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Innovation and competition under weak institutions: An empirical analysis of Russian firms

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Abstract

This study examines the relationship between competition and innovation of Russian firms. We mainly explore (i) the role of competition in stimulating or suppressing product and process innovation and (ii) if the relationship is affected by institutional conditions, such as court fairness, corruption, and informal competition. The results show that innovation, particularly process innovation, has an inverted U-shaped relationship with competition but that product innovation is negatively associated with competition. Further, the negative relationship with product innovation is observed only among firms confronting problems in institutional conditions. The results imply that, whereas the promotion of competition can both encourage and discourage innovation, depending on the initial competition level, an improvement in institutional conditions can mitigate the negative effect of competition on innovation.

Keywords: innovation, competition, institution, Russia.
JEL classification: L1, O, O3, P2, P3.

1. Introduction

Innovation and economic modernization have become major issues in Russia. Economic crises having taken place several times since the collapse of the Soviet Union have highlighted the problem of high dependence on natural resources, and there is growing awareness of the need to diversify the economy by improving the quality of manufacturing and business processes (Gokhberg et al., 2009; OECD, 2011, 2013). The government has strongly expressed its intention to focus resources on the high-tech sector and introduced several policies to pro-

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mote innovative activities since the early 2000s. Skolkovo Innovation Center in suburban Moscow, announced in 2009, has been known as one of flagship national projects.[1]

While these policies have achieved certain success (Dezhina, 2020; Schiermeier, 2020), the scale of innovation performance in the Russian industry remains limited. According to the Global Innovation Index, Russia's innovation performance has shown little progress, ranking 51st in 2012 and 47th in 2020 (Cornell University et al., 2021). Russia's R&D spending has not changed greatly over the past two decades, staying around 1% of GDP. Innovation activities in the private sector also remain weak. Over the past two decades, the share of non-governmental R&D funding has stayed around 30–40% in Russia, whereas the OECD average has been 70–75% (OECD, 2020, p. 23). The share of firms engaged in technological innovation has remained around 10% during the same period (Federal State Statistics Service, 2021), which is a few times lower than in most other European countries, including Eastern European transition economies (Fridlyanova, 2017).

One of the important factors affecting innovation activities is the level of market competition. The debate about how competition affects innovation incentives dates back at least to Schumpeter (1934), who stressed the importance of monopolistic rent, and Arrow (1962), who regarded competition pressure as a stimulus of innovation. Subsequent theoretical and empirical studies have provided evidence for both views, and the overall relationship between competition and innovation can be non-linear (see Shapiro, 2012, for a review). Further, the shape of the competition–innovation link can depend on the background economic and institutional conditions (Aghion et al., 2015; Hashmi, 2013; Nuruzzaman et al., 2019), suggesting the possibility that the shape of the link varies by case.

Russia is a unique case in this context. The country boasts a unique economic background, such as a regulative market structure, a high degree of vertical integration, and geographical segmentation (Broadman, 2000; Crescenzi and Jaax, 2016), as well as the experience and legacy of a centrally planned economic system. Market reform and promotion of competition have made progress but are still ongoing problems (EBRD, 2020; OECD, 2013). Institutional quality has also been a serious issue. The rule of law is poorly enforced, ranking 114th in the Global Innovation Index 2020 (Cornell University et al., 2021), corruption is widespread, ranking 129th in the Corruption Perception Index in 2020 (Transparency International, 2021), and shadow economy is profound (Medina and Schneider, 2018). These unique backgrounds can make the relationship between competition and innovation in Russia distinct from that in other European countries, and examining the relationship in the Russian industry is of interest to both the academic discussions and the country's policy discussions. The previous empirical studies on Russia and transition countries have provided mixed results. While an inverted U-shaped relationship is often supported (Bessonova and Gonchar, 2019; Friesenbichler and Peneder, 2016), the relationship can vary

[1] Other policies include "Fundamental policy of science and technology development until 2010 and after 2010" issued in 2002, "Development strategy of science and innovation of the Russian Federation until 2015" adopted in 2006, "Innovative development strategy to 2020" adopted in 2011, and "National project for 'science'" issued in 2018.

by the background conditions of firms (Bessonova and Gonchar, 2017, 2019). Regarding institutional conditions, the literature has argued that improper institutional conditions have undermined innovation activities in the Russian industry (Aleksashenko, 2012; Gianella and Tompson, 2007; Osipian, 2012). However, little has been investigated about the interaction between the competition–innovation link and institutional factors.

This study examines the association between competition and innovation in Russia, mainly using the firm-level dataset of the Russian Federation Enterprise Survey (ES) conducted in 2011/12 (World Bank, 2012). We mainly pay attention to product and process innovation but also employ a more inclusive measure that covers both types of innovation, more detailed measures, and R&D investment. As for the measure of the level of competition, we mainly focus on the number of competitors that firms confront in their markets. We supplement our analysis by using the price–cost margin (PCM) to measure the level of competition, although the PCM is not available for the entire samples and, thus, the interpretation of the results requires caution. To further check the robustness, we supplement our analysis with the data of an additional round of the ES conducted in 2019 (World Bank, 2019). Then, we examine if and how institutional factors influence the shape of the competition–innovation link, hypothesizing that these factors can alter the incentives and pressures for innovation that firms receive from competition. Specifically, we focus on three institutional factors, court fairness, corruption, and informal competition.

The contributions of this study are twofold. First, this study illustrates the influence of institutional conditions on the shape of the competition–innovation link in Russia. Although the shape can be influenced by the background conditions to which firms are faced, and the progress and problems of institutional reforms have been major issues in Russia since its independence, this study is the first to examine this point to the best of our knowledge. Second, we examine the competition–innovation relationship in Russia in a different framework from the existing studies. Bessonova and Gonchar (2017, 2019) are closest to our study, but we employ different datasets and different indicators of competition. Friesenbichler and Peneder (2016) similarly used the ES datasets, but they widely covered all Eurasian transition countries rather than pay a specific attention to Russia.

Our main findings are as follows. First, the number of competitors has an inverted U-shaped relationship with innovation, particularly with process innovation, but a negative relationship with product innovation. Innovation in production and supply methods, management, and marketing is intensified at a moderate level of competition compared to monopolistic or oligopolistic cases, although an excessively high level of competition rather discourages these types of innovation. The negative relationship between competition and product innovation is robustly observed regardless of the novelty level. However, if the PCM is used as the measure of competition, then competition has a negative correlation with innovation, particularly process innovation. Thus, the two measures of competition do not provide the same results, but at least they support the view that high levels of competition discourage innovation. Second, institutional conditions affect the relationship between competition and product innovation, and their negative relationship is observed only among firms confronting problems in the current institutional conditions. This suggests that poor institutional conditions hinder the innovation-stimulating effect of competition, rather than that competition is always harmful for product innovation. This also suggests that an improvement in institutional conditions, such as an appropriate patent protection and reduction of corruption and informal competitions, can mitigate the disincentives for innovation that competition provides to firms.

The structure of the article is as follows. Section 2 reviews the literature. Section 3 describes the data and methodological framework. Section 4 presents the results. Discussion and concluding remarks appear in Section 5.

