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EXPLORING INNOVATION MODES OF RUSSIAN COMPANIES: WHAT DOES THE DIVERSITY OF ACTORS MEAN FOR POLICYMAKING?

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Recent studies of innovation behavior characteristics focus on analysis of microdata (enterprise level) as the key instrument to reveal facts and hypotheses describing the innovation activities under diverse economic, political and infrastructural conditions. This paper applies the state-of-the-art innovation modes approach [OECD, 2008] to provide insights on the Russian innovation environment, highlighting the variation of innovation strategies across sectors of Russian industry. Cross-country comparison based on the OECD data and Russian firm-level findings is presented along with the discussion of possible development of systemic instruments and evidence-based methods for policymaking.

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1. Introduction

Resent research on trends in economic growth patterns testifies the presence of certain common generalities, including the growing importance of science and innovation as a major factor of social and economic progress [OECD, 2008]. Sustainable and high economic growth rates, as well as improved (or even intact) positions in the world labor differentiation process do hinge on the availability of efficient mechanisms for continuous replenishment of knowledge and integration of scientific achievements in high-tech products and services. As far as Russia is concerned, the pressing need for researching problems of the innovation process stems both from obvious the external challenges and the complex of domestic factors. Despite eight years of fast growth, as shown by many indicators reflecting the level and prospects of its economy, Russia has actually failed to develop an efficient National Innovation System (see [Gokhberg, Roud, 2012] for discussion). Moreover, the industry's structural misbalances and technological lags, fragmented institutional links, and low output of the science sector make Russia's standing extremely vulnerable and unsound from a global perspective and due to the world crisis the gap is even likely to grow.

In fact, most Russian companies have failed to acquire solid strategic interest to generating and implementing innovations, be it R&D or experimenting or acquisition of new technologies and IP rights. The innovation expenses still concentrate on purchasing machines and equipment, mostly abroad. The efficiency of networking with other economic entities, including research centers and universities is still quite low (discussed e.g. in [Meissner, Zaichenko, 2012]). Stifled by legal, administrative, financial and other limitations, organizations and enterprises often use innovation behavior models and strategies that are unproductive in generating knew knowledge.

The scientific literature has accumulated a lot of facts and hypotheses describing the innovation activities under diverse economic, political and infrastructural conditions. This article focuses on analysis of microdata (enterprise level) and its state-of-the-art methods adapted to the Russian environment. It is a case of possible creation and application of a system of instruments (hypotheses, models, indicators) for application of evidence-based methods in the survey of innovation activities, including the spread of innovation models behavior and the enterprises' proclivity to various types of innovation modes (or regimes).

As a special branch of analytical work, the empirical studies in the innovation area originate from the mid-20th century. Their outputs produce insight into a number of areas – from the nature of innovation proper and companies' economic dynamics to revealing the typology of the innovation activity forms, identification of the activities' regulation specifics and pinpointing the state priorities for promotion of a competitive environment.

The advanced analytical apparatus, ultimately based on the evolutionary economics ideas and the related concept of the innovations' systemic nature [Schumpeter, 1934; Nelson, Winter, 1989; Kline, Rosenberg, 1986, et al.], provides for construction and classification of models that combine econometrics and heuristic methods of data analysis for evaluating the particular preferences in the innovation strategies. Within this general context, the innovation survey acts as a kind of a mirror for scrutinizing the specifics and generic features of the existing system and is deemed vital for construction of efficient regulation mechanisms.

2. Diversities of innovation strategies

The construction and classification of models of companies' innovation behavior is a persistent topic along the entire history of the innovation theory development. The demand for novel approaches in this area primarily stems from researchers engaged in development of structural schemes that would account for the great diversity of mechanisms and methods in various innovation activities. Policy developers also need an assessment of the innovation system effectiveness, as they increasingly design and implement the regulatory mechanisms on the basis of discernible indicators.

Evolution of the methodology for innovation studies has been accompanied by the deepening comprehension of motivation in the companies' behavior. At the same time, the emergence of the increasingly intricate classification methods can be traced back to the more widespread availability and accessibility of empirical data. At a certain moment, their structural complexity and volume have made it possible to describe in a sufficiently inclusive manner the assortment of theoretical concepts used to build the modern idea of innovation, both on the sectoral and individual levels.

The world's scientific literature on innovation theory has paid reasonable attention to the diversity of mechanisms for the implementation of new knowledge, explicitly expressed in various strategies and achievements of companies. One of the best known and most elaborate theoretical and empirical constructions in this field is the approach that hinges on the concepts of the technological regimes and technological trajectories.

The technological regime concept surfaced in the 1980s as a tool for analysis of the diverse companies' behavior along the innovation and competition lines. It is based on the idea that competitive positions depend on correlation between the company's organizational structure and strategy and the technological, socio-economic, sectoral and other limitations (external and internal). The notion of *technological regimes* (or *technological paradigms*) [Dosi, 1982, 1988; Malerba, Orsenigo, 1993; Nelson, Winter, 1982; Winter, 1984] has undergone detailed analysis later as well. The technological regime characterizes the operation environment for a company in a certain economic sector in the terms (measurements) of its potential, alienability, cumulativeness and complexity of the technology base. In substance, the concept is similar to the Schumpeterian regimes of technological competition (see Table 1).

Table 1. Approaches to Describe Innovation Behavior Specificities

Diversity in innovation behavior	**Aggregation level**	**Defining measurements**	**Approaches used**
Technological competition regimes: Schumpeterian competition of Type 1 (entrepreneur) and Type 2 (competition)	Economy sector	Inflow of new economic actors; innovation activity and its concentration; stability in hierarchy of key innovators.	Sectoral-level taxonomy (Pavitt's taxonomy; sector classification based on level of technology intensity)
Technological paradigm (or technological regimes, technological trajectories)	Economy sector	Consistency and generality of the knowledge base within the sector; ability to prevent knowledge dissipation by IP protection mechanisms; cumulativity of innovation activities at the company level; technological opportunities (level of potential profits from innovation investments).	
Innovation behavior outputs	Company	Innovation novelty; share of innovation products in the turnover; codified outputs of knowledge generation; their outflows.	Innovation modes, heuristic classifications of innovation behavior.
Resources and mechanisms of companies' innovation behavior.	Company	Innovation intensity; structure of expenses; interaction with other participants of the innovation process.	

