TRANSFER REVENUES OF RESEARCH AND DEVELOPMENT ORGANIZATION (RTOs) IN TIMES OF ECONOMIC CRISIS

THOMAS WOLFGANG THURNER

Institute for Statistical Studies and Economics of Knowledge, Higher School of Economics, Moscow, Russian Federation
Thomas.wolfgang.thurner@gmail.com

Published 4 August 2016

Profit-oriented transfer activities have become a center piece of STI policies. There is little understanding tough of how companies facing financial headwind re-adjust their knowledge transfer activities in the light of economic downturn. This paper studies influence factors for transfer revenues during the years 2009, 2010 and 2012 in around 1000 Russian Research and Technology Organizations (RTOs). The data shows that in times of crisis, quality-related variables like scientific papers, patents or successful application for competitive research funds were no longer positively correlated to transfer revenues. Also recruitment strategies or long-standing relationships between customer organizations and RTOs had no influence. The paper concludes that RTOs are in a very weak position if economic outlooks are darkening and require public financial support to maintain their ability to continuously provide their services once until the economy will recovers.

Keywords: Research and technology organizations; public research organizations; technology transfer; Russian federation.

Introduction

External knowledge provides firms with access to increasingly difficult technologies and new ideas, either as a substitute for their own R&D or as an add-on (West and Bogers, 2014; Chuma, 2006; Laursen and Salter, 2006; Witzeman et al., 2006). With product development becoming faster and increasingly expensive (e.g., Luo, 2007), the number of firms seeking access to external knowledge has grown steadily (Galati, 2015; Arora et al., 2001; Hagedoorn, 2002; Amara and Landry, 2005; Chatterji, 1996). The emergence of open innovation as the dominant innovation paradigm has further increased the speed of this development and firms actively engage in the search for novel ideas and new technologies outside...
their immediate boundaries. This includes mainly actors along their own supply chain like preferred supplies, but also stretches towards customers (user-innovation) and third parties (e.g., Enkel et al., 2009). In line with transaction cost theory, firms choose between a continuum of mechanisms to govern such transactions (Bogers, 2012). Increasing attention is paid to the innovation potential of user-innovation which goes back to early works by Von Hippel (1978). See Fursov and Thurner (2016) for a recent study on user-innovation in Russia.

When newly acquired organizational capabilities build on rare, costly and difficult to imitate knowledge, such capabilities stand a good chance to result in superior performance (Lane and Lubatkin, 1998). Rothaermel and Alexandre (2009) suggest that for the US market, a 61% external sourcing of innovation maximizes the return on equity. While gaining access to new knowledge is a prerequisite for today’s innovation, the successful integration of this knowledge into decisions on a firms’ production lines is a non-trivial task. In consequence, efforts were directed towards studying how companies absorb new knowledge. The success and related costs of knowledge transfer was interpreted as a function of a company’s experience and absorptive capacity (e.g., Mansfield et al., 1979; Teece, 1976, 1977). Other contributions identified differences in transfer activities between science- and development-based regimes (e.g., Thurner and Zaichenko, 2014a, 2014b; D’Este and Patel, 2007; Bekkers and Bodas Freitas, 2008; Yusuf, 2008; Teitelman, 1994).

The inclusion of professional knowledge providers like Research and Technology Organizations (RTOs) or universities into innovation processes has a long tradition and became topical long before the emergence of the open innovation paradigm. Excellent tertiary educational institutes and research facilities were seen as drivers for regional competitiveness. Especially when the empirical literature established a positive relationship between investment in public science and economic returns, such as productivity growth (Adams, 1990) or new product and process development in firms, policy makers felt strongly about investing in such institutions. Still, with the emergence of the neo-liberal paradigm of new public management, publicly funded research had to prove its relevance — mostly in economic terms (e.g., Bryson, 2000; Gstraunthaler and Piber, 2008). As such, successful knowledge transfer activities from RTOs to firms are increasingly taken as a measurement of their relevance and as a proxy of how important their research activities actually are. Such a focus builds on the assumption that demand of firms for technology transfer activities is stable and only an outcome of the quality of the services offered. Still, there is little insight into how companies readjust their demand for transfer activities in the light of economic downturns as seen during the financial crisis of 2008–2009. When the financial crisis hit in full force in 2008/2009, the technological catch-up processes of new member states in

T. W. Thurner

Int. J. Innov. Mgt. Downloaded from www.worldscientific.com
by UNIVERSITY OF OREGON on 12/21/16. For personal use only.
Europe’s east were largely interrupted. Scholars voiced concerns that these countries might well fall behind their western European neighbours and that the already wide technology gap could increase even further (Archibugi and Filippetti, 2013). In Russia, the negative effects were eased by strong public spending. Still, enterprise related R&D spending declined rapidly.

