Do innovation-active companies possess greater stability?

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Abstract

This paper is concerned with firm sustainable development. Does innovation activity stipulate more sustainable development of a firm which means that a firm could resist more successfully to economic crisis? Or innovation-active companies have better performance only in good time but when economic conditions worsen dramatically they become more vulnerable than non-innovative companies? So the research question is to analyze how adherence to innovation strategy influences firm sustainability in short-term and mid-term periods. So economic crisis is a good occasion to check validity of a firm strategy.

There are plenty of studies devoted to the impact of economic crisis (especially 2008 one) on firm development including its innovation behavior (Archibugi et al., 2013; Hausman and Johnston, 2014; Paunov, 2012). Crisis forces firms to make strategic decisions so that to fit with external environment. So there are studies which analyze how firm behavior changes during economic crisis (Banerji et al., 2009a), but results depend on firm strategic orientation. If a firm adheres to entrepreneurial strategic orientation its performance during crisis is better (Soininen et al., 2012). So this study is in line with this direction of management research.

All data on firms’ indicators are obtained from the database of enterprises and organizations FIRA-PRO. The observation period is 2010-2016 as current economic crisis in Russia started from the end of 2013. So the period of study is divided in two parts: before crisis (2010-2013) and during crisis (2014-2016). Firms of the sample are small and medium enterprises. They are related to several industries like engineering, chemical, production of plastic, metal and non-metal mineral products. The total sample size is 239 companies. Some companies that could be outliers are also excluded from the sample. Accordingly the data are the balanced panel. To test hypotheses we use OLS. But there could be latent variables which influence performance of each company. So models with fixed-effects, random-effects are also tested. To compare pooled regression with FE-model, FE-model with RE-model and pooled regression with RE-model we use Wald’s test, Hausman test and Breusch and Pagan test respectively. Results confirm that crisis impacts negatively on firm performance. Innovation-active companies suffer more than non-innovative. But there are no differences between short-term and long-term crisis consequences.
References:
Do innovation-active companies possess greater stability?
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Abstract
This paper is concerned with firm sustainable development. Does innovation activity stipulate more sustainable development of a firm which means that a firm could resist more successfully to economic crisis? Or innovation-active companies have better performance only in good time but when economic conditions worsen dramatically they become more vulnerable than non-innovative companies? So the research question is to analyze how adherence to innovation strategy influences firm sustainability in short-term and mid-term periods. And economic crisis is a good occasion to check validity of a firm strategy.

The aim of this paper is to analyze if innovation activity of individual companies and regions where companies are situated influences its performance. We hypothesize that if a firm is innovation-active it performs worse in short-term period only. In mid-term its performance is the same as of non-innovation companies. Also we test hypotheses on the impact of the regional knowledge –exploitation and knowledge-exploration competences on firm development. To test these propositions panel dataset of 227 companies for seven years was compiled. Results indicate that economic crisis influence innovation-active firms harder than non-innovation ones but the influence is opposite to hypotheses. Innovation-active firms are resilient to the economic crisis in short-term period but perform worse in mid-term. Regional knowledge-exploitation and knowledge-exploration capacities do not influence significantly firm performance but if regional innovation system possesses both competences its impact is significant and positive.

Keywords: organizational innovation, economic crisis, regional innovation system, regional resilience

JEL: O12, O32, O39, O52
1. Introduction

The economic crisis is a sharp deterioration of the state of the country's economy, violation of market equilibrium which creates significant difficulties for firm activity [Grewal and Tansuhaj, 2001; Bao et al., 2011]. Distinction of the economic crisis from unfavorable conjuncture in the industry or a group of industries lies in the systemic (global) scale of the consequences of the economic crisis for the country's economy. In other words, the economic crisis affects all companies in a particular country. Decrease in price level and change in relative prices, reduction of resource demand due to decline of aggregate product demand, increase in the level of risks, reduction of available financial resources, and etc. influence on the strategy of companies, their investment plans and business models. The impact of the economic crisis is manifested not only in the deterioration of financial indicators, decreasing R&D expenditures or surge in the number of bankruptcies. The economic crisis could also stimulate changes in the structure of the country's economy [Geroski and Walters, 1995; Cincera, 2012; Archibugi, 2013]. It could be positive, pro-innovation. Or structural changes may be negative, namely, aimed at simplifying the structure of the economy, increasing the role of industries with low added value.

The longer the crisis, the greater the impact and the deeper the structural transformation of the whole economy and separate companies. Some industrial companies could flourish and realize active strategies even during economic crisis while others are forced to withdraw from the market [Archibugi, 2013]. It means that successful firms possess more reliable and strategically influential competitive advantage than others.