2. Literature review

2.1. The relationship between competition and innovation

The debate about the link between innovation and competition has a long history. One view, dating back to Schumpeter (1934), regards large firms operating in a concentrated market as the main engines of technological progress. Monopolistic firms can more eagerly perform R&D than firms in competitive markets because of rents, low market uncertainty, and stable funding. Theories from various fields, such as industrial organization, international trade, and endogenous growth theory, have confirmed that markups and market barriers are associated with intense innovation (Dasgupta and Stiglitz, 1980; Delbono and Denicolo, 1991; Kamien and Schwartz, 1972; Loury, 1979; Spence, 1984; Vives, 2008). Although empirical support was weak initially, several empirical studies have provided evidence to support this view (Hashmi, 2013; Kraft, 1989; Mulkay, 2019). The opposite view, that competition stimulates innovation, was suggested by Arrow (1962) and also supported both theoretically and empirically (Aghion et al., 2001; Amiti and Khandelwal, 2013; Bento, 2020; Bloom et al., 2020; Lee and Wilde, 1980; Nickel, 1996). In particular, Aghion et al. (2001) argue that firms in a competitive market have greater incentives to innovate and receive the large rent from post-innovation market power than firms protected from competition.

A hybrid of these two views is the inverted U-shaped relationship hypothesis, which harmonizes both the Schumpeterian and Arrowian views. At low levels of initial competition, an increase in the competition level stimulates innovation. However, the marginal effect of competition diminishes as the level of competition increases, and the incentives for innovation reach a peak at an intermediate level of competition. If the initial competition is already intense, then a further increase in the competition level decreases innovation incentives because the margin of economic rent becomes prohibitively small. Aghion et al. (2005) empirically find such a relationship between product market competition and R&D investment based on UK industry data. Tingvall and Poldahl (2006), Askenazy et al. (2013) and Peneder and Woerter (2014) also found similar results, using data from Sweden, France, and Switzerland, respectively.

2.2. The conditions on the competition–innovation link

The literature has also argued that the effect of competition on innovation can depend on surrounding conditions and institutional factors. Hashmi (2013) argues that the distance to the technology frontier influences the shape of the competition–innovation link. Hashmi (2013) finds a mildly negative relationship between competition and citation-weighted patents among US manufacturing firms, which differs from an inverted U-shape for the UK industry found by Aghion et al. (2005), and relates the difference in these results to the advanced technology levels of the US industry.

Institutional conditions also play a role. In their study of EU market reforms, Aghion et al. (2015) provided evidence that competition stimulates innovation conditional on an adequate patent protection system. Firms under a weak patent protection system confront the risk of imitation by competitors, whereas a strong system removes this risk, which is the very rationale for patent protection, and the innovation-stimulating effect of competition can play a role. However, institutional conditions can have the opposite influence on the competition–innovation link. In a laggard economy in which innovation is more of imitation and generics of the existing technologies than a technological breakthrough, weak institutions can rather facilitate these types of innovation and form a positive competition–innovation link. Nuruzzaman et al. (2019), using a dataset covering the Middle East and North Africa, find that strong institutions weaken the positive competition–innovation link.

Further, the relationship between competition and innovation can change by the type of innovation: namely product innovation, which improves the quality and variety of products, and process innovation, which reduces costs and improves the efficiency of production and sales processes. Although economic theories tend not to distinguish these two types of innovation, firms' incentives, costs, obstacles, and required technology levels for these two types of innovation can differ, and this can affect the shape of the competition–innovation link (Weiss, 2003). Although earlier empirical studies tended to use R&D investment and patent as the primary measures, several recent empirical studies separately examine product and process innovation and show that these two types of innovation react differently to competition (Bessonova and Gonchar, 2019; Hecker and Ganter, 2013; Tang, 2006).

2.3. The studies on Russia and transition economies

Several studies have examined the relationship between innovation and competition in Russia and transition economies and provided mixed results. In the early years of transition, the effects of competition on firms' reforms or innovative activities were found to be weak (Bhaumik and Estrin, 2007; Djankov and Murrell, 2002; Earle and Estrin, 2003). However, Carlin et al. (2004) showed that non-monopolistic firms were more likely to engage in innovation than monopolists in transition countries, suggesting the innovation-stimulating effect of competition. Friesenbichler and Peneder (2016), focusing on almost all European and former Soviet Union transition countries with the ES data, supported an inverted U-shaped relationship between the number of competitors and the R&D expenditure. Likewise, Bessonova and Gonchar (2019) found an inverted U-shaped relationship between product innovation and competitive pressure, although a significant effect was not found for process innovation. Further, the shape of the relationship between competition and innovation is not uniform across all firms, and the technology level and ownership structure are considered factors affecting the shape (Bessonova and Gonchar, 2017, 2019). Institutions can also be a factor affecting the shape of the competition–innovation link, considering their condition in Russia and their effects suggested in the literature (Aghion et al., 2015; Nuruzzaman et al., 2019). However, their effects on the competition–innovation link have not been examined in the case of Russian firms.

2.4. Hypotheses based on previous findings

In the light of foregoing discussion, we propose the following three main hypotheses in the case of Russian firms.

H1. The relationship between competition and innovation can be an inverted U-shape. Such a relationship is widely observed in the literature, including studies on Russia, and could be considered a benchmark hypothesis. Nevertheless, we do not preclude the possibility of other shapes, particularly under the following two cases.

H2. Weak institutions can affect the shape of the competition–innovation link. Although the role of institutions in the competition–innovation link is not straightforward, firms can have additional incentives and disincentives for innovation under weak institutions. Specifically, we focus on the court fairness, informal payments (corruption), and the presence of informal firms as institutional conditions, which would be related to weak patent protection and distorted market incentives. We hypothesize that problems in these conditions can hinder the innovation-stimulating effect of competition since the risk of imitation would grow as the number of competitors increases. Consequently, among firms confronting these problems, the shape of the competition–innovation link can deviate from the one among firms not confronting these problems (or those confronting these problems to a lesser extent).

H3. The shape of the competition–innovation link can differ by the type of innovation. The incentives and obstacles for product and process innovation can differ, and this can differentiate the relationships of these types of innovation with competition. The shape of the relationship can further vary by the novelty of innovation.

3. Data and methodology

3.1. Data description

This study employs the firm-level data obtained from the fifth round of the ES in Russia, jointly financed by the European Bank for Reconstruction and Develoment (EBRD) and World Bank and conducted in 2011/12 (World Bank, 2012). The implemented questionnaire covers a broad range of items on business environments, including innovation activities, the degree of competition, and institutional conditions. The sample firms were selected based on a stratified random sampling and include those operating in the manufacturing, construction, IT, and service sectors and employing at least five workers. Firms in the agricultural sector, employing less than five employees, or operating informally were not covered by the survey. In total, 4,220 firms from 37 regions (*oblast*) of Russia were surveyed,[2] and we use 3,774 of them in the main analysis after dropping firms with missing data for the variables to be explained.

In addition, we use the data of the next round survey, the ES 2019 (World Bank, 2019), conducted under basically the identical sampling and questionnaire frameworks, in supplementary estimations.[3]

3.2. Main variables

The ES 2012 reports various types of innovation activities conducted within the three years prior to the survey. We mainly use the following three binary variables: innovation of all kinds, product innovation, and process innovation. Product innovation takes the value of one if a firm introduced a new or significantly improved product or service in the three years prior to the survey, including both the products new to the market and the imitations and generics of existing products. Process innovation takes the value of one if a firm introduced a new or significantly improved method for production, supply, organizational and management practices, and marketing in the three years prior to the survey. Innovation of all kinds covers both product and process innovation. In supplementary estimations, we divide product innovation by the novelty level and process innovation into three items, innovation in production and supply methods, that in organizational and management practices, and that in marketing methods. Further, we consider the binary variable for firms having invested in R&D.

The main measure of the degree of competition is the number of competitors. The ES 2012 asked firms to report the number of competitors in the market of their main products, which could be local, national, or international. The number was continuously reported up to 100 but reported as "too many to count" for firms faced with more than 100 competitors.