This paper sets out to fill this void and studies how changing strategic positioning of firms facing financial headwind is affecting transfer revenues in RTOs and asks which properties of RTOs are connected with technology transfer revenues.

Russia provides an excellent environment for such a study. Although Russia’s system of science and technology took a different development path as most western states, today’s challenging environment for her RTOs is no different. Especially in recent times, the country struggled with linking its advanced basic science system to the needs of its manufacturing industry and closing the technology gap to the west. Russia’s innovation system is relying heavily on its 3500 active research and development organizations. The majority (55%) are classified as RTOs. They perform a vital bridging function for successful technology transfer by specializing in the creation and distribution of new knowledge and technologies. More than 40% are functionally connected with industries, employ half of all employees in the R&D sector and consume 64.2% of the national expenditure on R&D.

Science, Technology, and Innovation of Firms

Science and technology build on different institutional arrangements for the knowledge production process, the allocation of resources and their preferred transfer channels (Barba Navaretti et al., 1998). Generated knowledge in science is treated as a public good, which is why scientific institutions receive compensations from public funds through annual budgets or research grants. Scientific results are shared among the community through publications in respected journals, quality controlled by double-blind review processes. Technology, on the other hand, allows for the generation of property rights on generated knowledge through a rigid patent mechanism that can be traded through market-based transactions. This

---

1The term RTOs is here used to include public, semi-public and private research institutions. In line with EARTO is approach, we see their predominant activities in providing research and development, technology and innovation services to enterprises, governments and other clients. This contrasts with universities, whose main mission is education, and from enterprises which produce goods and services.

2During the USSR, most universities were discouraged to engage in their own research activities.
translates into economic profits and requires a close orientation towards potential customers (like manufacturing firms). Science and technology coexist in the same research field as researchers choose different institutional mechanisms, private versus public or market versus nonmarket. The reason for these choices rests in personal preference (individual risk aversion) or historical orientation of fields (see for example Carraro and Siniscalco, 2003).

The roles science and technology play has changed rapidly with the rise of the neo-liberal paradigm of New Public Management. The private sector, so the argument, ensures increased efficiency of resource allocation due to its orientation towards the market and its profit maximization paradigm. Consequently, policy makers required scientific organizations not to consume public funds but to demonstrate relevance through generated profits out of transfer activities of their research. Social benefits of scientific progresses became assessed by marketplace transactions (Bryson, 2000). Major stimulus for profit-making science came from the US Bayh–Dole Act of 1980, which granted universities the right to patent research results using Federal research funding, and to receive royalties on these patents (Mowery et al., 2001). For some, the Bayh–Dole Act provided the necessary legal security for private firms to buy into commercial development and application of the results of federally funded academic research (Mowery and Sampat, 2001).

R&D expenditure of firms on the other hand has been used as a proxy for a firm’s level of knowledge absorption (Narasimhan et al., 2006). Also Eurostat classifies (using NACE aggregations) industries by their technological intensity through different levels of R&D spending.

The Role of RTOs in Contemporary Innovation Management

The open innovation paradigm was first embraced by the high-technology industries and later spread out to various low-technology sectors (De Wit et al., 2007; Gassmann et al., 2010) and to small- and medium-sized enterprises (Chiang and Hung, 2010; Van de Vrande et al., 2009; Zeng et al., 2010). Among the preferred sources of external knowledge identified by researchers are suppliers (Li and Vanhaverbeke, 2009), customers (Gassmann et al., 2005; Grimpe and Sofka, 2009) and competitors (Lim et al., 2010).

As firms are seeking access to scientific findings or access to knowledge which allows them to learn to develop capabilities faster than their competitors (Dangello et al., 2010), scientific institutions have been identified as core innovation partners (Svetina and Prodan, 2008; Cassiman et al., 2010; Harryson et al., 2008). In fact, the role of universities and RTOs as a source of innovations and their role
in commercialization success of firms has attracted attention long before the OI paradigm was first described. For example, Jaffe quantified the value added of university developed technologies commercialized by firms in 1989, and Link and Rees studied this at the firm level in 1990. External knowledge from universities or RTOs shows different economic impacts compared with other sources. While information transfer from informal network and technology acquisitions have positive relationships with the technology innovation performance, R&D collaboration shows an inverted-U-shape relationship with technology innovation performance (Kang and Kang, 2010).