The company's competitive advantage can be reliably verified in acute conditions of economic recession. Of course on the growing market the position of firms or the dynamics of their growth is not constant too. Over time some companies begin to develop more slowly than others, becoming an object of acquisition for their more successful competitors. However the upward trend in the development of the economy makes it possible not to pay attention to internal problems of the company compensating such intra-corporate crises with additional
financing. For example, the management of the firm may not pay due attention to the problem of excessive staff because of the ambitions of individual directors, or the problem of unnecessary employees may be the result of insufficient attention to the technological development. The growing market allows taking risky, insufficiently deeply grounded investment decisions. As a consequence, the company's position may become unstable. At the same time, the assessment of the financial market may not indicate such problems, if the profitability remains high and the company directs a significant share of profit on dividends.

The economic crisis can dramatically change this favorable situation. Crisis forces firms to make forced strategic decisions so that to fit with external environment [Kunc, Bhandari, 2011]. The inability to finance profitably all the desired directions and projects forces to select them. Reducing market prices makes it necessary to reduce costs, etc. The decreased availability of financial resources stimulates the introduction of financial management technologies, cost management, etc. Under these conditions, companies that previously managed reasonably, in a balanced manner, can gain a competitive advantage.

The concept of creative destruction by J. Schumpeter assumes that significantly changed parameters of the market make it possible to implement projects, the implementation of which was postponed in the past because of the lack of incentives for change. The concept of creative accumulation complements the previous one. Innovative projects are implemented in conditions of uncertainty and their regular implementation requires the creation of the necessary infrastructure within the firm [Malerba and Orsenigo, 1995]. The presence of the company in innovation-intensive market segments facilitates the implementation of subsequent innovations due to market power and a wider range of technological opportunities [Duguet and Monjon, 2004]. As the growth of economic activity gradually leads to excess supply over demand, it increases competition, forces companies to seek new markets. Therefore, competitors that do not have the expertise and resources to develop and implement innovations will find it more difficult to develop and perform innovation projects. Consequently, the degree of competition for firms
more experienced in innovation is reduced, and their ability to use resources, on the contrary, grows.

On the other hand the possibility of rent-seeking behavior can discourage innovative behavior. For example, if a company can gain advantages in obtaining public procurement contracts, it could be much more effective to invest in maintaining corrupt relations than in innovation projects. Preferential access to government contracts can play a significant role in maintaining a company's financial position. The government support through subsidies, belonging of the company to a group of companies (part of a holding), the presence of a state in the ownership structure, etc. may have a similar impact.

The effectiveness of the company's strategy also could be influenced by innovation activity of other firms co-located with the company in the same region. This is due to a number of reasons. First, the effect of competition has an impact. Industry rivalry manifests itself not only directly on the market of the final product, but also indirectly in the struggle for resources. Secondly, the specialization of companies in the region on more knowledge-intensive activities leads to increased efficiency through the effect of learning, the creation of related institutions, and the effect of agglomeration. Third, the economy of the region with a higher level of innovation activity can be more diversified, which gives added resilience to exogenous shocks. On the other hand, the manifestation of the above-mentioned positive effects depends on the degree of competitiveness of the companies of the region on the national or world market, on different physical, economic, social, etc. regional characteristics, the availability of public funding, on the importance of innovative projects of local firms for national security or the leading national development projects, etc.

Economic crisis is a good occasion to check validity of a firm strategy. Thus, the research questions can be formulated as follows: is the company's innovative activity a factor that increases its competitiveness and sustainability? Or it is more strategically efficient to invest in
achieving monopolistic advantages? Does the regional innovation activity provide a more stable development of the company?

The paper is structured as follows. Literature review and research hypotheses propositions are made in section two. In section three data and methodology of the research are described. In section four research results are analyzed and discussed. In the last part conclusions, limitations and practical implications of the research are described.

2. Literature review and research hypotheses

2.1. Economic crisis and company strategy

As indicated above, the economic crisis has a significant and multidirectional impact on the national economy and the activities of individual companies. Researchers identify various strategies that firms adhere to in a crisis: reactive, characterized by a passive reaction of the firm to external circumstances, and proactive, aspiring to the leadership and effectiveness [Alonso-Almeida et al., 2015]. The reactive strategy is defensive. It is focused on financial results and cost reduction. A proactive strategy is aggressive, involves expanding the firm's activities on new markets or product categories. Also there is a third kind of strategy - inertial. In this case companies do not take actions either to preserve their position or to take advantage of the economic crisis. For example about a quarter of financially sustainable companies have not developed a strategy for using excess stock of financial resources by December 2008 [Banerji et al., 2009a]. Also the short-term and long-term consequences of the economic shock should be distinguished. In a short-term period most firms choose a strategy to reduce costs and investments (reactive strategy). However, if the crisis is long-term, then there is a need to adjust the strategy due to a possible significant change in economic parameters after the crisis [Archibugi et al., 2013].