One of the best known attempts to formalize the sectoral specifics of innovation has been the classification of their technology level developed by the OECD [Hatzichronoglou, 1997]. Its major function is in discernment of high-tech sectors that are leaders in intensity of innovation processes and new market development. Describing the sector types, the OECD classification uses only one measurement, namely, the R&D expenditure intensity. The empirical analysis produces three main classes of manufacturing sectors– high-tech, medium-tech and low-tech. According to the classification's underlying concept, it is the high-tech companies that are most dynamic in international trade; offer best conditions for their workers and stimulate development of adjacent sectors. In other words, the high-tech enterprises are considered as the locomotives of the innovation growth.

A major step to alternative understanding of the diversity and complexity of the innovation behavior was the emergence of Pavitt's taxonomy [Pavitt, 1984] based on the analysis of companies' technological development trajectories. The approach additionally accounts for indicators that describe the innovation adaptation process[2] including the sources of technologies in use, mechanisms for obtaining new knowledge and technologies, economic potential (company size, key profile, etc.). All in all, 26 sectors were scrutinized and split into three large groups by the dominating type of innovation behavior:

Science-based sectors – dominated by companies that feature high internal R&D costs and vigorously collaborate with universities and research centers (intersection with the high-tech group to the OECD classification);

Production-intensive sectors – include companies of two subtypes: 1) *scale-intensive companies* that feature significant scope of in-house R&D meant to realize process innovations and scale down costs; 2) *specialized suppliers* that focus on product innovations for other sectors. Mostly, these are small- and medium-size companies;

Supplier-dominated sectors – comprise companies characterized by sluggish in-house generation of knowledge. They specialize in providing demand for new technologies, i.e. creation of stimuli for further innovation development in sectors linked to *suppliers.*

The essence of Pavitt's approach is in classification of the sectors' functional designation, as he has identified companies at the pinnacle of technological development and proved the theory of support industries that make possible the circulation of new progressive technologies. In fact, these companies make the key factor of the economic growth and the technological regime change.

Further elaborations of the above approaches also cover the national level. In Italy, on the basis of the evolving monitoring system for the services sector, an expanded classification was created to differ from that offered for the processing industry [Evangelista, 2000]. For the first time such company types as *technology users* were defined to correspond to the Pavitt's *supplier-dominated companies.* Their strategy is based on capital input in purchase of new equipment. There are also some other remarkable company groups: science-and-technology-based services companies in the peak of knowledge generation activities; large-scale investors in software who are both interactive and IT-based; technical consultancies orientated to generation and distribution of technological innovation.

[2] The experiment covered data representing 2000 cases of successful innovation adaptation in the UK industry from 1945 to 1979.

3. Innovation Modes: definitions and interpretation

The concept of inseparability between differentiation of functional roles of different innovator types and visible characteristics of their behavior, pioneered by Pavitt's methodology, has made ground for an entire school of classification approaches. Multiple statistical surveys and plentiful empirical data ensures a classification analysis on a sufficiently detailed level.

The following influential papers in the area should be emphasized: multidimensional microdata analysis supporting Pavitt's basic conclusions on diversity and stability of innovation behavior types [Cesaratto, Mangano, 1993]; microdata cluster analysis that has provided the unassailable proof for the diversity of innovation activity models in various sectors, and within the same sector [Arvanitis, Hollenstein, 1997, 2001; Archibugi, 2001]; classification of companies' innovation behavior types for immediate validation and construction of technological regimes (as per classical definitions of technological regimes and technological trajectories) [Castellacci, 2007].

The microdata-based classification practice positively confirms the existence of noticeably identifiable types of innovative behavior. It has been clearly shown that firms of a similar class in different sectors often display more resemblance in their innovative behavior than the same-sector companies that belong to different types (note that in certain cases the firms' behavior was markedly influenced by sectoral specifics). However, implementation of the microdata-based approaches involves major methodological and methodic difficulties, which basically surface in attempts of comparative analysis. Resting on an elaborate combination of statistical and heuristic methods, this methodological complexity hampers replication of research on new sets of data (e.g. for other countries). One more problem lies in the use of different theoretical concepts. The final clusters may turn unstable to complicate the use of obtained results. In many cases, researchers have to develop theoretical constructions and tentative instruments for each classification from scratch.

The above and other limitations, as well as the aspiration to adapt new innovation data sources, give a thrust to further the 'innovation mode' concept. The essence of the approach is in application of predetermined classifying rules based on the available information about the nature and efficiency of the innovation behavior, and in creating a typology basically targeted on the inter-country comparisons appropriate for generating recommendations on regulation decisions. Specifically, relevant work is underway within an OECD research project on analysis of microdata in the innovation area (OECD

Microdata Project) [Innovation in Firms, 2009]. It offers two key measurements for companies' innovative efficiency, i.e. the innovation novelty level and presence of the knowledge generation process. Also noted should be the clarity and inner consistency of the final classification, as each enterprise may be attributed only to one type or one group (see Table 2).

Table 2. Classification of Innovation Modes

By innovation activity output		**By collaboration type**	
International innovators	New-to-international-market product innovations implemented mostly by the firm itself. Potential for radical innovations.	**Inventive, collaborative**	Innovation based on knowledge generation. Availability of formalized results; participate in innovation diffusion.
National/local innovators	Successful product innovations – new to national and local but not international markets, implemented mostly by the firm itself.	**Inventive, non-collaborative**	Knowledge generated, formalized results available. Do not participate in innovation diffusion.
Imitators	Minor innovation activity implemented mostly by the firm. Resultant product and process innovations already available at local markets. Capable of technology borrowing using their own resources.	**Informal, collaborative**	Never generate knowledge. Formalized results available; participate in innovation diffusion.
Technology adopters	Development of technological innovations with help of external organizations (irrespective of novelty level)	**Informal, non-collaborative**	Never generate knowledge or participate in innovation diffusion. Formalized results available.

Source: OECD Microdata Project [OECD 2008].

The novelty level distinguishes new to the company's markets and new-to-the-firm products. Products new to the international market are considered more innovative than the local-market novelties. The knowledge generation process accounts for in-house research vis-à-vis outsourcing, technological design and purchase of technology and equipment. The classification dimensions include patent activity, availability of research, knowledge diffusion, development of innovations by external actors (complete or partial), and cooperation.

