterprises that introduced a product innovation decided to spend on R&D. This means that the existence of financial constraints led companies to avoid activities that require high investments or that associated with high risks. Process innovations are less risky and do not require large investments, so the enterprise can introduce them whether or not it is constrained.

These results have many policy implications, especially considering the notion that credit finance is not vital for innovation activities. Government endeavors should be evenly directed to support enterprises' access to external financial resources in order to increase their ability to spend on R&D and to introduce product innovations. This support should be directed evenly to help enterprises to develop new products and to engage in R&D activities such that enterprises under credit constraints are equally inclined to undertake such activities. Among the main limitations of this work was the absence of panel data to consider the relationships over time and to check the causality relationship. Is there only a correlation between credit constraints, product innovation, process innovation, and R&D spending? Or does limited access to external financial resources lead companies to decide not to introduce new product innovations and not to spend on R&D?

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