The effectiveness of an anti-crisis strategy depends on many factors in itself. For example, the company's readiness for an economic crisis. If anti-crisis measures are carried out ad hoc, without a preliminary comprehensive analysis of the possible consequences, the actual
results are much worse than expected [Heckman et al., 2009; Banerji et al., 2009a]. The development of an effective anti-crisis strategy is closely related to the company's ability to correctly predict changes in the external environment. To a large extent this ability is peculiar to firms with entrepreneurial orientation, since the orientation towards innovation implies functioning under conditions of uncertainty [Keh et al., 2007].

Company's effectiveness and survival during economic crisis depend on fundamental factors. To survive, the company needs a stable supply of resources, which, in turn, depends on the firm's ability to generate added value under any market conditions. Entrepreneurial orientation should be one of the components of the company's strategy. It is an active strategic position of the company and is aimed at the continuous development of innovative activities, proactive behavior, willingness to consider investments in projects with a high degree of uncertainty [Covin and Slevin, 1989]. Proactivity manifests itself in the identification and use of new opportunities to strengthen competitive positions, willingness to set trends in the market, shaping the external environment, which may be a key factor of the competitiveness of a firm [Lumpkin and Dess, 1996]. This dependence can be positive [Rauch et al., 2009], negative [Arbaugh et al., 2009], nonlinear [Wales et al., 2013]. The reasons for these differences in the results can be either subjective, related to the imperfection of the research instruments, or objective, that is, due to the peculiarities of the external environment of companies. A number of studies have shown that in a hostile environment (reduction of product markets, tightening of access to resources, government intervention, etc.), entrepreneurial firms achieve better results [Covin, Slevin, 1989; Kreiser, Davis, 2010; McGee et al., 2012; Soininen et al., 2012; Osiyevskyy et al., 2015]. Companies which follow proactive strategies are more likely to carry out bold, large-scale steps that will enable them to benefit from implementation of new opportunities that have emerged in the crisis [Alonso-Almeida et al., 2015].

The company's strategy may not be related to innovations at all. The company can focus on cost control, well-known goods and creation the highest value for consumers [Narver and
Slater, 1990], diversification of activities. The firm’s strategy can also be based on the search for rent, i.e. redistribution of public welfare to its own advantage [Krueger, 1974]. Rent-seeking allows the company to concentrate on maximizing the income of owners to the detriment of investment in development. The search for rent can be carried out in various ways: obtaining contracts for the supply of products for state needs, obtaining of preferences for product tariffs or other provisions for the supply of goods (if the company's goods are included in the list of products which are due to state regulation), the provision of public resources on non-market conditions, the reduction of competition, the receipt of government subsidies, etc. This requires the implementation of both explicit, as well as hidden (corrupt) investments. Corruption investments involve investing in creating relationships with individual officials, promoting affiliated persons to government bodies, bribes and the like. Explicit investments consist in maintaining social initiatives of the authorities. First of all, this is sponsorship, creation of social infrastructure facilities, etc. The company can also seek to gain a monopoly position on the market. Accordingly, it invests in expanding the scale of the business to the detriment of the quality level. However market competition may imply informal support of officials.

During the economic crisis, access to budgetary funds, preferences within the framework of state programs can be a significant source of revenue for companies to substitute shrinking commercial sector. Of course monopoly position could also support stability of a company. However in the future after a few years innovation-active companies could adapt well to the new economic reality and the differences in effectiveness may disappear [Laitinen, 2000]. Based on these arguments, we test the following hypotheses:

H1a. Innovative-active companies show results worse in comparison with non-innovative companies immediately after the beginning of the economic crisis

H1b. In the medium-term period there are no significant differences in efficiency between innovation-active and non-innovative companies.

2.2. Region innovation capacity, firm performance and economic crisis
Territorial concentration of companies, universities, research organizations, etc. could be the source of competitive advantage influencing positively on firm innovation activity. This economic and social phenomenon received a lot of names: innovation system, learning region, local buzz, innovative milieu, cluster. The causes of territorial competitiveness are not only of technological nature like economy of scale, but also of institutional one, i.e. the system of interconnected institutions for creation, preservation and transfer of knowledge, skills and artifacts that define the technological opportunities [Freeman, 1987; Carlsson and Stankiewitz, 1991]. The system of institutions provides not only interaction of area residents among themselves but also with external agents whose competences are necessary for the development of sectors of the local economy [Lundvall, 2010]. Effective institutions reduce the uncertainty and costs of exchange of information, thereby facilitating the transfer of technology [Rodriguez-Pose, 2013].