While universities as external knowledge providers have been well studied, RTOs have received surprisingly little attention. This is even more surprising as RTOs are often targeted by science and technology policies and are frequently used to strengthen links between industry and public research (Hagedoorn et al., 2000). Most insights into RTOs derive from studies on an international level from major (supranational) organizations, like the (European Commission, 2009), OECD (2002, 2003, 2009), or PREST (2002). RTOs pursue own projects, starting from basic research (blue sky) and applied research to product development or technical services and engineering (Mas–Verdu, 2007) and are often engaged in mission-orientated research programmes in emerging technologies, such as biotechnology or telecommunications. RTOs also play a vital support role in the ‘search process’ in which companies identify technological opportunities (Nelson and Winter, 1982; Eisenhardt and Martin, 2000; Teece 1986; Laursen and Salter, 2004). At the same time they act as a channel for “guiding” companies towards national priorities in science and technology (e.g., “green” technologies).

RTOs hold an advantage in effectively distributing the costs associated with the acquisition of technology and technology-related knowledge through transfer activities to different users and provide bridging functions for the dissemination and uptake of new technologies between science and their client firms as they realize economies of scale (Autio et al., 2004). For policy makers, RTOs have been seen as tools and channels for innovation policy through addressing market failures like barriers to access innovation. Also, RTOs play a vital role in fixing system failures by reorganizing the working relationship between RTOs, universities and firms and to promote awareness of potential innovation and market opportunities (Metcalf, 2005). Especially for low-technology producers, a close connection with policy makers is highly relevant and a reason for engaging in research cooperation with RTOs. See for example Thurner and Zaichenko (2014b) for agriculture, Thurner and Proskuryakova (2014) for oil- and gas producers and De Jong et al., (2006); Vanhaverbeke and Cloodt (2006) for the food industry. RTOs are often targeted by science and technology policies and are frequently used to strengthen links between industry and public research (Hagedoorn et al., 2000).
Research Question and Methodology

The focus on transfer activities valued at market prices has now become an unchallenged reality for most research organizations. Transfer offices have moved into universities, and scientific institutes face one or the other performance measurement that relates to profits generated out of transfer activities. This new paradigm has been even further embraced with public budgets at historic lows all over the world. However, there is little insight into how companies readjust their knowledge transfer activities in the light of economic downturn. Such insights are vital to understand how changing strategic positioning of firms facing financial headwind is affecting transfer activities. Only then, revenues out of knowledge transfer can be meaningfully interpreted. We ask how times of economic crises influence the generation of revenues out of transfer activities and which strategy could make RTOs less prone to a sudden decline in transfer revenues? Times of economic crises are trigger events in the restructuring of the economic system. Strategic positioning of firms or regions are reconsidered, and policy makers are likely to unite with industry players to find ways out of the misery. Solutions are often found in the modernizing production facilities or infrastructure.

Previous research approached the question of technology transfer through addressing only the receiving industry actors in the technology transfer process (e.g., Fontana et al., 2006), focusing on academia (Di Gregorio and Shane, 2003; Calderini et al., 2007) or combining both sides (Gilsing et al., 2011; Robin and Schubert, 2013; Thurner and Zaichenko, 2016). The present study models technology transfer through financial measures and connects these monetary dimensions to certain specifics of RTOs. Very few studies have approached technology transfer through revenues (e.g., Jensen and Thursby, 2001). Instead, the effect of R&D transfer to industries is measured indirectly through spill-overs, through patents and publications (Henderson et al., 1998) or contractual research (Zucker et al., 1998).

Determining transfer revenues in RTOs is not a trivial task. Besides technology transfer activities, non-R&D activities are of vital importance for the implementation and success of the innovation (e.g., Barge-Gil et al., 2008). Also, firms are not only interested in new information but will seek comprehensive service packages with non-R&D services (Preissl, 2006). However, not all such services offered by RTOs are connected with innovation, for example expert opinions in legislation processes or “due diligence” studies to support the decision process in venture capital operations. In fact, this enhanced service character of RTOs makes them difficult to distinguish from other knowledge intensive business services (services for supporting product development, testing or certification services, or prototyping services).
This analysis is based on three datasets collected in 2010, 2011 and 2013 (reporting years 2009, 2010 and 2012, respectively) under the project “Monitoring of innovation activity of innovation actors” conducted in the framework of the HSE Basic Research Program. Responding organizations represent Russian (whole-country sample) research and development organizations excluding universities and institutes of the Russian Academy of Sciences (the latter are focused mainly on basic research). A detailed questionnaire was sent out to RTOs, followed by a telephone call to check on certain areas that were unclear or to ask for further information. Thereby, a very high response rate of 76-84% was achieved, which resulted in a final sample size of 1001 RTOs in 2011 and 979 RTOs in 2013 which represents almost half of the total population of RTOs (non-university and non-academy RTOs). The high response rate is also owed to a support letter by the Ministry for Education and Science of the Russian Federation. The 2010 survey was a pilot with a sample size of more than 305 observations (with same selection criteria). The sample representation criteria were set to keeping the geographic proportions, but the sample selection on the regional level was random.