4. Cross-country Comparison

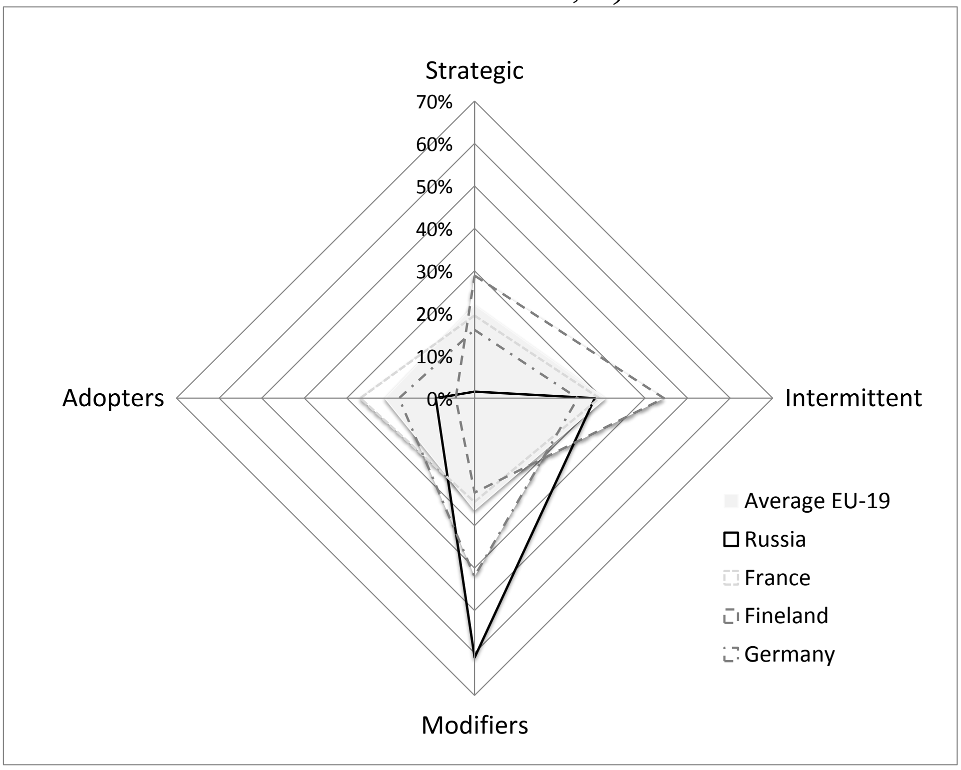
Application of microdata has produced some noteworthy results in the field of inter-country comparison, undeniably enriching the study of innovation modes by an essentially novel demonstrative and analytical quality. Figure 1 clearly depicts major disproportions in the structure of Russia's innovation modes vis-à-vis certain European countries.

In fact, the survey proves the finding about paucity of Russian strategic innovators able to regularly produce quality goods and competitive at the national and foreign markets. Quite the opposite, there are a lot of irregular innovators – firms that develop and realize innovations but are either reluctant or incapable to diffuse them over the economy, i.e. transfer novelties to other participants of the innovation process.

The most distinctive feature of the Russian innovation system is obvious and overriding prevalence of *technology adopters*, who concentrate their resources (intellectual resources included) on acquisition and actively upgrade production process. Less pronounced in Russia is simple *imitation* (although twice more popular that *strategic innovation*). In innovation, firms of this group practically never rely on their own resources.

Figure 1. Innovation Modes Across Countries

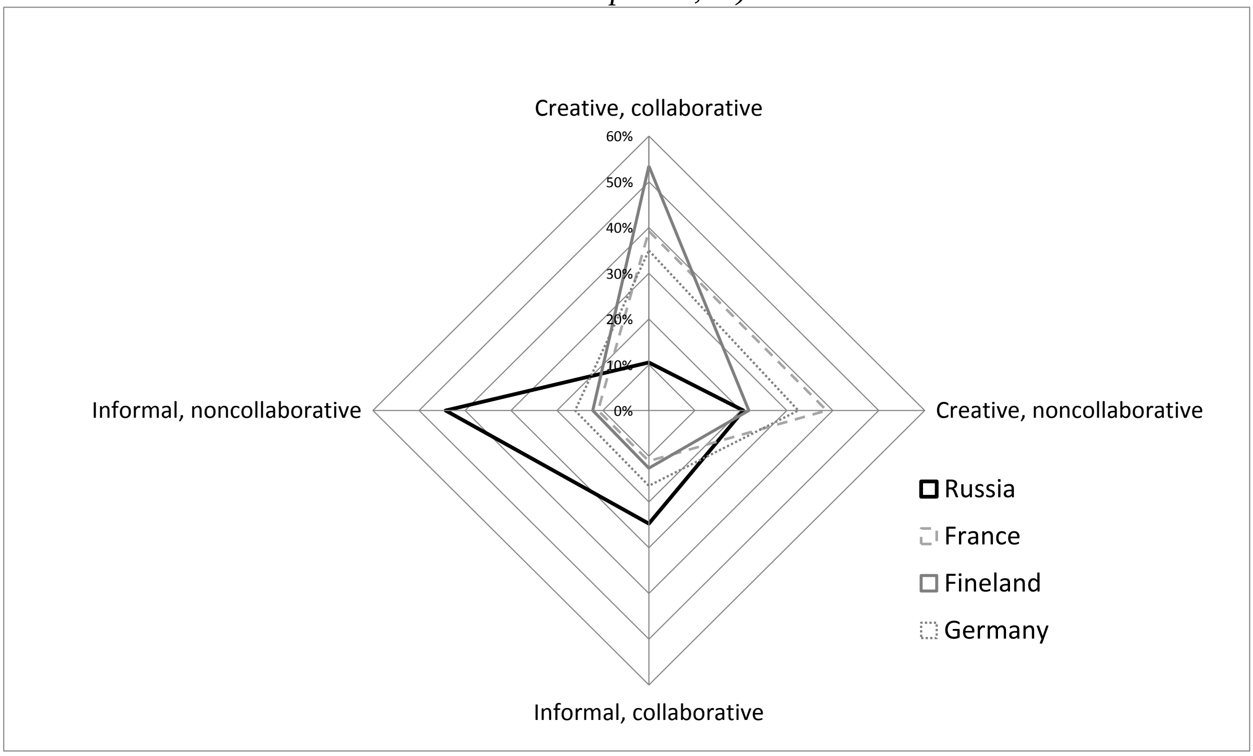
(share of enterprises with a certain innovation regime in the total of the country's innovation entities, %)



Source: ISSEK analysis, OECD Microdata Project, Arundel, Hollanders, 2008.