Analysis of the influence of territorial factor on innovation activity multiplied by economic crisis usually concentrates on state level impact. The first reason is that a lot of parameters are under the central government regulation. And the more inter-budget relations are centralized the less role is played by regional institutions. The second explanation is that the innovative activity of firms during a crisis is significantly influenced by the characteristics of the national innovation system. This is due to the fact that a completely innovative project is not implemented by any company, even a very large one. And the larger, more complex the project, the wider the scope of the invention, the more complex commercialization strategies need to be developed, including cooperative partnership strategies. And these cooperation agreements could include companies from different regions especially in small countries.

Above we pointed to the significant role of financial security as a factor in counteracting the crisis (especially financial!). In study [Alvarez et al., 2010] on the basis of data analysis for 2008-09 crisis this is confirmed: the better the financial sector of the national economy is developed, the more countercyclically the firms behave, increasing the costs of innovation.
during the crisis. An important factor of the dampening of the decline in innovation activity is the expanded access of firms to public financial resources, especially for small and newly established companies. If a firm received public financial support in time of crisis the probability that it interrupts innovation activity after crisis is lower [Cruz-Castro et al., 2017]. On the country level the impact of the knowledge stock expressed as the volume of R&D to GDP does not affect the policy of firms in the field of innovation. This may be due to the inertia of knowledge: the level accumulated before the crisis can exceed the ability of firms to commercialize them, so reducing investments in R&D does not affect the intensity of the implementation of innovative projects in the medium term [Alvarez et al., 2010]. On regional level it depends positively on R&D intensity of the region before crisis. If a region already has strong knowledge exploitation system there is negative dependence between changes in the intensity of regional R&D policies during the crisis and probability of ceasing of the innovation activity by companies [Cruz-Castro et al., 2017]. Regional specialization on knowledge-intensive industries complements R&D expenditures as factor of local innovation persistence [Tavassoli and Karlsson, 2016]. Also researchers noticed significance of latent variables which were attributed to regional innovation system when some regions are more innovation-persistent then others, for example Basque Country in Spain [Holl and Rama, 2016]. Some regional innovation systems could be exploration in nature, i.e. based on knowledge-generation organizations and others are exploitative ones [Cooke, 2009]. So regional resilience could be due to different reasons including both current stimulation policies as path-dependence [Crespo et al., 2014].

Regional parameters also affect the performance of firms directly. The size of the region's economy reflects the size of the regional market, which can be a significant factor for firms producing consumer goods. Regional investment risk influences investment decisions, respectively, on the performance of construction, engineering and other companies operating in the B2B market. The regional level of poverty indirectly characterizes, on the one hand, the purchasing power of local residents, on the other hand, the level of wages in the region. Regional
ability to exploit knowledge could be more valuable in crisis period than exploration because it allows local enterprises to correct operatively market strategy. But before economic crisis this difference could be insignificant if the role of innovations in economic growth is low. Accordingly, we test the following hypotheses:

H2a. Regional innovation capacity is not significant for firm performance before crisis.

H2b. Firms which are situated in knowledge-exploitation regions are more sustainable during crisis than firms situated in knowledge-exploration regions.

H2c. Firm performance is higher during economic crisis if the region is simultaneously knowledge-exploitative and knowledge-explorative.

3. Data and methodology

3.1. Data

All data on firms’ indicators are obtained from the database of enterprises and organizations FIRA-PRO. The observation period is 2010-2016 as current economic crisis in Russia started from the end of 2013. So the period of study is divided in two parts: before crisis (2010-2013) and during crisis (2014-2016). Firms of the sample are small and medium enterprises. They are related to several innovation-active industries like engineering, chemical, production of plastic, metal and non-metal mineral products. This choice of industries is due to the fact that these industries are middle-high-technology or middle-low-technology [Technology…, 2011]. As the hypotheses of this study are concerned to innovation activity the sample is divided in two groups: innovation-active companies and non-innovation-active ones. To make the analysis as correct as possible firms are pair-wised approximately of the same size, industry, i.e. to each knowledge-based company at least one analogical company of approximately the same size and industry is selected. If possible, there is compliance with other parameters. The total sample size is 227 companies. We take companies with turnover no less than 50 mln. RUB. and no more than 2 bln. RUB. So the smallest microenterprises are excluded
because their indicators could be too volatile. Some companies that could be outliers are also
excluded from the sample. Accordingly the data are the balanced panel.