To supplement our discussion, we also use the PCM as a measure of competition. The PCM is defined by

$$PCM_i = (p_i - c_i)/p_i, \tag{1}$$

where p_i is the market price set by firm i and c_i is its marginal cost, although we instead calculate the PCM from the sales and variable costs following the practice in the literature (Aghion et al., 2005).[4] The PCM takes the value of one at the maximum, and higher values indicate a monopolistic market. The PCM close to zero indicates that the market is close to perfect competition. However, since the information needed to calculate the PCM was asked only to manufacturing firms, and approximately a half of them reported the information, we use the PCM only in supplementary analyses.

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2 A region in this paper refers to the administrative unit below federal districts (*okrug*). The cities (*gorod*) of Moscow and St. Petersburg, republics (*respublika*), and territories (*krai*) are treated as regions.

3 The ES 2019 was conducted in a small scale, covering 1,323 firms. Approximately 400 firms form a panel with the data in 2012. Considering the sample size, we do not use these data in the main estimations.

4 Among the cost items, we included the labor, material, electricity, and fuel costs in our calculation. Because not all firms would use both electricity and fuel, we included firms that reported either electricity or fuel costs, but firms not reporting any source of energy were dropped from the samples. Firms not reporting labor and material costs were also dropped.

These two measures of competition have strength and weakness. The number of competitors is the most straightforward measure and would reflect the actual competition conditions that firms encounter in their main markets although, due to its self-reported nature, its value can be disturbed by recalling and cognitive errors. The PCM can reflect further characteristics of competition. For example, two firms in the same market may be faced to different competition conditions if their market powers are different (e.g. one of them is a leader and the other is a follower). The PCM reflects such a difference better than the number of competitors since that difference would be reflected in their prices (sales), although the weakness in our case is the missing information as described above. These two measures also have strength compared to other measures. For example, the Herfindahl–Hirschman Index (HHI) is another measure of competition defined by the sum of the squared market shares over all firms in a market, and a market is conventionally defined by industry or geographic area (or their configuration) in a statistical analysis. However, since a market is more segmented than an industry or its sub-category and the area coverage of a market can vary by firm and product, the HHI may fail to reflect the actual competition conditions faced by firms (Peneder and Woerter, 2014; Tang, 2006). Our measures have strength in this respect since the reported number of competitors and prices (sales) would reflect the conditions of the markets where firms actually compete. Among previous studies focusing on Russia, Bessonova and Gonchar (2019) used a unique measure, the level of competitive pressure obtained from the question: "How does competition […] impact the performance of your enterprise?" (Bessonova and Gonchar, 2019, p. 19). Our measure could be considered more neutral since it does not refer to the impact on the firm performance.

Fig. 1 demonstrates the distribution of the number of competitors. The distribution is dense around five and ten competitors. Certain firms were in monopolistic or oligopolistic competition. Firms reporting more than 100 competitors represent approximately 36% of the samples.

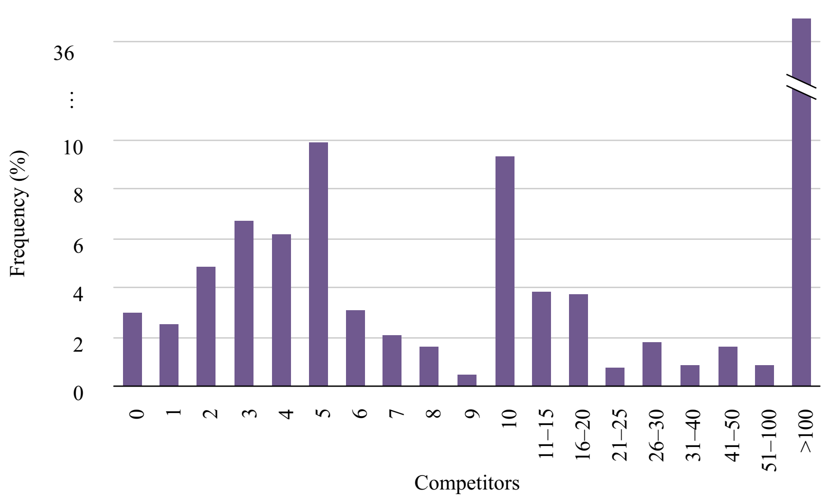

Fig. 1. Distribution of the number of competitors.

Note: Observations are restricted to 3,774 firms used in the estimations to be presented.
Source: Compiled by the authors based on World Bank (2012) data.

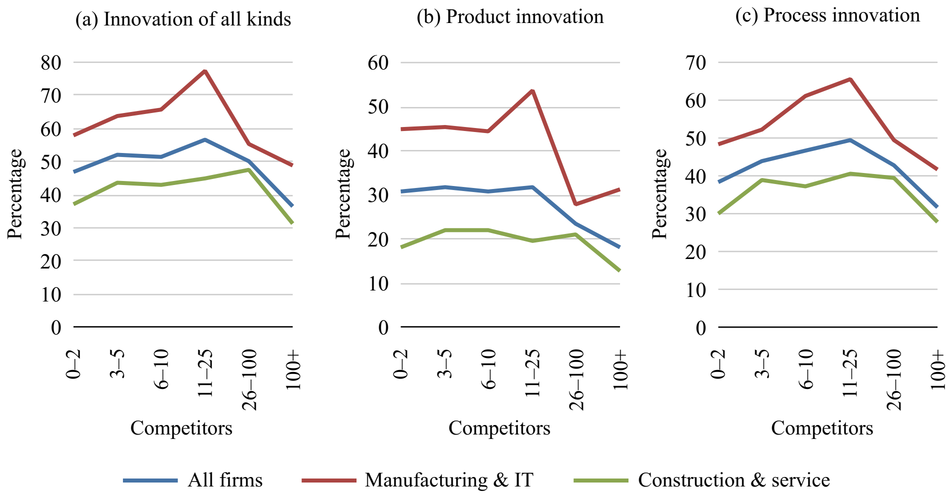

Fig. 2. Proportions of firms engaging in innovation.

Note: Observations = 3,774 for innovation of all kinds, 3,762 for product innovation, and 3,772 for process innovation (the same observations as those used in the estimations to be presented).
Source: Compiled by the authors based on World Bank (2012) data.

Fig. 2 demonstrates the percentages of firms engaging in innovation of all kinds, product innovation, and process innovation, grouped by the number of competitors. Among all firms, competition appears to have inverted U-shaped relationships with innovation of all kinds and process innovation. The percentage of firms engaging in product innovation is constant up to 25 competitors but then tends to decrease with the number of competitors, suggesting a possibility of a threshold effect. Fig. 2 also separately demonstrates the percentages in manufacturing and IT sectors and those in construction and service sectors.[5] While the intensity of innovation is generally higher in manufacturing and IT sectors, the relationship between innovation and competition also appears to differ. Among manufacturing and IT sectors, innovation, by any measure, reaches a peak at 11–25 competitors. The percentage of product innovation drops starkly with 26 competitors or more. In construction and service sectors, the relationship is relatively flat but appears to be a weakly inverted U-shape by any measure of innovation.