On the whole, Russia is increasingly demonstrating an objective and structurally framed inability for a leap to the innovation model. The slight share of innovative companies (below 10% as per [HSE, 2011]) and their leaning to certain behavior modes to a considerable extent stem from an inefficiency of external conditions and existing interconnections between economic actors of various types. In this situation, the most natural and hence most popular strategy is the adoption-based modernization, within which a considerable portion of technology adoption falls on the enterprise's own efforts. Still unanswered remains the question whether and how to speed up transition to other innovation modes. It seems more reasonable to allow the transition be completed naturally in the course of the global industrial modernization, with the analytical approach, based on revealing and monitoring of innovation processes, efficiently executing a diagnostic function to display the process's current status.

Figure 2. Knowledge Generation and Cooperation
(share of enterprises with a certain innovation regime in the total of the country's innovation companies, %)

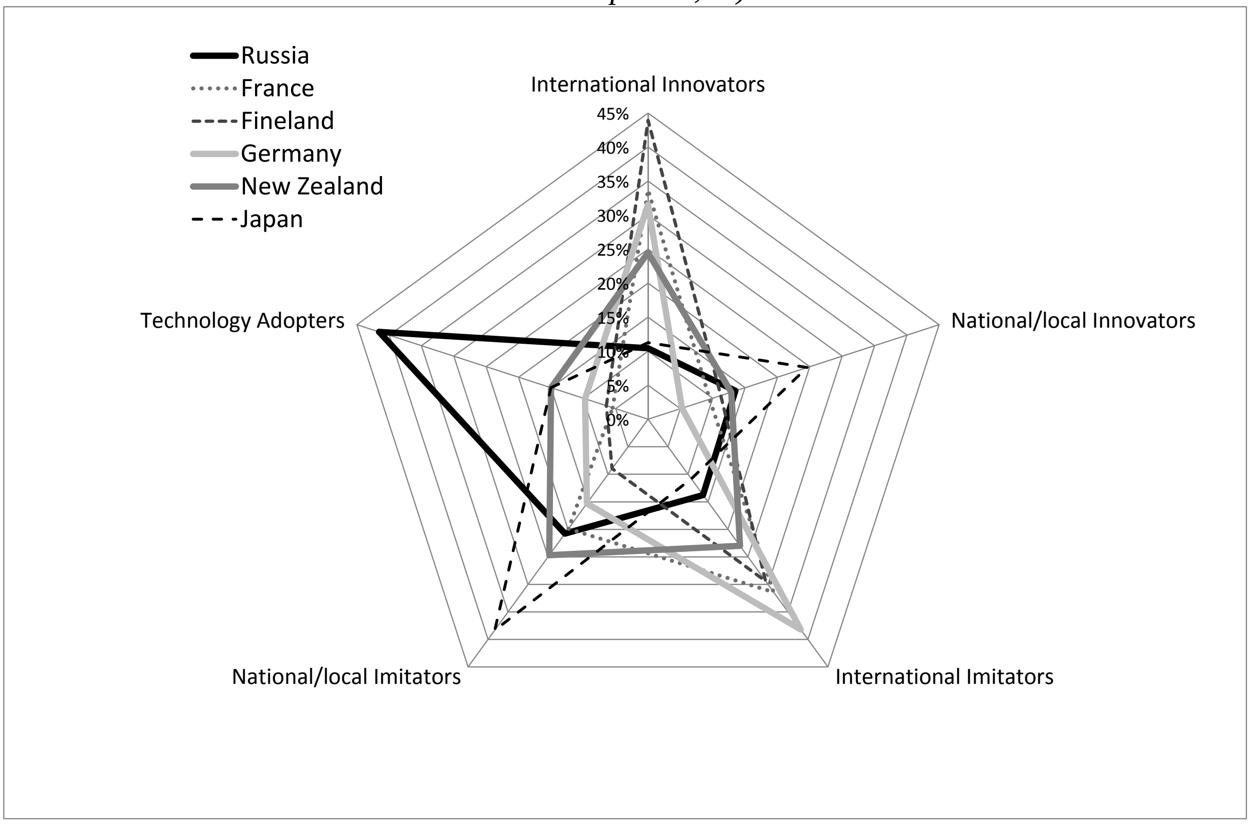


Source: ISSEK analysis, OECD Microdata Project.

Rather intriguing results have been obtained from analysis of parameters (measurements) characterizing the knowledge generation and cooperation (in its broader Oslo Manual definition, e.g. all types of joint activities, both formal and informal) during implementation of novelties, with inter-country differences as vivid as in the previous case. Figure 2 shows that European firms are markedly inclined to the generation of knowledge. This model, plus the energetic cooperation with various partners, absolutely dominates in Finland. French and German companies also step up in the generation of knowledge with emphasis on their own resources. On the whole, the share of European firms, which refrain from producing formalized knowledge and performing in-house research, is extremely small.

The indicators outline alternative tendencies in the implementation of innovations in Russia. As a rule, novelties are developed in isolation and without producing formalized IP outcomes. Another popular innovation development practice features external linkages but experiences limited knowledge generation activities. The two Russian modes, which may be regarded as sufficiently creative, have a negligible presence. And the rarest case for Russian enterprises is vigorous innovation combined with cooperation and pronounced knowledge generation.

Figure 3. Efficiency of Innovation Activities
(*share of enterprises with a certain innovation regime in the total of the country's innovation companies, %)*



Source: ISSEK analysis, OECD Microdata Project.

Analysis of the structure of the innovation modes' distribution in the context of the *knowledge economy* support/development (see Figure 3) has shown that over 50% of innovative companies in the foreign countries under consideration are orientated to the international market and successfully develop radical innovations, whereas the remaining firms enthusiastically adapt new technologies. Passive adaptation via technological diffusion is practically nowhere to be seen. Also weakly expressed is the orientation purely to the national and local markets, even in making new products for their needs.

In view of innovation novelty and foreign-market orientation, the distribution of Russian enterprises features quite the opposite proportions. The innovation strategy dominating abroad (international market orientation and development of radical novelties) has few adherents in Russia. Here, noticeable are national/local innovators, and most active – imitators of international and national levels. Many enterprises employ the passive technology borrowing regime, practically unused by world leaders, which reflects the import-orientated nature of Russia’s economy (as well as the national innovation system) including such areas as obtaining knowledge, technologies and innovations.

5. Empirical analysis of Innovation Modes

Proceeding from the above methodological approaches and techniques, the ISSEK study has used the data of the years-long surveys of innovation activities in Russia's economy to construct indicators and estimation models for the innovation behavior of Russian companies and has also carried out inter-country comparisons.