Data on patents is collected from website of Rospanent (Federal Institute of Patent
Property). It is Russian state agency which is in charge of IPR regulation. This web-source is
free and allows search on such parameters as name of a patent owner, address, authors, etc. Such
multicriteria search allows receiving valid results.

To collect the data on regional indicators Rosstat (official Russian statistical body) is
used. There are doubts about reliability of some statistical indicators, but these doubts are
concerned more of “public” average indicators of prosperity like average wage. But we use gross
variables like GRP and data on innovation activity which are not so prone for manipulations.

3.2. Dependent variable

Firm performance could be calculated in different ways. Absolute dependent variable
would correlate with others through latent variable firm size. It is most reasonable to use return
on assets (ROA) as dependent variable. It measures efficiency of exploitation of firm resources.
During the economic crisis indicators of company activity could change drastically up to firm
bankruptcy. On the contrary, the size of the company's assets may not change much if the
company reduces the level of business activity, and may also grow during a crisis, for example,
thanks to investments. Other variants of the dependent variable that are rejected: the revenue
growth rate (depending on the size of the company, so there may be bias of the dependent
variable), the profitability of sales and cost (the crisis reduces turnover, and the numerator and
denominator simultaneously decrease).

3.3. Independent variables

Key variables of our study which are used to test hypotheses are variables measuring firm
and regional innovation activity. Innovation activity of a firm could be characterized by such
indicators as R&D expenditures, patent statistics, survey results on innovation activity. Data
which is available do not allow evaluating innovation activity quantitatively or its separate
characteristics so we have to use dummy variable “Firm innovation activity” (IAF), which takes 1 if a firm conducted some activities so that to realize innovation projects and 0 otherwise. Patents possessed by a firm characterize its intention to perform innovation projects. The more patents a firm has, the greater probability that it is persistent innovator. But in some cases firm could protect its knowledge through know-how or firm owners could be patent owners. So we also use data contained in balance sheet, i.e. results of unfinished R&D.

Regional innovation capacity is characterized by two variables. The first one is share of innovators in total sample of industrial enterprises (IATS) and the second is share of innovation expenditures in total turnover of industrial enterprises (IETT). The first indicator depicts the prevalence of innovation behavior in regional economy, the second one characterizes the volume of innovation activity. These two variables also characterize knowledge-exploitation component of regional innovation system. To characterize knowledge-exploration component we use R&D to GRP ratio (KEC). As total R&D of the region include expenditures on R&D performed for innovation projects we also calculate additional knowledge-exploration indicator by subtracting innovation R&D expenditures from total one and dividing on GRP (KECS). This variable includes mainly fundamental research performed in universities and research organizations and financed by government. As knowledge-exploitation activity depends on R&D additional variable capturing moderating effect is added. It is calculated as multiplication of IETT and KECS (IETT\times KECS) or IETT and KECS (IETT\times KECS).

Quality of firm operational and financial management influence firm performance. We characterize sustainability of financial provision by analyzing the NAV – net asset value. The greater the role of owners’ sources the less firm activity is vulnerable to contract clauses with financial institutions’ on amendments of interest rates, early repayment of loans, etc. I.e. firm is less dependent on financial market conjuncture. Variable NAV is calculated as net asset value to total assets. Presence of foreign investor (FDI) could also impact firm’s performance. Transfer of technologies, financial resources, integration into corporation structure could make local firm
free from economic crisis influence. But if it is managed just like business unit, its operations are
dependent on exchange rate, it works in premium segment, etc. presence of nonstrategic investor
could influence negatively on performance. The next two variables reflect firm relations with its
partners: accounts payable turnover ratio (APR) and accounts receivable turnover ratio (ARR).
APR characterizes the ability of a company to get access to financial resources, because delay of
payment is the same as loan. ARR evaluates level of risk the company is ready to accept in its
sales activity, ability to manage risk, to select clients, etc. The reasons of high value of
coefficients could be multiple: qualified financial management, greater power of the firm,
flexibility of firm operations, marketing activity, diversification of firm commodity assortment,
etc. Alignment of assets and liabilities structure is characterized by quick liquidity ratio (QLR).
It is important to use it because firm could go bankrupt even if value of its debt is quite low. The
dependence of firm performance and QLR could be nonlinear because to high coefficient means
that firm assets are kept in cash or other liquid forms which decrease profitability. Other
coefficient - asset turnover ratio (ATR) characterizes partially the efficiency of resource
exploitation. For example firm doesn’t keep redundant assets, uses outsourcing if necessary, etc.
The other control variables are firm size measured as ln of revenue (SIZE), period of company
existence (TERM), size of the regional economy measured as ln of GRP (RSIZE), industry and
year dummies. Also effects of interaction of the firm size and accounts receivable turnover ratio
(SIZE*ARR), accounts payable turnover ratio (SIZE*APR), shareholders’ equity in total assets
(SIZE*SCA) and asset turnover ratio (SIZE*ATR) are captured.