The ES 2012 further asked about the institutional conditions with which the firms were faced. We focus on three factors: namely, the court fairness, the frequency of informal payments to government officials, and the presence of informal competitors. For the court fairness, the survey asked firms if they strongly disagreed, tended to disagree, tended to agree, or strongly agreed with the statement: "[t]he court system is fair, impartial and uncorrupted." We regard firms that tended to disagree or strongly disagreed as ones perceiving that the court system was unfair. The frequency of informal payments refers to

[5] The classification is based on the industrial code in the ES 2012, which follows the industry divisions of the United Nations International Standard Industrial Classification Revision 3.1. Manufacturers of fabricated metal products, plastic/rubber, and machinery/equipment, and IT firms have the largest shares in the manufacturing and IT sectors. Wholesale, retail, and construction firms have the largest shares in construction and service sectors.

the commonness of such payments in the business of each firm, not the payments by the firm itself.[6] The survey asked firms if the following statement is always, usually, frequently, sometimes, seldom or never true: "[i]t is common for firms in my line of business to have to pay some irregular 'additional payments or gifts' to get things done with regard to customs, taxes, licenses, regulations, services etc." We regard firms choosing "always" to "sometimes" as ones perceiving informal payments common. The presence of informal competitors was directly asked in the survey with the following question: "[d]oes this establishment compete against unregistered or informal firms?"

These measures reflect the degree of the rule of law and formal protection, although the proportions of firms confronting these problems demonstrate a variation: 66.3%, 40.3%, and 31.2% of firms, respectively, reported that the court was unfair, that informal payments were common, and that they competed against informal firms. Since these measures are subjective, the strength and weakness analogous to the competition measures apply. That is, although these measures may be disturbed by recalling and cognitive errors, they can reflect the actual conditions with which each firm is faced better than objective measures, such as regional or subregional indices of institutional conditions.

3.3. Estimation methods

We econometrically examine the relationship between competition and innovation. Since the three dependent variables we consider are binary, we employ the Probit model that estimates the probability of innovation. Specifically, we estimate the following equation as our benchmark model, based on the literature of Russia and other transition countries (Bessonova and Gonchar, 2019; Friesenbichler and Peneder, 2016):

$$\Pr(innovation_i = 1) = \Phi\{f(competitors_i) + \boldsymbol{X}_i\boldsymbol{\delta} + \theta_j + \tau_r\}, \quad (2)$$

where i, j and r — index for firms, industries, and regions, respectively; $innovation_i$ is one of our binary measures of innovation; $competitors_i$ is the number of competitors; $\boldsymbol{X}_i$ is the vector of control variables; θ_j and τ_r are the industry and region fixed effects (or the federal district fixed effects); Φ is the cumulative distribution function of the standard normal distribution; δ is the vector of parameters to be estimated. We estimate the equation by the maximum likelihood.

We consider several specifications for $f(competitors_i)$. To flexibly reflect a potentially non-linear relationship, such as an inverted U-shape and a threshold effect, we mainly use a categorical specification, in which we divide firms into six groups: those competed with 0–2 competitors, 3–5 competitors, 6–10 competitors, 11–25 competitors, 26–100 competitors, and more than 100 competitors. The dummy variables for these groups are used, with 0–2 competitors being the reference category. Although the behaviors of monopolist firms and those competing with one or two firms can be different, the proportion of monopolist firms is not sufficiently large to be classified as an independent group.

[6] The ES 2012 also asked about the informal payments made by each firm. However, we avoid using this question since non-negligible proportion of firms refused to provide answers.

Alternatively, we use the following linear and quadratic specification to check the robustness:

$$f(competitors_i) = I(competitors_i \leq 100) \times [\beta_1 competitors_i + \\ + \beta_2 competitors_i^2] + \beta_3 I(competitors_i > 100), \quad (3)$$

where $I(\cdot)$ is an indicator function taking the value of one if the argument condition is satisfied; $\beta_2 competitors_i^2$ is dropped if a linear form is assumed. As the number of competitors is continuously reported only up to 100 in our data, the effect of having more than 100 competitors is measured by the dummy variable for such firms.

To supplement discussion and further check robustness, we first separately examine firms in manufacturing and IT sectors and those in construction and service sectors. Second, several alternative measures of innovation will also be used (we describe the details before demonstrating the results). Third, we estimate the probability of innovation after pooling the data of the ES 2019 to the main dataset. Fourth, we use the PCM instead of the number of competitors.

Then, we examine if and how institutional conditions affect the relationship between competition and innovation with the following model:

$$\Pr(innovation_i = 1) = \Phi\{f(competitors_i) \times institution_i + \\ + \gamma\, institution_i + \boldsymbol{X}_i \boldsymbol{\delta} + \theta_j + \tau_r\}, \quad (4)$$

where the categorical specification is assumed for $f(competitors_i)$; $institution_i$ represents one of the three dummy variables for firms confronting problems with the institutional conditions. This model allows the relationship to be heterogeneous between firms perceiving and not perceiving these problems.

To account for confounding factors, we employ the following factors as $\boldsymbol{X}_i$. First, we use the dummy variable for exporting firms and that for firms not exporting but mainly serving the national market (firms not exporting and mainly serving a local market are the reference category). Firms in a large market can be exposed to frontier technologies, which can facilitate their innovation activities. However, this can also confound the competition–innovation link since firms in a large market are likely to confront a large number of competitors, and we directly control for such a confounding effect. Second, we use the dummy variable for foreign-owned firms (the capital of a firm is owned at least partially by foreigners) and that for state-owned firms (the capital is owned at least partially by the Russian national or regional government), with private firms owned exclusively by Russian nationals being the reference category. Foreign ownership can provide technology spillover from international market, whereas the ownership structure can affect incentives and financial flexibility for innovation, particularly in case of Russia (Bessonova and Gonchar, 2017). Third, we use the dummy variable for firms that have training programs. It captures human capital levels of employees and firms' intentions to invest in human capital, which are expected to be positively correlated with innovation. Fourth, we use the age and size of a firm, the latter of which is represented by the log of the number of employees. These variables reflect the resources, experiences, knowledge, creativity, and the market power that can affect innovation incentives. The list of these variables, as well as the measures of competition, innovation, and institutional conditions, are provided in the Appendix A, with descriptions and summary statistics.[7]

3.4. Endogeneity

Although we use several control variables and the industry and region fixed effects, our primary focus is to provide a refined association between innovation and competition and our methodology does not fully eliminate endogeneity bias. Two sources of endogeneity could be noted. First, firm-level unobservable factors and omitted variables can be simultaneously correlated to competition and innovation. Second, the reverse causality can also be a concern. For example, successful innovation by a firm can increase its market power and cause exit of competitors, leading to a negative association between competition and innovation.

Previous studies have widely used instrumental variables to deal with possible endogeneity. For instance, Aghion et al. (2005), in their panel data study of UK firms, exploited the external shocks of market reform programs and their differentiated timing across industries. Friesenbichler and Peneder (2016), in their cross-country study, used the appropriability in each sector and country. Bessonova and Gonchar (2019) used the regional unemployment and the industry-level entry barrier as instruments. However, an instrumental variable approach can also have cautions, particularly for a cross-sectional study focusing on a single country like ours. Industry- and region-level instruments do not allow the respective fixed effects, making it unable to control for the general differences in the intensities of competition and innovation across industries and regions. Further, in practice, it is generally difficult to apply an instrumental variable to a non-linear model, particularly the one with a categorical specification. Bessonova and Gonchar (2019) employed instrumental variable regressions only for a linear specification and dropped fixed effects in these estimations.

Thus, rather than to employ an instrumental variable in exchange for reduced control of confounding factors, we choose to keep industry and region fixed effects that control for the unobservable factors of the respective groups. This would at least mitigate an endogeneity bias and spurious correlation, even if not fully eliminating them.

4. Results

4.1. Benchmark results

We first estimate Equation (2) and employ the categorical specification for the number of competitors. The three measures (innovation of all kinds, product

[7] Of the control variables, the education level of employees could be used in addition to the training dummy to measure the human capital level, and firm size can be measured alternatively with the sales volume or the capital stock. However, while the survey has questions regarding these factors, their data are frequently missing, and we avoided using them in this study.