We use the data of 30,800 Russian enterprises in mining, manufacturing and utilities sectors (NACE rev 1.1. C, D, E) provided by the Institute for Statistical Studies and Economics of Knowledge of the State University – Higher School of Economics (ISSEK/HSE). The applied methodology of the enterprise innovation data collection is fully compatible with the Eurostat approaches to the Community Innovation Survey[3].

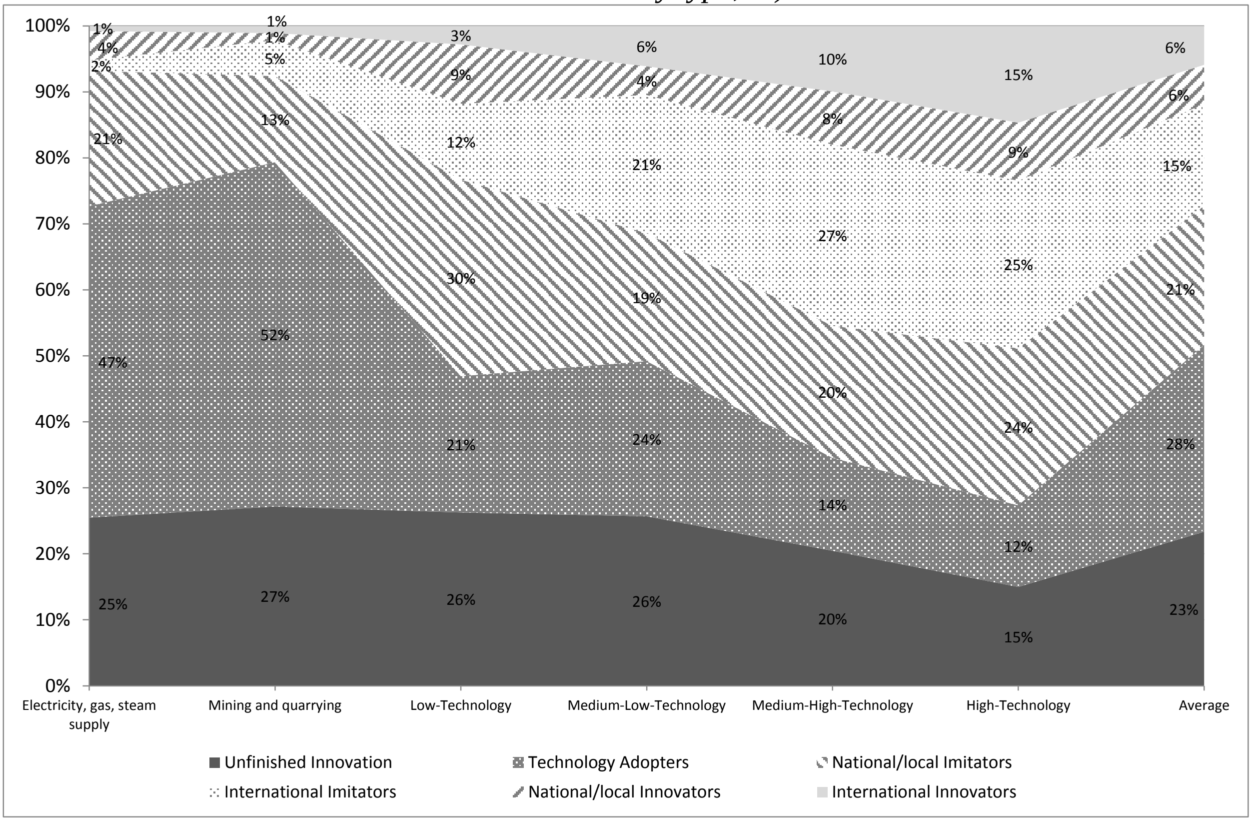
Our study explores the phenomenon of basic inefficiency of Russia’s innovation system that exhibits few innovation-active companies, low involvement of firms in R&D efforts, innovation tilted towards technology adoption and imitation despite sufficiently energetic innovation drive of the government and domination of profitable companies[4]. We analyze the innovation strategies and factors that influence the behavior of individual enterprises. The systematization of the obtained assessments has brought about a certain insight into the sectoral specifics of the innovation efforts and the nature of the inter-sector relationships. Figures 4, 5 and Tables 3, 4 below show various stages and results of *techniques* used to analyze the microdata (OECD and Pavitt’s methodologies) in relation to data on Russia.

[3] See http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/cis for details.

[4] Statistics show that the share of profitable industrial enterprises makes at least 70% [Gokhberg, Kuznetsova, 2009].

As shown in Figure 4, the sector-wise distribution of innovation modes in Russia's economy is somewhat lopsided[5].

Figure 4. Innovation Modes in Russia's Economy: 2008
(share of enterprises featuring a relevant innovation regime within the total of the innovation enterprises, and enterprises with incomplete or postponed innovations; by economic activity type, %)