Regardless of the high response rates, some RTOs did not respond to all the questions and only partially filled the questionnaire. On the other hand, the respondents (which were directors or vice-directors of the responding RTOs) found filling the quantitative questions most difficult. To keep our valid samples as large as possible quantitative variables with a high likelihood of failure were avoided and instead fairly straightforward concepts like intramural R&D expenditure, RTO size, turnover, etc were used. Due to the absence of normal distributions in most of our independent variables, Kendall correlation coefficients were applied. A Harman single factor test showed no evidence of common method bias. As the list of variables is extensive (most variables are combined in reducible blocks, some variables are duplicated), variables with missing values were excluded. The tick-box questions include several groups: ownership type of RTO (public, private), level of novelty of goods and services created using RTO’s technologies (totally new or not), quality control side in the TT transactions (RTO, customer, third party), tools used for quality control (local, national and international standards, specific requirements), participation of RTO in groups and networks (institutionalized or not), etc.

The statistical analysis is based on five linear regressions. These were planned not as structured models, but as a tool to observe possible interdependence between variables (LOGs were used for specific non-normally distributed variables). Therefore, the focus rested on separate significant coefficients rather than on the whole-model quality statistics (like r-square). For all cases, LOG revenues from technology transfer per researcher served as the dependent variable. The first regression examined the impact of possible control variables (control by size,
R&D scales, by the target sector). The other four linear models reproduced relationships between relative technology transfer revenues and particular strategically-related features of RTOs: attraction of the public funding, collaboration activities, R&D performance, and recruitment activity.

Hypotheses Development and Testing

RTOs are funded through a variety of possible income streams, including membership subscriptions, fees-for-services, government core funding, and competitive contracts for public grant-funded R&D projects (Hales, 2001). Funding sources have been associated with different activities. While the German Fraunhofer institute receives a 30–40% core funding, they engage in substantial amounts of basic and applied research. In Sweden, on the other side, where core funding is in the 10–15% range, RTOs are more engaged with experimental development and service provision. Until 1991, the funding of Russian RTOs was based on revolving budgets. Subsequently, a funding distribution system aimed at selecting excellent research proposals became more dominant. The research projects are suggested by firms or RTOs and submitted for funding to the relevant agency. Despite the changes, government remained the main resource of R&D funding. In 1995 this share fell to 61.5%. Meanwhile, in 2008–2012, the share of government sources in the total R&D expenditure averages 67% (Science Indicators, 2014).

RTOs often recruit the necessary staff or invest in equipment only once customer organizations agree on research or transfer activities. Public funds are tendentially long-term oriented, respectively have a set time frame and give RTOs the necessary security for planning and to build up competences. This is especially valuable for RTOs if demand from firms is declining.

H1: In times of crisis, the attraction of a higher level of competitively distributed public funds is positively related to revenues of transfer activities.

The factors which affect knowledge transfer in organizations have long been in the focus of attention (see, e.g., Bonaccorsi and Piccaluga, 1994; Argote, 1999; Abreu and Grinevich, 2013). Knowledge transfer is based on very heterogeneous processes, depending on the nature of the knowledge and the industry (Benneworth and Jongbloed, 2010; Gulbrandsen et al., 2011; Thurner and Zaichenko, 2014). Especially if the knowledge is not appropriate for the required task or cannot be adapted to the recipient’s context, these activities may affect the flow of business and even threaten the company’s competitive position (e.g., Baum and Ingram, 1998).
Earlier works focused on organizational aspects of knowledge transfer within companies and found evidence that a culture of sharing strongly facilitates the flow of new knowledge (Bartlett and Ghoshal, 1986; Mansfield and Romeo, 1980; Davidson, 1980; Birkinshaw and Morrison, 1995). Also, particularities of individuals or organizations are studied as determinants for success in transfer activities (Boardman and Corley, 2008; Ponomariov, 2008). In this respect, findings suggest a high importance of trust as an enabler of knowledge transfer (Davenport and Prusak, 1998; Levin et al., 2003; McEvily et al., 2003; Levin and Cross, 2004; Mooradian et al., 2006; Darvish and Nikbakhsh, 2010; Holste and Fields, 2010). This has been proved to be valid in different context such as mentoring (Dymock, 1999), in relationships between consultants and clients (Ko et al., 2005; Ko, 2010), or in inter-organizational cooperation (Niui, 2010).