To test hypotheses we use OLS. But there could be latent variables which influence
performance of each company. Often these variables couldn’t be expressed quantitatively or
even reliable data is absent. For example conflicts in board of directors or top-management could
impede a firm from developing productive anti-crisis strategy. Some firms could pursue policy
of pure market relationships in organization while other companies could focus on providing
intra-organizational rules and institutions. It makes working in such firm much more comfortable
and attractive so allows keeping valuable staff during economic crisis. Data about real owners of a firm could be absent because it is registered in offshore jurisdiction. So in reality firms function in different environment and models with fixed-effects, random-effects are also tested. To compare pooled regression with FE-model, FE-model with RE-model and pooled regression with RE-model we use Wald’s test, Hausman test and Breusch and Pagan test respectively. Descriptive statistics of variables is shown in Table 1.

Table 1: Summary statistics

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Variable description</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std.dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAF - Firm innovation activity</td>
<td>Dummy variable. It takes 1 if a firm has intention to perform innovation projects, 0 - otherwise.</td>
<td>0</td>
<td>1</td>
<td>.340708</td>
<td>.4740972</td>
</tr>
<tr>
<td>ROA - return on assets</td>
<td>Continuous variable. It measures efficiency of exploitation of firm resources (assets).</td>
<td>-2.02</td>
<td>1.33</td>
<td>.084412</td>
<td>.1817087</td>
</tr>
<tr>
<td>IATS - share of innovators in total sample of industrial enterprises (%)</td>
<td>Continuous variable. It evaluates prevalence of innovation behavior among regional companies. It characterizes knowledge-exploitation component of the regional innovation system.</td>
<td>3.1</td>
<td>32.1</td>
<td>12.46283</td>
<td>4.68663</td>
</tr>
<tr>
<td>IETT - share of innovation expenditures in total turnover of industrial enterprises (%)</td>
<td>Continuous variable. It characterizes the volume of innovation activity and indirectly its persistence and radicalness. It characterizes knowledge-exploitation component of the regional innovation system.</td>
<td>.1</td>
<td>16.7</td>
<td>2.936915</td>
<td>1.961944</td>
</tr>
<tr>
<td>KEC - R&amp;D to GRP ratio</td>
<td>Continuous variable. It characterizes knowledge-exploitation component of the regional innovation system.</td>
<td>0</td>
<td>.065765</td>
<td>.0172282</td>
<td>.0133475</td>
</tr>
<tr>
<td>KECS - difference between total R&amp;D expenditures and innovation R&amp;D expenditures of business</td>
<td>Continuous variable. It characterizes knowledge-exploitation component of the regional innovation system, but unlike KEC it describes the research component only.</td>
<td>-.1617404</td>
<td>.0415364</td>
<td>.0056713</td>
<td>.0214272</td>
</tr>
<tr>
<td>Variable</td>
<td>Description</td>
<td>Estimates</td>
<td>Significance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------</td>
<td>--------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAV</td>
<td>Net asset value to total assets ratio. Characterizes degree of firm independence from external financial institutions and rules.</td>
<td>-2.05</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDI</td>
<td>Presence of foreign investor. Dummy variable. Takes 1 if a firm has a foreign investor in capital, 0 - otherwise.</td>
<td>0</td>
<td>1</td>
<td>.5221239</td>
<td>.4996682</td>
</tr>
<tr>
<td>APR</td>
<td>Accounts payable turnover ratio. Continuous variable. It evaluates the ability of a company to access financial resources.</td>
<td>.011</td>
<td>331.133</td>
<td>10.71722</td>
<td>20.7556</td>
</tr>
<tr>
<td>ARR</td>
<td>Accounts receivable turnover ratio. Continuous variable. It evaluates level of risk the company is ready to accept in its sales activity.</td>
<td>.0123</td>
<td>228.2612</td>
<td>10.11316</td>
<td>16.68039</td>
</tr>
<tr>
<td>QLR</td>
<td>Quick liquidity ratio. Continuous variable. It evaluates alignment of assets and liabilities structure.</td>
<td>0</td>
<td>895.96</td>
<td>3.32536</td>
<td>26.61367</td>
</tr>
<tr>
<td>ATR</td>
<td>Asset turnover ratio. Continuous variable. It characterizes the overall efficiency of resource exploitation.</td>
<td>0</td>
<td>17.17</td>
<td>1.510605</td>
<td>1.275116</td>
</tr>
<tr>
<td>SIZE</td>
<td>Firm size. Continuous variable. It is calculated as ln of revenue.</td>
<td>4.754</td>
<td>18.192</td>
<td>13.18775</td>
<td>2.135403</td>
</tr>
<tr>
<td>TERM</td>
<td>Period of company existence. Continuous variable. Number of years a company exists starting from the year of registration.</td>
<td>7</td>
<td>224</td>
<td>18.02655</td>
<td>14.87432</td>
</tr>
<tr>
<td>RSIZE</td>
<td>Size of the regional economy. Continuous variable. It is measured as lnGRP.</td>
<td>10.26795</td>
<td>16.00483</td>
<td>13.56031</td>
<td>1.126477</td>
</tr>
<tr>
<td>SIZE*ARR</td>
<td>Multiplication of two variables. Continuous variable. It characterizes relation between ARR and ROA mediated by company size.</td>
<td>0</td>
<td>2653.513</td>
<td>124.6357</td>
<td>195.0774</td>
</tr>
<tr>
<td>SIZE*APR</td>
<td>Multiplication of two variables. Continuous variable. It characterizes relation between APR and ROA mediated by company size.</td>
<td>0</td>
<td>5328.42</td>
<td>141.2841</td>
<td>279.3983</td>
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</table>
SIZE*NAV - multiplication of two variables. Continuous variable. It characterizes relation between SCA and ROA mediated by company size.