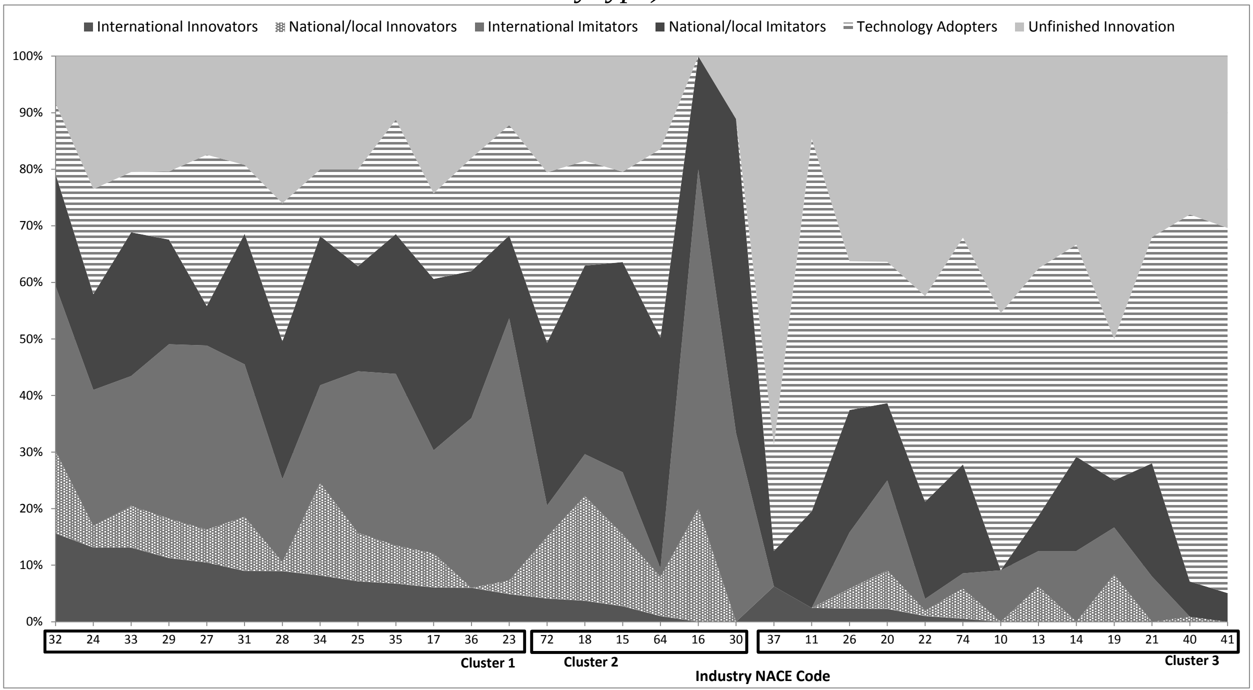
Source: ISSEK/HSE

One may suppose that *propensity* of an individual enterprise to a ceratin innovation mode essentially hinges on the overall economic conditions, patterns and limitations, and, to a lesser extent, on sectoral affiliation. At the same time, the *completeness* of the innovation process, possibilities (and intension) to achieve this goal, as well as the internal structure of the innovation modes do correlate with the sectoral affiliation, which is shown by Figure 5 and Tables 3, 4 depicting clusterization of sectors by similarity of regime distribution.

[5] For aggregation purposes, types of economic activities have been grouped by technology intensity (OECD methodology). Incomplete innovations make an additional group, which includes firms that stated incomplete or unsuccessful innovation at the survey period.

Figure 5. Clusterization of Innovation Modes in Russia's Economy: 2008

(share of enterprises with a relevant innovation regime within the total of the innovation enterprises, and enterprises with incomplete or postponed innovations; by economic activity type)



Source: ISSEK/HSE

Box 1. Industry codes (NACE codes)

NACE rev 1.1 codes: black and brown coal, peat extraction – 10; crude oil and natural gas production – 11; metallic ore production – 13; production of other minerals – 14; food production – 15; tobacco production – 16; textiles – 17; clothing, fur finishing and dyeing – 18; leather, leatherwear and footwear production – 19; wood processing, production of timber and cork items – 20; production of cellulose, wood pulp, paper and cardboard and appropriate items – 21; publishing and printing – 22; production of coke, oil products and nuclear materials – 23; chemicals production – 24; production of rubber and plastic goods – 25; production of other nonmetallic goods – 26; metallurgy – 27; metalwork manufacture – 28; machinery and equipment manufacture – 29; office equipment and computers manufacture – 30; manufacture of electrical machines and electrical equipment – 31; manufacture of equipment for radio, television and communications – 32; manufacture of medical equipment, measuring devices, optical instruments and equipment, clocks and watches – 33; automobile and trailer production – 34; manufacture of boats, aircraft, spacecraft and other vehicles – 35; furniture production – 36; processing of secondary raw materials – 37; production, transportation and distribution of electric power, gas and hot water - 40; water collection, treatment and distribution – 41; communications – 64; computer- and IT-related activities – 72; other services – 74.

The exclusively sector-orientated regulatory measures do not seem to account for many vital aspects of the innovation process. Hence, they may not only turn insufficiently effective (in certain parts) but also entail absolutely unpredictable and harmful outcomes for some companies.

The calculation has resulted in three large industry clusters. Number one, configured closest to the European-style distribution of innovation modes, features the greatest concentration of radical innovators (23% of Russian companies). Number two reflects the Russia-balanced distribution of innovation modes, tilted towards active imitation (19% of companies). Number three (58% of companies) is dominated by passive technology adopters and incremental innovations.

Table 3. Main Characteristics of Clusters (%)

	Cluster 1	**Cluster 2**	**Cluster 3**
Share of cluster enterprises in total number of companies engaged in extracting, processing, production and distribution of power, gas and water	**23**	**19**	**58**
Volume of products shipped by cluster enterprises, % of the total sales of companies engaged in extracting, processing, production and distribution of power, gas and water	**47**	**11**	**42**
Share of enterprises with apportioned innovation regime in the total of innovative enterprises and unfinished-innovation enterprises in the cluster:			
Total	100	100	100
Among them:			
International innovators	10	2	1
National/local innovators	7	11	3
International imitators	27	8	4
National/local imitators	21	37	14
Technology adoption	16	22	45
Unfinished innovations	19	20	33

Source: ISSEK/HSE

Table 4 shows the assessments of regime-prone companies' input in development of economy. Russia has few innovation-active firms not to mention strategic innovators, with their economic input determined by the selected behavior model.

Analysis indicates that in Russia the most successful companies (in terms of economic outcomes) are international imitators followed by international innovators and technology adopters, whereas the smallest effect comes from non-innovative enterprises.

Table 4. Outcomes of Innovation Modes in the Russian Economy: 2008 *(percentage of aggregated data on entities engaged in extracting and processing industries, production and distribution of power, gas and water)*

	International innovators	**National/ local innovators**	**International imitators**	**National/local imitators**	**Technology adoption**	**Unfinished innovation**	**Non-innovative companies**
Total sales	4	2	11	3	15	3	62
Number of employees	4	2	8	4	10	3	69
Innovation expenditure	16	4	19	6	40	15	---
Number of organizations	0.7	0.7	1.9	2.6	3.5	2.9	87.5

Source: ISSEK/HSE

Table 5 offers a systematized ranking of barriers hampering innovation under various modes. The key conclusion helpful for the substantiation of an adequate policy runs that the first three meaningful factors (lack of internal funds, high innovation costs, and insufficient financial support by the state) are similar for all innovative enterprises, i.e. invariable relative to sectoral and cluster affiliation. In this case, regulatory action seems to be fairly potent. As for other limitations, diversely configured differences emerge. For example, inadequate innovation demand seems principal for radical innovators, whereas imitators suffer most from shortage of skilled labor.