Of great interest for the knowledge transfer literature is the collaborative development of knowledge between alliance partners (e.g., Inkpen, 1996, 1997; Khanna et al., 1998; Doz, 1996; Simonin, 1997). Hansen (1999) for example found that infrequent and distant relationships (so-called weak ties) between the actors might be beneficial if the knowledge was not complex and codifiable. However, explicit knowledge requires to be tacitly understood and applied (Polanyi, 1966). This is even more important if knowledge transfer happens across cultural boundaries, which is a result of globalization (McDonough et al., 2001). If the knowledge was of considerable complexity and not codified but required a fine-tuned adjustment to the recipient’s environment, success depended on long-term relationships. These supporting activities could quickly be put on hold when the economic output would bleak.

**H2:** *In times of crisis, long-standing collaboration between RTOs and their customer organization will result in higher revenues per researchers.*

The switch to a technology-based transfer regime leads to rising transaction costs associated with patenting and licensing which will in fact hamper especially long-term oriented exploratory research programs. The focus on profit-generating market-oriented activities further endangers the university’s traditional roles like teaching (see e.g., David, 2004; Nelson, 2001; Just and Huffman, 2009). Adams and Griliches (1998) studied research output and advanced degrees produced by universities and found decreasing returns to scale at the level of the individual universities but constant returns to scale at the aggregate level. Coupe’ (2003) used Poisson and negative binomial models for estimating the university patent production functions and also found decreasing returns to scale at the institutional level. Foltz et al. (2007) modelled cost functions for patents, publications, and doctorates for university research and found the presence of economies of scale.
Scientific papers and patents are not only a measure for efficiency, but also for quality of scientific activities. Scientists operating at the knowledge-frontier will make their activities visible through publications and registered patents (Gilsing et al., 2011). When demand for knowledge transfer activities will decline, the few remaining customers will seek services of the most advanced RTOs.

**H3:** In times of crisis, the production of scientific papers or the registration of patents has positive effects on the revenues of technology transfer.

With more and more competition between peers, RTOs became engaged in best-practices for quality of internal operations and customer management. To facilitate learning activities among RTOs, many got together in various professional associations (see WAITRO at the global level, or national ones like AIRTO in the UK).

**H4:** In times of crisis, transfer revenues will increase with common industry standards over international standards.

In contrast to universities, the RTO’s mission is to generate knowledge aimed at enhancing firms’ competitive advantages as their unique set-up and industry links allow overcoming many of the institutional barriers to knowledge transfer (Autio et al., 2004). In contrast to universities, RTOs not only possess the necessary applied knowledge, they are also better at understanding and relating to specific firm needs (Arnold et al., 1998; Bessant and Rush, 1995; Bruce and Morris, 1998; Tether, 2002). In fact, previous contributions such as that of Brockhoff (2003) showed that RTOs fine-tune their transfer approach to specific target audiences, including the research design and methods they use. RTOs are also strongly engaged in education and training activities (e.g., supervision of PhD candidates and hosting post-doctorate researchers, skills development and on-the-job learning). The success of RTOs depends strongly on its workforce (Barge-Gil et al., 2008).

**H5:** In times of crisis, transfer revenues will depend on the recruitment of more industry experts.

**Controlling for size and sector**

To cater for size effects we normalize revenues by the number of employees instead of total amount. The ability to take on very large research projects might also affect the productivity-levels of its R&D staff. Also, higher intramural R&D expenditure per R&D staff should naturally result in higher revenues (unless R&D activities are unprofitable). Due to a decreasing marginal productivity per
researcher (after some critical point each additional researcher hired does not increase the outputs and revenues), we expect a correlation between zero to slightly negative. And indeed, we find proof for a non-positive elasticity between the size of R&D institutions and their transfer revenues per researcher. Although, the absolute value is neither very high nor significant, it shows a remarkable decline in 2010 with a subsequent recovery. This dynamic might be linked to a drop in gross R&D expenditure and transfer revenues in constant prices together with R&D staff layoffs in 2009–2010. We further expect a positive relationship between revenues from technology transfer per researcher and intramural enterprise R&D per R&D staff. If an RTO has previously attracted funding from RTOs, it is likely to result in a closer connection between the RTO and its funder. Also, some RTOs belong partly to companies. In this case, more enterprise R&D funds would be available to them. And indeed, the data proves a significant and positive correlation. Finally, revenues from transfer could vary by sectors. The focus of knowledge transfer has traditionally been on new product development of manufacturing companies, as most transfer activities happen in natural and technical sciences (engineering, chemistry, physics) (Schartinger et al., 2002, p. 317). However, knowledge intensive business services and creative industries increasingly seek consulting and advice from knowledge providers to improve their innovation performance (Jaaniste, 2009). Recent studies have shown a potential market also in humanities and in the social sciences, mostly in the form of teaching courses, direct consultancy and participation in networks (Gascoigne and Metcalfe, 2005; Hughes et al., 2011). No correlation with technology transfer per researcher and sector variables have been found (Table 1). The sectors in which customer organizations were active appeared insignificant as predictors for relative revenues from technology transfer.