SIZE*ATR - multiplication of two variables. Continuous variable. It characterizes relation between ATR and ROA mediated by company size.

ENGINEER Dummy variable. It takes 1 if a firm belongs to engineering, 0 - otherwise.

CHEMICAL Dummy variable. It takes 1 if a firm belongs to chemical industry, 0 - otherwise.

PLASTIC Dummy variable. It takes 1 if a firm belongs to production of plastic goods, 0 - otherwise.

METALL Dummy variable. It takes 1 if a firm belongs to production of metal products, 0 - otherwise.

NMMINERAL Dummy variable. It takes 1 if a firm belongs to production of non-metal mineral products, 0 - otherwise.

<p>| | | | | |</p>
<table>
<thead>
<tr>
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<tr>
<td>SIZE*NAV</td>
<td>-23.56602</td>
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<td>5.657557</td>
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<td>ENGINEER</td>
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<tr>
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<td>.4344198</td>
</tr>
<tr>
<td>PLASTIC</td>
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<td>1</td>
<td>.1637168</td>
<td>.3701354</td>
</tr>
<tr>
<td>METALL</td>
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<td>.079646</td>
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<tr>
<td>NMMINERAL</td>
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<td>.2654867</td>
<td>.4417317</td>
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</tbody>
</table>

Sample is balanced. Companies are split almost equally on FDI. Approximately third part represents innovation-active firms. There is no dominance of any industry but production of metal goods is underrepresented. Companies represent 51 region of Russian Federation. This is more than half of its total quantity and 86% of GRP.

4. Results and findings

As economic crisis in Russia started at 2014 we take data on 2014 to analyze short-term consequences of the crisis and 2015-2016 data for analyzing long-term consequences and 2010-2013 to describe interrelations in pre-crisis economy. Separate calculations are made for time period 2014-2016 to analyze hypotheses 2a-c. For periods of 2010-2013 and 2015-2016 different types of models are tested. FE-model is better than two others. But as it excludes dummy variables and variables to check hypotheses are dummy ones so pooled regressions are presented. For crisis period 2015-16 FE-model is the best again but there are no differences
between RE-model and pooled regression. The same is for period 2014-2016. For 2014 it is OLS regression. Nevertheless significance of variables of interest is the same for all types of models. Results are shown in Table 2.

Table 2. Regression results

<table>
<thead>
<tr>
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<tr>
<td>ARP</td>
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<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Year dummies</td>
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<td>No</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>N</td>
<td>807</td>
<td>210</td>
<td>418</td>
<td>628</td>
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<tr>
<td>R² adj.</td>
<td>.33</td>
<td>.42</td>
<td>.28</td>
<td>.30</td>
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<tr>
<td>F-statistics</td>
<td>17.69***</td>
<td>8.31***</td>
<td>8.24***</td>
<td>12.55***</td>
</tr>
</tbody>
</table>

* *, **, *** means significance on 0.1, 0.05, 0.01 p-level respectively
PLASTIC is reference point for industry dummy variables.