Table 5. Rating of Factors Hampering Innovation for Firms within Various Innovation Modes

Rating	International innovators	National/local innovators	International imitators	National/local imitators	Technology borrowing	Incomplete innovations	Non-innovative companies
1	Short internal finances	Short internal finances	Short internal finances	Short internal finances	Short internal finances	Short internal finances	Short internal finances
2	Innovation high costs	Innovation high costs	Innovation high costs	Innovation high costs	Innovation high costs	Innovation high costs	Innovation high costs
3	Poor financial support by state	Poor financial support by state	Poor financial support by state	Poor financial support by state	Poor financial support by state	Poor financial support by state	Poor financial support by state
4	Low consumer demand for innovative products (services)	Low consumer demand for innovative products (services)	Low consumer demand for innovative products (services)	Low consumer demand for innovative products (services)	Low consumer demand for innovative products (services)	Skilled personnel shortage	Skilled personnel shortage
5	Skilled personnel shortage	Skilled personnel shortage	Skilled personnel shortage	Skilled personnel shortage	Skilled personnel shortage	Low consumer demand for innovative products (services)	Low consumer demand for innovative products (services)
6	Short info on sales markets	Short info on sales markets	Short info on sales markets	Skilled personnel shortage	Short info on sales markets	Short info on sales markets	Short info on up-to-date technologies
7	Limited capability for cooperation with other firms and research centers	Short info on up-to-date technologies	Short info on up-to-date technologies	Short info on up-to-date technologies	Limited capability for cooperation with other firms and research centers	Short info on up-to-date technologies	Short info on sales markets
8	Short info on up-to-date technologies	Limited capability for cooperation with other firms and research centers	Limited capability for cooperation with other firms and research centers	Limited capability for cooperation with other firms and research centers	Short info on up-to-date technologies	Limited capability for cooperation with other firms and research centers	Limited capability for cooperation with other firms and research centers

Source: [Gokhberg et al 2010].

For a bottom-line analysis of the composition and impact of factors that define the *propensity* of firms to certain innovation modes and assessment of their effectiveness, we applied the multinomial logistical regression (see Table 6).

The explanatory variables include:

- enterprise size (logarithm of number of employees);
- productivity (logarithm of sales per employee);
- strategy for distribution of the innovation expenditure, namely logarithm of costs per employee for intramural and extramural R&D, purchase of

technologies, machines and equipment, design and development, software purchase and personnel training;

- human capital, i.e. share of university graduates among the employees
- access to external financial support for innovation, including support from public budgets of all levels, and foreign funds;
- availability of a dedicated R&D department;
- intellectual property protection strategy as an importance of formal and informal instruments of intellectual property protection;
- external cooperative links that support the process of innovation development (cooperation with universities, sectoral or academic research centers, clients, consumers, competitors, consultancies or suppliers);
- sectoral specifics as dummies differentiating firms by the industrial sectors (OECD classification of the industries according to their technology level, with the mining enterprises assumed as the base level);
- enterprise ownership type (distinguishing private, state, state-private and foreign firms (private property is assumed as the base level).

The innovation modes were treated as an unordered set of *qualitative choices* (dependent variables), whereas the "Unfinished innovation" mode was used as the basic level. The model assessment was estimated using maximum likelihood method.

The summary of key estimation results is as follows.

Higher innovation productivity is significantly associated with the innovative modes that execute knowledge-creative activities (national and international innovators and imitators), while the productivity growth decreases the probability of technology adoption and unfinished innovation modes.

Concerning the strategy of innovation expenditure, more allocations to intramural R&D would help implementation of the international market-oriented modes. Focus on the extramural R&D appears to decrease the probability of the advanced innovation modes. Purchase of machines and equipment is specific for the imitative modes and the technology adoption and would notably influence the ability to complete the innovations. Excessive tilt to personnel training would hold back innovation efforts. Greater investment in technology purchase would obstruct transition to advanced modes. Design and development priority is linked with the national/local innovation modes. Aggressive software purchases are significantly associated with the 'unfinished innovation' mode.

Table 6. Assessments of the Innovation Mode Choice Regression

Explanatory variables		International market innovators		National market innovators		International market imitators		National market imitators		Technology Adoption		Unfinished Innovation	
		Marg. Effect	Stat. sign.	Marg. Effect	Stat. sign.	Marg. Effect	Stat. sign.	Marg. Effect	Stat. sign.	Marg. Effect	Stat. sign.	Marg. Effect	Stat. sign.
Scale	Workers (log)	0.000001	***	-0.00002	***	0.00002	***	-0.000003	***	0.00002	***	-0.00002	***
	Sales per worker (log)	0.010	***	0.002	**	0.025	***	0.013	**	-0.012	**	-0.033	***
Innovation expenditure (log per worker)	Internal R&D	0.014	***	0.008		0.013	***	0.005		-0.004		-0.036	***
	External R&D	-0.001	**	-0.002	**	-0.006		0.001		0.014		-0.008	
	Technology purchase	-0.014	***	-0.003	***	-0.018	**	0.002		0.025		0.007	***
	Design and development	0.005		0.014	**	0.006		-0.004		0.004		-0.025	
	Machines Purchace	0.008		0.004		0.015	***	0.031	***	0.037	***	-0.095	***
	Software purchase	0.001		0.005		-0.015	***	-0.009		0.005		0.013	***
	Training	-0.012	***	-0.015	***	-0.021	***	-0.041		-0.011	***	0.100	***
	Graduates Share	-0.084		-0.039	**	0.050		0.068		-0.070		0.075	***
External financing	Public budget	0.031	***	0.036	*	0.096	***	0.068		-0.030		-0.201	***
	Foreign funds	-0.750		-0.723		1.020	**	1.041		0.909		-1.497	
Organisation of R&D	Has R&D dept	0.029		0.014	**	0.082	*	0.002		-0.081	***	-0.046	***
Intellectual Property Protection	Formal	0.020	***	0.004		0.030	**	-0.029	***	-0.058		-0.024	***
	Informal	0.010		-0.004		0.010		0.014	*	-0.032		0.001	
Collaboration for innovation development	Research centers	0.013	*	0.005	***	0.010	***	0.017	***	-0.022	***	-0.006	
	Universities	0.011	**	-0.016		0.050		0.015		-0.032	***	-0.029	
	Clients	0.040	*	0.027		0.010		0.051		0.080	**	-0.049	***
	Suppliers	-0.029		0.006		-0.030		-0.014	**	0.062		0.005	
	Competitors	0.004		0.010		0.026		-0.016		0.034	*	0.010	
	Consultants	0.006		-0.012		-0.009		0.031	**	0.004		-0.021	**
Sector	High-tech	0.122	**	0.068	*	0.240		-0.040	**	-0.225	***	-0.165	***
	Medium-tech, high level	0.091	***	0.064		0.239	**	-0.077		-0.196	***	-0.121	***
	Medium-tech, low level	0.067	**	0.029		0.202	*	-0.080		-0.162	***	-0.057	
	Low-tech	0.037		0.081	***	0.179		0.025	***	-0.202	**	-0.121	***
	Power, water and gas supply	0.0004		0.005		0.001		0.012	***	0.002	***	0.002	
Property type	Public	-0.021		0 .008	***	-0.056		0.023	**	-0.108	**	-0.017	
	Foreign	0.004	**	-0.052	***	0.040	***	-0.077	***	0.056		0.029	***
	Private-public	0.007		0.004	*	-0.007		-0.022		0.048		-0.030	***