Table 1
Estimation results with categorical specification.

Variable	Innovation of all kinds	Product innovation	Process innovation	Innovation of all kinds	Product innovation	Process innovation
3–5 competitors	0.1750**	0.0681	0.1850**	0.1410*	0.0561	0.1430*
	(0.0817)	(0.0861)	(0.0830)	(0.0801)	(0.0852)	(0.0811)
6–10 competitors	0.1630*	0.0240	0.2610***	0.1400*	0.0271	0.2230***
	(0.0869)	(0.0912)	(0.0872)	(0.0850)	(0.0901)	(0.0854)
11–25 competitors	0.3150***	0.0747	0.3440***	0.2920***	0.0815	0.3130***
	(0.1010)	(0.1050)	(0.1020)	(0.0990)	(0.1040)	(0.0997)
26–100 competitors	0.1410	–0.1580	0.1560	0.1560	–0.1080	0.1630
	(0.1230)	(0.1350)	(0.1230)	(0.1180)	(0.1330)	(0.1180)
More than 100 competitors	–0.1020	–0.2670***	0.0104	–0.1410*	–0.2630***	–0.0561
	(0.0797)	(0.0852)	(0.0809)	(0.0772)	(0.0834)	(0.0782)
Exporting firms	0.2330***	0.1630***	0.2370***	0.2180***	0.1770***	0.2190***
	(0.0569)	(0.0596)	(0.0570)	(0.0546)	(0.0574)	(0.0546)
Firms not exporting but serving national markets	0.3550***	0.4260***	0.2470***	0.3310***	0.4300***	0.2290***
	(0.0886)	(0.0857)	(0.0875)	(0.0850)	(0.0841)	(0.0837)
Foreign owned	0.1660	0.1120	0.3080**	0.1680	0.1240	0.2950**
	(0.1410)	(0.1430)	(0.1360)	(0.1380)	(0.1420)	(0.1330)
State owned	–0.2880	–0.1690	–0.2070	–0.3240	–0.2240	–0.2330
	(0.2450)	(0.2580)	(0.2500)	(0.2460)	(0.2580)	(0.2500)
Training	0.4950***	0.3370***	0.5040***	0.4790***	0.3140***	0.4920***
	(0.0474)	(0.0517)	(0.0475)	(0.0453)	(0.0499)	(0.0454)
Firm age	–0.00200	–0.00142	–0.00207	–0.000394	–0.000399	–0.000552
	(0.00253)	(0.00243)	(0.00248)	(0.00244)	(0.00241)	(0.00241)
Firm size (log of number of employees)	0.1080***	0.0958***	0.1000***	0.0947***	0.0858***	0.0899***
	(0.0223)	(0.0232)	(0.0222)	(0.0216)	(0.0227)	(0.0215)
Region dummies	Yes	Yes	Yes	No	No	No
Federal district dummies	No	No	No	Yes	Yes	Yes
Pseudo-R^2	0.148	0.152	0.136	0.109	0.130	0.097
HL test (p-value)	0.730	0.031	0.654	0.283	0.363	0.814
Observations	3,772	3,755	3,770	3,772	3,755	3,770

Note: Probit coefficients are presented. The coefficients of the industrial and region or federal district dummies and the constant are omitted. HL test refers to the Hosmer–Lemeshow goodness-of-fit test. Heteroskedasticity robust standard errors are in brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

innovation, and process innovation) are used as dependent variables. Table 1 shows the coefficients. The first three columns correspond to the model in which the region dummies are used. On the innovation of all kinds and process innovation, competition has a positive and significant coefficient if the number of competitors is 3–5, 6–10, and 11–25, with the coefficient volume reaching the peak and the significance level being 1% at 11–25 competitors. However, the coefficient volume decreases and becomes insignificant for 26–100 competitors and more than 100 competitors. This implies an inverted U-shaped relationship, with the probabilities of these two measures of innovation reaching the highest around 11–25 competitors. On product innovation, competition does not have a significant coefficient up to 100 competitors. Only firms competing against more than 100 competitors have a lower probability of product innovation with the significance level of 1%. The results are almost the same in the rightmost

Table 2
Estimation results with linear and quadratic specifications.

Variable	Innovation of all kinds	Product innovation	Process innovation	Innovation of all kinds	Product innovation	Process innovation
Competitors	0.00140	–0.00369	0.00101	0.0102*	0.00208	0.0116**
(up to 100)	(0.00236)	(0.00252)	(0.00227)	(0.00522)	(0.00551)	(0.0052)
Competitors squared				–0.1420*	–0.0940	–0.1700**
(up to 100)				(0.0779)	(0.0848)	(0.0775)
More than	–0.2480***	–0.3330***	–0.1750***	–0.1960***	–0.2990***	–0.1130*
100 competitors	(0.0538)	(0.0591)	(0.0540)	(0.0600)	(0.0654)	(0.0604)
Pseudo-R^2	0.146	0.152	0.134	0.147	0.152	0.135
HL test (p-value)	0.979	0.030	0.476	0.961	0.032	0.700
Observations	3,772	3,755	3,770	3,772	3,755	3,770

Note: Probit coefficients are presented. The coefficients of the industrial and region or federal district dummies and the constant are omitted. HL test refers to the Hosmer–Lemeshow goodness-of-fit test. Heteroskedasticity robust standard errors are in brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

three columns, where the federal district dummies are used instead of the region dummies, although most coefficients shift slightly downward.[8]

Throughout these estimations, most of the coefficients of other control variables are intuitive and consistent. Exporting firms and firms serving national markets have significantly higher probabilities of innovation than firms operating in local markets (p-value of 1%). Foreign ownership has a positive coefficient, albeit significant only for process innovation (p-value of 5%). Training programs are positively associated with innovation (p-value of 1%). Firm age is not significantly associated with innovation, but the firm size has a positive and significant association (p-value of 1%).

In Table 2, we assume a linear and quadratic form of competition up to 100 competitors (hereafter, the coefficients of control variables are omitted, and we demonstrate only the model with the region dummies unless specified otherwise). For innovation of all kinds and process innovation, the number of competitors has a significant coefficient only under a quadratic specification, supporting for an inverted U-shaped relationship (p-value of 10% for innovation of all kinds and 5% for process innovation). The number of competitors does not affect the probability of product innovation unless it exceeds 100 competitors, which is in line with the previous result in Table 1.

In Table 3, we separately estimate the innovation probabilities for the firms in the manufacturing and IT sectors and those in the construction and service sectors. The negative relationship between competition and product innovation becomes clearer for the manufacturing and IT firms, and competition begins to lower the probability of product innovation at 26–100 competitors with the significance level of 5%. In contrast, product innovation in construction and service firms is almost independent of competition. The relationship between process innovation and competition appears similar and inverted U-shaped in both groups of firms.

[8] The Hosmer–Lemeshow test, a common test of goodness-of-fit, was significant for product innovation when the region dummies are used. However, this could be due to the use of various dummy variables in our model. Indeed, the test was insignificant when federal district dummies are applied, which uses less dummy variables. In addition, the test is insignificant in various other specifications (Tables 3 and 5). Thus, the test does not necessarily indicate a critical misspecification risk.

Table 3
Heterogeneity with respect to sector.