Table 1. Linear regressions for control variables.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Reporting years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2009</td>
</tr>
<tr>
<td></td>
<td>Beta</td>
</tr>
<tr>
<td>LOG R&amp;D staff total headcount</td>
<td>−0.167</td>
</tr>
<tr>
<td>LOG intramural ERD per R&amp;D staff</td>
<td>0.309</td>
</tr>
<tr>
<td>Primary sector transfer</td>
<td>0.027</td>
</tr>
<tr>
<td>Manufacturing sector transfer (dummy)</td>
<td>0.187</td>
</tr>
<tr>
<td>Services sector transfer (dummy)</td>
<td>0.064</td>
</tr>
<tr>
<td>Other sectors transfer (dummy)</td>
<td>−0.001</td>
</tr>
</tbody>
</table>

*Note:* Dependent variable: LOG revenues from technology transfer per researcher.
Results of the Study

Attraction of public research funds

A larger share of annual R&D funding gives the RTO greater security in their planning and eases pressure to generate revenues through technology transfer. Transfer revenues per researcher (with the same size of R&D organization and level of intramural enterprise R&D staff) show significant correlations with the shares of annual public funding and competitive funding in an RTO’s R&D expenditure (Table 2). Interestingly though, the data from all three years indicate a negative correlation. For 2009–2010 the coefficient fell significantly and did stay low in 2012. In all three years under discussion, those RTOs with a share of public funding higher than average do generate in turn lower transfer revenues. This might indicate that these RTOs are not geared towards knowledge transfer and rather engage in classical science. It could also be indicative that these RTOs do not have to generate revenues as public funds are available. The opposite is true for RTOs with a higher than average share of competitive funding. Competitive funding depends on successful research proposals which are often submitted together with partners from industry. Their beta is strongly positive before and after the crisis, but insignificant in the crisis year of 2010. Many R&D organizations failed to enter into new contracts with enterprises in 2009 or could not prolongate existing ones, so in 2010 their R&D funds became biased towards government funds. These failures were connected mainly with strongly decreasing R&D expenditures of firms and did not depend on R&D competitiveness of research institutions. Even the most competitive and successful RTOs were not able to generate revenues accordingly. In 2012 the betas did not reach the levels of 2009 and probably, the situation did not stabilize until 2012. H1 had to be rejected.

Table 2. Linear regressions for attraction of public research funds.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Reporting years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2009</td>
</tr>
<tr>
<td></td>
<td>Beta</td>
</tr>
<tr>
<td>LOG R&amp;D staff total headcount</td>
<td>−0.115</td>
</tr>
<tr>
<td>LOG intramural ERD per R&amp;D staff</td>
<td>0.172</td>
</tr>
<tr>
<td>Public funding share $\geq$ median (dummy)</td>
<td>−0.243</td>
</tr>
<tr>
<td>Competitive funding share $\geq$ median (dummy)</td>
<td>0.387</td>
</tr>
</tbody>
</table>

Note: Dependent variable: LOG revenues from technology transfer per researcher.
Long-standing collaborations

RTOs started transfer projects from early research stages or offer ready-to-implement technologies. Such transfer activities may follow customers’ initiatives or RTOs approach their potential customers on their own initiatives. The questionnaire checked for institutional ties with customer organizations which would bring down transaction costs and improve technology transfer performance of RTOs. Indeed, in 2009 institutional ties with enterprises did increase revenues from technology transfer per researcher (Table 3). However in the next year, when the economy reacted to the crisis, this small positive effect vanished. At least in the mid-term, the crisis destroyed profits from ties between actors. Many host enterprises (even ones integrated in big associations and holdings) reduced their technology purchases from their subordinated RTOs, so the latter had to search for external customers elsewhere. H2 had to be rejected.

Scientific outcome

Scientific publications and patents registered by research organizations are seen as indicators for their transfer capacity. Such forms of explicit knowledge dissemination signal a well-developed intellectual base of R&D activities to potential customers. However in times of economic crisis, patents might lose their competitively advantageous function. In 2009, elasticity between transfer revenues per researcher and publications per 100 researchers was positive and rather significant (Table 4). In 2010 and 2012 this significant relationship disappeared as RTOs with a high number of patents faced negative influences on transfer activities. Many technology transfer projects would discontinue in 2009 and RTOs protected R&D results they had created thus far. Hence, in 2010 and 2012 a slight positive but insignificant correlation can be seen. In 2010 and later publication and patenting