Hypotheses H1a and H1b are not confirmed. On the contrary, performance of innovation-active companies doesn’t differ significantly from non-innovation companies immediately after economic crisis started. May be this is effect of inertia because before crisis performance doesn’t differ either. For the next time periods performance of innovation-active companies becomes significantly worse. Economic crisis doesn’t change the model of company’s growth. Size, ability to use resources efficiently and low level of debt keep being significant after crisis. But smaller companies receive advantage in mid-term period after crisis as SIZE*SCA variable becomes significant and negative. They are able to have greater debt and still be as effective as bigger ones. One of possible explanations is that smaller companies are more mobile while bigger ones can reap the rewards of returns to scale but they are more assailable to creditors because of greater share of fixed cost.

Regional variables are not significant before economic crisis. So hypothesis H2a is confirmed. But after crisis started, in mid-term period, companies situated in bigger regions also become significantly less productive. Regional knowledge-exploitation level doesn’t influence significantly on firm performance. So effects of local competition or network interaction are not pronounced. So hypothesis H2b is not supported. The same is true for level of knowledge exploration. It impacts on the decline of local companies but in short-term period only. But if a region possesses both competences its companies have competitive advantage. So hypothesis H2c is supported.
To conduct robustness check different variables are used. Instead of KEC we use KECS and instead of IETT*KEC IETT*KECS respectively. Also we use share of innovation-active companies (IATS) instead of IETT (innovation expenditures to total turnover of industrial enterprises ratio). It do not change results significantly and conclusions about hypotheses are still valid.

5. Discussion and conclusion

This paper is devoted to the problem of firm sustainability during economic crisis. The aim of it is to analyze could innovation activity of individual companies and regions where companies are situated sustain its performance. We hypothesize that if a firm is innovation-active it influences negatively its performance in short-term period and don’t influence in mid-term one. These hypotheses were not supported, but may be because of absence of strict definition of the period duration. May be strength of Russian economy is quite enough to sustain crisis for more than one year. But on the longer time period performance of innovation-active firms was worse. So it is necessary to test hypotheses on more durable dataset.

Also territory of a company affiliation could influence on its sustainability for many reasons. But pure ability to conduct R&D or use it is not significant factor of company sustainability. Only if both competences are well developed regional impact is significant. But it raises a question about influence of complexity of regional economy. If regional innovation system is able to generate and implement innovation projects it means that economy of such region is less dependent on external shocks.

The present study can be continued in the following directions. It is reasonable to add other variables. For example if a firm has crisis plan, its loss in terms of revenues or lay-offs are less than for firms which are not prepared [Penn, Schoen and Berland Associates, 2009]. The company de-facto can consist of several parts. In case that the division of the organization is based on the motives others, than improving the quality of management (for example, tax optimization, asset protection, etc.) or the firm is affiliated with big business or if it has state as one of the owners, real size and resource power of the firm could be skewed. State owner could
be the source of subsidies or public procurement contracts which could really support a company.

On the regional level effects of economic complexity should be studied. Diversified economy should be more stable than of more specialized regions. But regions with primary sector dominating economy could be more sustainable during crisis. Performance of companies situated in regions with weaker economy could be supported due to inter-regional effects. So it is necessary to include neighboring regions in the model.

The analysis presented here is limited by the data and the statistical models. First, the company's innovative activity is evaluated on the basis of such an indicator as the presence of patents in the company's assets. This approach has some advantages, the most important of which are the objectivity and ease of obtaining information. However, patenting is characterized by industry specificity. Protection of intellectual property rights may be exercised through know-how. The expenditures on innovative projects are an integral, accordingly more reliable indicator. Secondly, the findings of the study depend on the state of the investment climate in the region, on the quality of institutions, on the relationships between local and federal authorities, and on many other factors that are difficult to quantify. The same applies to the activities of firms. For example, it is difficult to reflect such parameters as the competitiveness of the firm's products, the quality of corporate governance, dynamics of the company's product market, and so on. Thirdly, the study concerns only Russia. The current crisis has economic reasons (as it follows from the discussion in the community of Russian economists), but it is strengthened by the actions of other geopolitical opponents. This prevents the normal recovery of the economy due to an artificial disruption of production and financial ties. Finally, not all variables are totally satisfactory. For example the age of a company could be biased. In some cases the company could be reorganized or assets could be transferred to the newly created organization formally disconnected with the previous one.
References