Variable	Manufacturing & IT firms			Construction and service firms		
	Innovation of all kinds	Product innovation	Process innovation	Innovation of all kinds	Product innovation	Process innovation
3–5 competitors	0.184	–0.0355	0.105	0.158	0.156	0.232**
	(0.125)	(0.124)	(0.123)	(0.111)	(0.128)	(0.115)
6–10 competitors	0.146	–0.131	0.293**	0.146	0.162	0.218*
	(0.136)	(0.134)	(0.133)	(0.117)	(0.133)	(0.121)
11–25 competitors	0.570***	0.189	0.443***	0.204	0.0465	0.290**
	(0.171)	(0.158)	(0.163)	(0.134)	(0.153)	(0.137)
26–100 competitors	–0.0026	–0.494**	0.0721	0.231	0.0935	0.196
	(0.205)	(0.216)	(0.202)	(0.155)	(0.178)	(0.159)
More than 100 competitors	–0.207	–0.390***	–0.119	–0.0604	–0.146	0.076
	(0.126)	(0.126)	(0.124)	(0.107)	(0.124)	(0.111)
Pseudo-R^2	0.151	0.148	0.134	0.130	0.106	0.125
HL test (p-value)	0.785	0.550	0.584	0.809	0.567	0.349
Observations	1,348	1,345	1,347	2,421	2,407	2,420

Note: Probit coefficients are presented. The coefficients of the other control variables used in Table 1, those of the industrial and region dummies, and the constant are omitted. HL test refers to the Hosmer–Lemeshow goodness-of-fit test. Heteroskedasticity robust standard errors are in brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

4.2. Robustness check with alternative data and measures

In Table 4, we use the pooled data of the ES 2012 and 2019. The estimation method is slightly modified here by adding the dummy variable for year 2019 and using federal district fixed effects instead of region fixed effects (the region-level location is not available in the ES 2019 data; for the definition of a region and federal district, see footnote 2). The coefficients of competition variables shifted upward compared to the benchmark estimates in Table 2. This can imply that the shape of the competition–innovation link changed slightly between the two years, whereas it can also reflect the bias from the inability to control for the regional characteristics. Nevertheless, the changes in the results are minor, and the overall relationship from the benchmark model is maintained.

Backed to the ES 2012 samples, in Table 5, we use alternative measures of innovation. First, we examine the novelty of product innovation with the following two binary variables: one taking the value of one only if products and services newly introduced by a firm were also new in its market, and the other taking the value of one if newly introduced products or services were neither licensed from other firms nor imitations of products already supplied by other firms (columns 1 and 2). In column 3, we estimate the probability that a firm spent in R&D. The coefficients are similar to those on product innovation in the previous tables. That is, having more than 100 competitors significantly reduces the probabilities of these measures (p-value of either 5% or 1%), but competition below that level does not have large effects (albeit the 10% significant coefficient of having 26–100 competitors in (1)). Thus, a negative relationship between competition and product innovation is robustly observed regardless of the novelty level. Then, we examine the details of process innovation, separately estimating the probability of innovation in production and

Table 4
Estimation results based on the pooled data from years 2012 and 2019.

Variable	Innovation of all kinds	Product innovation	Process innovation
3–5 competitors	0.1820**	0.0886	0.1910**
	(0.0728)	(0.0771)	(0.0742)
6–10 competitors	0.2530***	0.0930	0.2790***
	(0.0781)	(0.0824)	(0.0790)
11–25 competitors	0.3940***	0.1300	0.3750***
	(0.0911)	(0.0959)	(0.0930)
26–100 competitors	0.2900**	–0.00992	0.2220*
	(0.1140)	(0.1270)	(0.1140)
More than 100 competitors	–0.0453	–0.1740**	0.0325
	(0.0695)	(0.0740)	(0.0708)
Pseudo-R^2	0.123	0.130	0.147
HL test (p-value)	0.909	0.019	0.308
Observations	4,920	4,892	4,915

Note: Probit coefficients are presented. The coefficients of the other control variables used in Table 1, those of the industrial, federal district, and year dummies, and the constant are omitted. HL test refers to the Hosmer–Lemeshow goodness-of-fit test. Heteroskedasticity robust standard errors are in brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

Table 5
Estimation results with alternative measures of innovation.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
3–5 competitors	–0.0410	0.0426	–0.0996	0.1370	0.1430	0.2130**
	(0.0907)	(0.0913)	(0.1100)	(0.0879)	(0.0894)	(0.0899)
6–10 competitors	–0.0285	0.0388	0.1090	0.1250	0.2500***	0.3470***
	(0.0956)	(0.0967)	(0.1140)	(0.0925)	(0.0929)	(0.0930)
11–25 competitors	–0.1210	0.0834	–0.0179	0.1810*	0.3200***	0.4570***
	(0.1120)	(0.1110)	(0.1370)	(0.1100)	(0.1070)	(0.1080)
26–100 competitors	–0.2800*	–0.1190	–0.1110	0.0389	0.1830	0.3460***
	(0.1460)	(0.1470)	(0.1710)	(0.1290)	(0.1310)	(0.1290)
More than 100 competitors	–0.3780***	–0.2520***	–0.2420**	–0.0173	0.00548	0.1260
	(0.0907)	(0.0912)	(0.1080)	(0.0855)	(0.0876)	(0.0880)
Pseudo-R^2	0.120	0.163	0.228	0.139	0.119	0.119
HL test (p-value)	0.607	0.354	0.328	0.643	0.396	0.167
Observations	3,749	3,755	3,748	3,753	3,751	3,743

Note: The following dependent variables are used. (1) Product innovation that is new in the market. (2) Product innovation that is neither licensed from other firms nor imitation of products already supplied by other firms. (3) Binary variable for firms having spent in research and development (R&D). (4) Innovation in production and supply methods. (5) Innovation in organizational and management practices. (6) Innovation in marketing. Probit coefficients are presented. The coefficients of the other control variables used in Table 1, those of the industrial, and region dummies, and the constant are omitted. HL test refers to the Hosmer–Lemeshow goodness-of-fit test. Heteroskedasticity robust standard errors are in brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

supply methods, that in organizational and management practices, and that in marketing (columns 4–6). The competition–innovation link has an inverted U-shape in any type of process innovation, although the level of significance varies. Innovation in marketing is the most dependent on competition, and firms facing up to 100 competitors have significantly higher probability of innovation than firms facing 0–2 competitors (p-value of either 5% or 1%). Innovation in

Table 6
Estimation results with the price-cost margin (PCM).

Variable	Innovation of all kinds	Product innovation	Process innovation	Innovation of all kinds	Product innovation	Process innovation
PCM	0.511**	0.302	0.416*	0.727*	0.580	0.664
	(0.227)	(0.221)	(0.220)	(0.400)	(0.400)	(0.404)
PCM squared				–0.266	–0.333	–0.324
				(0.471)	(0.477)	(0.474)
Pseudo-R^2	0.196	0.161	0.179	0.189	0.152	0.175
HL test (p-value)	0.223	0.963	0.599	0.233	0.819	0.267
Observations	677	647	679	677	647	679

Note: Probit coefficients are presented. The coefficients of the other control variables used in Table 1, those of the industrial and region dummies, and the constant are omitted. HL test refers to the Hosmer–Lemeshow goodness-of-fit test. Heteroskedasticity robust standard errors are in brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

production and supply methods has the flattest relationship with competition, and even the peak coefficient (11–25 competitors) is of 10% significance.

Then, we use the PCM as the measure of competition instead of the number of competitors. Since the PCM is measurable only for manufacturing firms, we focus on them. Table 6 shows the estimated coefficients. We first employed a linear specification. The PCM has a 5%-significant coefficient on the innovation of all kinds. Note that, unlike the number of competitors, higher values of the PCM indicate less competitive market conditions. Thus, the positive coefficient implies that innovation and competition have a negative relationship. In the three right-most columns, we employed a quadratic specification. However, the squared term does not have a significant coefficient on any measure of innovation. Therefore, with the PCM, an inverted U-shaped relationship is not observed. On the one hand, this suggests the possibility that the relationship between innovation and competition is sensitive with the measure of competition, although we need to pay attention to the decreased sample sizes owing to the missing information. On the other hand, both the results with the PCM and the number of competitors share the view that high levels of competition discourage innovation.