<table>
<thead>
<tr>
<th>Predictors</th>
<th>2009 Beta</th>
<th>Sig</th>
<th>2010 Beta</th>
<th>Sig</th>
<th>2012 Beta</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOG R&amp;D staff total headcount</td>
<td>-0.156</td>
<td>0.168</td>
<td>-0.111</td>
<td>0.067</td>
<td>-0.141</td>
<td>0.042</td>
</tr>
<tr>
<td>LOG intramural ERD per R&amp;D staff</td>
<td>0.310</td>
<td>0.007</td>
<td>0.257</td>
<td>0.001</td>
<td>0.320</td>
<td>0.001</td>
</tr>
<tr>
<td>Zero-stage collaboration (dummy)</td>
<td>0.036</td>
<td>0.547</td>
<td>-0.031</td>
<td>0.648</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer’s initiative (dummy)</td>
<td>-0.046</td>
<td>0.446</td>
<td>-0.003</td>
<td>0.970</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institutional ties with customers (dummy)</td>
<td>0.164</td>
<td>0.139</td>
<td>0.071</td>
<td>0.237</td>
<td>0.022</td>
<td>0.750</td>
</tr>
</tbody>
</table>

Note: Dependent variable: LOG revenues from technology transfer per researcher.
activities did not contribute to transfer revenues anymore. R&D organizations with
good academic background switched to publicly-funded research while sectoral
research institutions paid more attention to reliable and less knowledge-intensive
activities like engineering services (their impact to technology transfer revenues
became significant in 2010 and grew by 2012). H3 had to be rejected.

Quality control
During 2009 quality control standards were of little importance as technology
markets were still relatively stable. This changed in 2010, when long-term ties and
channels for transfer activities were suddenly interrupted and companies were cut
off from the exchange of information about technology projects. During these
times, transfer activities reverted back to commonly accepted national standards as
the dominant measurement for quality control. This system of standards was de-
veloped in the former Soviet Union and served as a uni-
fied tool in the command planning system. Its quality standards are simple and universally applicable in any
sector and any type of organization. These sets only served as temporary solution
as its level of complexity does not suffice to guide particular production processes.
Moreover, it is incompatible with contemporary international quality standards.
Consequently in 2012, RTOs and receiving organizations reverted back to both
international and sectoral national standards. H4 was supported.

Recruitment strategy
Transfer activities rely on human skills and competences. RTOs in science-based
transfer regimes usually hire new qualified researchers from other research insti-
tutions and universities and/or promote young researchers graduating from univer-
sities. Their recruitment strategy of university graduates is expensive as

<table>
<thead>
<tr>
<th>Predictors</th>
<th>2009</th>
<th>2010</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOG R&amp;D staff total headcount</td>
<td>0.071</td>
<td>-0.115</td>
<td>-0.101</td>
</tr>
<tr>
<td>LOG intramural ERD per R&amp;D staff</td>
<td>0.296</td>
<td>0.231</td>
<td>0.321</td>
</tr>
<tr>
<td>LOG publications per 100 researchers</td>
<td>0.306</td>
<td>0.034</td>
<td>0.018</td>
</tr>
<tr>
<td>Patent applications &gt;= 5 (dummy)</td>
<td>-0.272</td>
<td>0.030</td>
<td>0.019</td>
</tr>
<tr>
<td>Providing engineering services (dummy)</td>
<td>0.104</td>
<td>0.145</td>
<td>0.221</td>
</tr>
</tbody>
</table>

Note: Dependent variable: LOG revenues from technology transfer per researcher.
additional training efforts (training and supervising activities) are required. To attract researchers from other RTOs, higher salaries and better work conditions need to be offered. The model shows that immediately after the crisis none of these two strategies did contribute to transfer revenues (Table 5). However, by 2012 research organizations increased their intellectual and human resources to remain competitive in the long run. By this year impact of hiring HEI graduates and researchers from other RTOs has grown both in intensity and significance. Recruitment of university faculty staff, on the contrary, lost in significance.

Attracting specialists from enterprises (engineers, designers, technologists, technology project managers, etc.) generates various advantages for the RTO. Such employees understand decision making processes in companies and find it easier to communicate with their company peers. In 2009 such a recruitment strategy showed a strong positive relationship with transfer revenues per researcher. In the following year the actual transfer performance did not depend on intellectual background or human resources of RTOs, but was defined by residual innovation activity in their customers’ sectors. Therefore significant influence of recruiting enterprise specialists disappeared. This trend reversed in 2012 and probably will continue to recover in the years to come. H5 had to be rejected.

**Conclusion**

This paper studies how technology transfer revenues by RTOs are affected by times of economic crisis. The observations were collected before, during and after the financial crisis that struck in the second half of 2008 and extended into 2009.
Indeed, the data revealed great influences on transfer revenues and observed strategies of RTOs. Especially properties that are indicative for excellence in science and technology are losing importance in generating transfer revenues. Also, the degree of competitive funds an RTO has won no longer could be translated into transfer revenues. This is surprising as such competitive funds are seen as a mean for governments to fund activities that have a connection with industries. The same is true for high quality research papers or registered patents. What under normal circumstances signal excellence in science and technology loses its appeal in times of economic crisis. Sure, patents are a lagging indicator and also in Russia — like in many emerging markets — patenting is still not a fully trusted means of intellectual property protection.

Strategies connected to excellence in science and technology production are not the only ones that fail. When economic sentiments are high, RTOs recruit enterprise specialists to facilitate the communication with clients and to have greater insights into decision-making processes in firms. These experts also help with facilitating the integration of innovations in receiving firms. This strategy also loses its appeal as the positive correlation between enterprise specialists an RTO recruits and the transfer revenues fades. Instead, the RTOs hired HEI graduates, which are comparably cheap and help with further scientific development. Another aspect is noteworthy. Long-standing relations with the customer organizations that RTOs managed to establish or even belonging to the same owners then the client firm has no influence.

The strategies that Russian RTOs have chosen — at least on the short term — are to either orient themselves towards public funds or to provide knowledge intense services to their customers. This flight to security is understandable, but has negative consequences on the mid- to long run. It is likely that vital capacities are lost and the ability to upgrade production technologies in manufacturing firms is getting increasingly difficult. Especially policy makers will search for ways to kick-start economic growth through providing support measures for manufacturing forms to upgrade their production facilities. With technology transfer capacities and talent lost in RTOs, firms may well struggle to find the necessary support to turn financial aid into productivity gains.

What do these findings imply for the comparability of technology transfer revenues? As described in the introduction, policy makers and public administrators see such market-oriented values as a well-suited proxy for the quality of science and technology production in RTOs. The findings presented in this paper demand caution. While transfer revenues surely are an indicator of demand, these metrics need to be interpreted in the light of greater economic forces that impact the technology transfer. Here, further research would be required to see the sensitivity of certain industries to economic downturns. Some industries like Russia’s
strong extractive industry might further be influenced by volatility of commodity prices.

Although some influence of the economic crisis was expected, these findings indeed are puzzling. For RTOs, an economic crisis as seen in 2008 and 2009 has in fact dramatic consequences as they seem to be in a very weak position if economic outlooks are darkening. This vulnerability might well be further enhanced by the economic set-up of Russia with competitive advantages in classical low-technology industries. There, competition is fierce and profit margins are tight. In difficult times, producers are most likely forced to cut back on spending with immediate effect.

As their services are vital for a recovering economy, RTOs as multipliers of production-oriented knowledge are predestined as addressees for public support measures. However, the question remains which tools would best be suited. Raising more science funds leads to a reorientation of RTOs towards scientific production and away from technology development for immediate transfer. Co-investment activities through public funds could reduce the economic risk of research and technology transfer. However, in times of crisis it seems that firms reduce their willingness to invest in such new technologies to zero and rather focus on their established markets. Also direct payments towards firms are a questionable means as it is unlikely that these public funds could instigate real demand. Support measures for RTOs to help kick starting the economy could prove a rich field for further research, especially in the light of still very low growth rates.

Acknowledgement

This study was conducted within the framework of the Basic Research Program at the National Research University Higher School of Economics (HSE) and supported within the framework of implementation of the HSE 5-100 Program Roadmap.

References

Abreu, M and V Grinevich (2013). The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities. Research Policy, 42(2), 408-422.


Darvish, H and R Nikbkakhsh (2010). Studying the relations of social capital factors with knowledge sharing: A case study at research department of IRIB. Transylvanian Review of Administrative Sciences, 6(31), 28–47.


European Commission (2009). Non University Research Performing Organisations: Who are they? What are their Challenges in ERA?


Hales, M (2001). *Birds were Dinosaurs Once: The Diversity of Evolution of Research and Technology Organisations*. UK: CENTRIM, University of Brighton.


Li, Y and W Vanhaverbeke (2009). The effects of inter-industry and country difference in supplier relationships on pioneering innovations. Technovation, 29(12), 843–858.


innovation in SMEs: Trends, motives and management challenges. Technovation,
29(6), 423–437.
Von Hippel, E (1978). Successful industrial products from customer ideas. The Journal of
Marketing, 39–49.
West, J and M Bogers (2014). Leveraging external sources of innovation: A review of
research on open innovation. Journal of Product Innovation Management, 31(4),
814–831.
Harnessing external technology for innovation. Research-Technology Management,
49(3), 19–27.
Research Policy, 37(8), 1167–1174.
Zeng, SX, XM Xie and CM Tam (2010). Relationship between cooperation networks and
Spillovers or markets?. Economic Inquiry, 36(1), 65–86.