4.3. Competition, innovation, and institution

Now we consider if and how institutional conditions affect the relationship between innovation and competition, based on equation (4). We graphically show the results. That is, for each case of institutional conditions and at each level of competition, we estimated the probability of innovation, fixing the control variables at the means. Thus, the difference in the innovation probabilities between given two points indicates the marginal effect of the different levels of competition. We do not report the probit coefficients here since, in an non-linear probability model, a direct comparison of the coefficients of interaction terms can mislead interpretation (Ai and Norton, 2003).

Fig. 3 presents the results (the solid lines represent the probabilities and the shaded areas represent the 95% confidence intervals). In (a), we estimate the probabilities of innovation of all kinds, separately for firms perceiving that the court system is fair and for those perceiving that the court system is unfair.

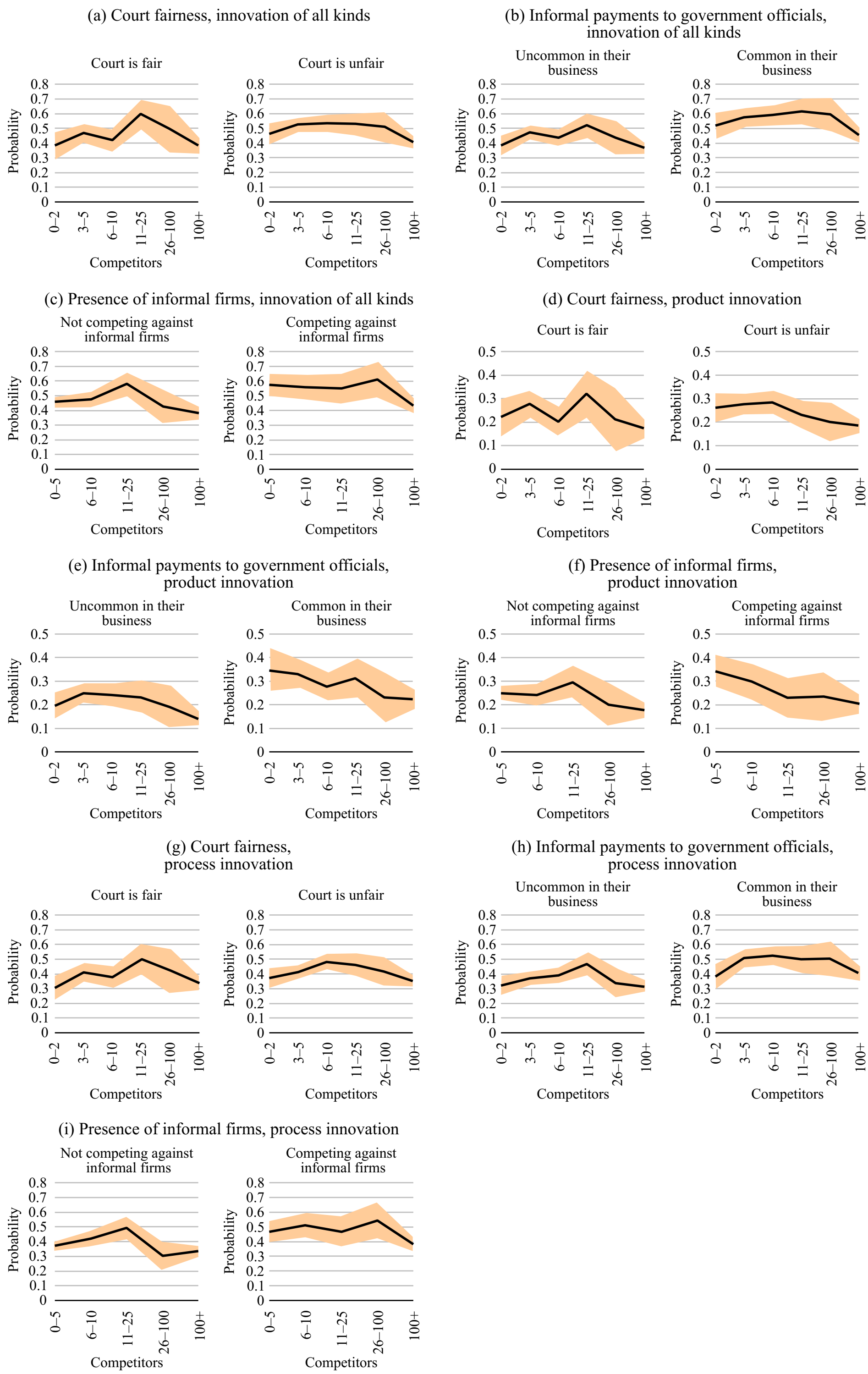

Fig. 3. Estimated probabilities of innovation at different levels of competition and institutional conditions.

Note: The solid lines represent the estimated probabilities, and the shaded areas represent their 95% confidence intervals. The levels of control variables are fixed at the means.
Source: Authors' calculations.

An inverted U-shape is more clearly observed among firms perceiving that the court system is fair, with the peak probability at 11–25 competitors (0.598) being significantly different at a 5% level from the probabilities at 0–2 competitors (0.384) and more than 100 competitors (0.382). The relationship is mostly flat among firms perceiving that the court system is unfair. Similar results are obtained if (c) the presence of informal firms is considered, and the relationship has an inverted U-shape among firms not confronting competition against informal firms, with the peak probability at 11–25 competitors (0.580) being significantly different at least at a 10% level from the probabilities at 0–5 competitors (0.457) and more than 100 competitors (0.383). A technical note is that, when we use the presence of informal firms, we grouped firms competing with 0–2 firms and 3–5 firms into one, since few of these firms compete with informal firms. The relationship is relatively flat if we divide the firms by whether they confront the problems of informal payments to government officials (b), although the peak probability of innovation at 11–25 competitors (0.522 among not confronting this problem and 0.614 among those confronting it) is higher than the probability at more than 100 competitors (0.367 and 0.453, respectively) at least at the 5% significance level.

In (d) to (f), we consider product innovation. Among firms not perceiving or confronting problems with institutional conditions, the relationship appears to have a weakly inverted U-shape. Although the peak probability (0.321 in (d), 0.249 in (e), and 0.296 in (f)) is not significantly different from the probability at 0–2 competitors (or 0–5 for the presence of informal firms; 0.221 in (d), 0.196 in (e), and 0.250 in (f)), it is significantly different from the probability at more than 100 competitors in any case (p-value of 5%) (0.173 in (d), 0.140 in (e), and 0.176 in (f)). In contrast, among firms perceiving or faced with these problems, the relationship appears monotonically decreasing. Although the confidence intervals at 0–2 competitors are often wide, the probability at more than 100 competitors (0.186 in (d), 0.223 in (e), and 0.203 in (f)) is lower than the probability at 3–5 competitors (0.277 in (d) and 0.33 in (e)) or 0–5 competitors in (f) (0.341) with the p-value of around 5%. In (g) to (i), we consider process innovation. Unlike the previous two innovation measures, the relationship appears to have an inverted U-shape regardless of institutional conditions. Except for firms confronting competition with informal firms, the peak probability of innovation, which is 0.465–0.525 and located either at 6–10 or 11–25 competitors, is different from the probabilities at 0–2 (or 0–5) competitors (0.303–0.383) and those at more than 100 competitors (0.314–0.405) with a 5% or 10% significance level.

5. Concluding remarks

We examined the relationship between competition and innovation in Russia, mainly using the firm-level dataset of the ES 2012. Our results are summarized by two points, and we discuss them stepwise. First, competition has an inverted U-shaped relationship with innovation, particularly process innovation (see Tables 1–2), which support our hypothesis (H1). For example, the coefficients imply that having 11–25 competitors (intermediate-level competition) increases the probability of process innovation by 12.9% and 12.6% compared to firms having 0–2 competitors and more than 100 competitors, respectively

(p-value of less than 0.01). This suggests that, compared to a monopolistic and oligopolistic market, a moderate level of competition provides incentives and pressures for efficient operations, which lead to the increased probability of process innovation, as in the view of Arrow (1962), but high levels of competition do not increase the probability of process innovation. As for product innovation, a moderate level of competition does not increase its probability, but high levels of competition decrease it (see Tables 1–2). Specifically, having more than 100 competitors lowers the probability of product innovation by 7.7% compared to firms having 0–2 competitors (p-value of less than 0.01). This tendency is observed particularly among manufacturing and IT firms, for which product innovation would be more relevant than for service sector firms (see Table 3). Thus, the shape of the competition–innovation link varies by the type of innovation, which supports H3, and, as for product innovation in Russia, the negative effect of innovation plays the main role compared to its innovation-stimulating effect. These results were robustly observed after accounting for the novelty of product innovation, employing subdivisional measures of process innovation, and extending the period coverage of the data (see Tables 4–5). When we used the PCM as the measure of competition, however, the correlation between innovation and competition is rather monotonically negative (see Table 6). Although this result needs a caution due to the small sample size, it at least agrees with the view that high levels of competition discourage innovation.

Second, the shape of the innovation–competition link differs by institutional conditions, particularly for product innovation (see Fig. 3), which supports H2. We accounted for the court fairness, informal payments to government officials, and informal competitions as the problems that firms encounter in their operation. Among firms confronting these problems, the shape of the link is monotonically decreasing, whereas a weakly inverted U-shape is observed among firms not confronting these problems. These results suggest the possibility that, as in the view of Aghion et al. (2015), the problems in the institutional conditions suppress the innovation-stimulating effect of competition and magnify the negative effect of competition in the case of Russia, rather than that competition is always harmful for product innovation. That is, the lack of the rule of law, corruption, and the informality of the economy might lead to inadequate patent protection and increase the risk that an innovated product would be immediately imitated, and this made the shape of the innovation–competition link monotonically negative since this risk would grow as the number of competitors increase.

These results demonstrate a difference from the previous studies covering Russia and transition countries. Bessonova and Gonchar (2019), the closest study to ours exclusively covering Russia, find an inverted U-shaped relationship with respect to product innovation but do not find a significant relationship with respect to process innovation. The difference in the results may partly reflect methodological differences, such as the measure of competition and the sample coverage. At the same time, after accounting for the institutional conditions, our results suggest an inverted U-shaped relationship among firms not encountering problems with institutional conditions. Thus, the difference in the results points out the role of institutional conditions in shaping the competition–innovation link.

The policy implications of this study are mixed. On the one hand, regardless of an inverted U-shape and monotonically decreasing cases, high levels of competition close to perfect competition can hinder the firms' incentives for innovation. Although both the promotions of competition and innovation are key areas that economic policies and reforms in Russia have targeted, and the promotion of these economic conditions *per se* would be beneficial for the national welfare, the negative effect of competition can offset the effort to promote innovation to a certain extent. On the other hand, our results also suggest that the improvement in the institutional conditions can mitigate the innovation-suppressing effect of competition and allow the effect of a moderate level of competition to play its role which stimulates innovation more than monopolistic and oligopolistic markets do. Thus, rather than to remark the harm of competition, our results point out the importance to simultaneously improve institutional conditions when promoting competition and innovation.

Clearly, this study is not free of limitations, and the room for further research remains. Although we tried several different measures of competition and innovation, there are some other measures we could not use in this study, such as the HHI for a competition measure and the actual patent application for an innovation measure. If our results remain holding with these measures is a potential topic for future research. Another limitation is that our approach is basically a cross-section analysis, and our claim could be further checked by examining if an intertemporal change in competition conditions within a market does change the innovation activities of firms. Although we employed two rounds of surveys in 2012 and 2019 as a robustness check, a rigorous examination that exploits such an intertemporal change would be an interesting topic both for academic and political discussions.

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Appendix A. List of variables

Variable	Description	Mean	SD
Innovation variables	Binary variable = 1 under the following conditions. All items refer to the three years prior to the survey		
Innovation of all kinds	If a firm conducted either product innovation or process innovation defined below (N = 3,774)	0.459	0.498
Product innovation	If a firm introduced a new or significantly improved product or service (N = 3,762)	0.259	0.438
Process innovation	If a firm conducted at least one of the following three types of innovation (N = 3,772)	0.397	0.489
Innovation in production or supply methods	If a firm introduced a new or significantly improved method for the production or supply of products or services (N = 3,759)	0.244	0.430
Innovation in organization or management	If a firm introduced a new or significantly improved organizational or management practices or structures (N = 3,758)	0.248	0.432
Innovation in marketing methods	If a firm introduced a new or significantly improved marketing methods (N = 3,749)	0.261	0.439
Novelty of product innovation	If newly introduced products or services were also new in local, national, or international markets (N = 3,762)	0.177	0.382
Non-licensed and non-imitative product innovation	If newly introduced products or services were neither licensed from other firms nor imitation of products already supplied by other firms (N = 3,762)	0.200	0.400
R&D investment	If a firm have spent in R&D (N = 3,766)	0.110	0.314
Competition variables	Number of competitors in the main market of the main product		
Number of competitors	Continuously reported up to 100 (N = 2,385)	9.875	12.66
0–2 competitors	Binary variable	0.104	0.305
3–5 competitors	Binary variable	0.229	0.420
6–10 competitors	Binary variable	0.166	0.372
11–25 competitors	Binary variable	0.083	0.277
26–100 competitors	Binary variable	0.050	0.218
More than 100 competitors	Binary variable	0.368	0.482
PCM	Price–cost margin defined by (sales – costs)/(sales) (N = 677)	0.360	0.272
Institutional conditions	Binary variable = 1 under the following conditions		
Unfair court	If a firm strongly disagreed or tended to disagree with the statement: "[t]he court system is fair, impartial and uncorrupted" (N = 3,407)	0.663	0.473
Informal payments	If a firm stated that the following statement was always, usually, frequently, or sometimes true: "[i]t is common for firms in my line of business to have to pay some irregular 'additional payments or gifts' to get things done with regard to customs, taxes, licenses, regulations, services etc" (N = 3,448)	0.403	0.491
Informal competitors	If a firm competed against unregistered or informal firms (N = 3,386)	0.312	0.463
Other variables			
Exporting firms	Binary variable = 1 if a firm exported the products or services	0.229	0.420
Not exporting but serving national markets	Binary variable = 1 if a firm did not export but operated in national markets	0.086	0.281
Foreign owned	Binary variable = 1 if the firm's capital was owned at least partially by foreigners	0.028	0.164
State owned	Binary variable = 1 if the firm's capital was owned at least partially by the Russian national or regional governments	0.008	0.092
Training	Binary variable = 1 if a firm had training programs for employees	0.447	0.497
Firm age	Years since the establishment of a firm	11.49	9.951
Firm size	The log of the number of employees	3.027	1.203

Note: Observations = 3,774 unless specified otherwise. SD is standard deviation.
Source: Compiled by the authors.