The table shows marginal effects of the explanatory variables on the probability of the innovation mode realization and the statistical significance of these effects: 10- (*), 5- (**) and 1-percent (***) significance level; blank cell – insignificant effect. Unfinished innovation mode was used as the base level for the multinomial logit. Mining enterprises made the base for sectoral specifics control.

Source: [Gokhberg et al 2010].

Estimation illustrate that a proper distribution of expenditure by itself would not bring success, whereas failure may occur under any costs structure and any regime. However, comparison of the variable effects indicates that risks (emergence of incomplete innovations) are definitely higher if technology adoption costs dominate. At the same time, increased spending on the R&D foster the probability of choosing *advanced* innovation behavior models (*international innovators, national/local innovators*, *international imitators*), while presence of a dedicated R&D department is typical only for the national/local innovators and technology adopters. On the whole, this finding agrees with the hypothesis about the special role of activities related with scientific knowledge generation.

The intellectual property protection strategy differs significantly along the innovation modes. Formal methods (e.g. patenting) appear to be essential for the companies that operate on the international markets. National/local market imitators focus on the informal (know-how-based) IP protection strategy, ignoring the formal instruments. However, an attention to the IP protection issues increases the possibility of innovation success.

At the innovation startup stage, financial support by the state renders a statistically significant positive effect (at the maximum significance level) on the probability of the innovation completion. Government allocations are especially influential for the most advanced modes. So far, more definite indicators of the state financing efficiency have not yet been obtained within this research. Foreign funds appear to be of the most efficiency for the international imitators. Other modes do not show the propensity of using the exterior financial support.

Comparing to the base property type (private companies), state enterprises have the propensity to become strategically headed to the local or national but not international markets. Mixed private-state property companies are more successful at completing innovations, showing the increased probability of national innovator mode. Foreign companies are targeted at the international market and tend to exploit the advanced innovation modes.

Sectoral specifics render complex effects on the regime choice probability. Due to uneven distribution of the innovation-active firms in the economy, the sectoral specifics generally seem to surface more vividly under less advanced modes. Higher-technology sectors experience a larger share of the internationally focused innovators and imitators. At the same time, Mining sector is characterized by the increased probability of national/local-focused innovation modes and technology adoption.

Cooperation strategy effects illustrate that within the configuration of the Russian innovation system, the company-university cooperation would not markedly influence the innovation startup and progress for most of the companies being the specific trait of the 'international innovator' mode. Of much greater importance is interaction with the research organisations, which is statistically significant and positive for all the innovation modes except 'Technology adoption'. Note that the output from cooperation with sectoral and academic institutes is noticeably higher for international imitators and national/local market innovators and imitators, while the most advanced modes concentrate on intramural innovation development. Interaction with clients appears to be more specific for the 'Technology adoption' mode, while this link appears to have a significant overall effect on the probability of innovation success. Moreover, clients involvement within the innovation implementation process does help both their startup and completion under all innovation modes. Cooperation with suppliers is critical for selection of natopnal/local imitating regime, which is reasonably logical for the largely catch-up nature of this business strategy. During implementation of novelties, when the creative constituent is minimal, equipment and component suppliers may play a decisive role. Interrelationship with competitors constitutes an essential part of the technological adoption strategy. Cooperation with consultancies is normally central for national/local imitators, while increases the overall probability of the innovation success.

Table 7. Examples of behavior-specific policy measures

Mode	Measures
International innovators	– monitoring of technological trends, stimulation of knowledge-intensive products export – subsidies of applications for international certificates of quality
International imitators	– large scale technological PPP programs (subsidized development or purchase of last generations of technologies) with higher shares of business
National/local innovators	– state co-financing (grants or) of projects that imply internal R&D or cooperation with national R&D organizations and universities – tax incentives for R&D – centres for technology transfer, centres for design, engineering, certification
National/local imitators	– centres for accumulation and dissemination of industry best practices, "technology brokers"
Technology Adoption	– tax incentives and special customs regimes for last generation machinery and equipment purchase – technology-oriented credit programs –technical regulation and standards providing incentives for acquisition of novel technologies

The estimation results confirm the need to considerably deepen the perception of the innovation processes, verify the hypotheses about the distribution of various innovation behavior models in Russia, and formulate conclusions viable for development of innovation policies. The proved diversity of firms that pursue different modes of innovation behavior can become a source for novel dimension of innovation policy specialization. The observed behavior types' characteristics can be the basis for proposing more targeted and result-oriented measures (for the case of innovation modes see Table 7.). At the same time, understanding distribution of this types within the NIS could provide an evidence for combining these measures into a proper policy mix.

6. Conclusion: On the Concept of Shaping an Evidence-based Innovation Policy

Key conclusion for the performed study of companies' innovation strategies is that **t**he up-to-date innovation polices should not be focused exclusively on attaining aggregated characteristics of the innovation system[6]**.** Heterogeneity of actors also challenges traditional types of policy specialization (see Table 8).

Table 8. Levels of policy specialisation

Level	Object	Limitations
Macro: National innovation system	Comparison and benchmarking of nations	Weak focus on mechanics Limited knowledge on the contribution of knowledge to economic development Weak understanding of the individual actor strategies
Meso: Sectoral innovation system	Understanding of sectoral differences	Focus on industrial sectors and lack of account for technology and business model shifts Focusing on one sector ignoring linkages to others
Meso: Regional innovation systems:geographical proximity	Governance of NIS/cross-border networks/regional development strategies	Assumption that all the regions are innovative Poor linkages in both horizontal and vertical contexts
Meso: Cluster approaches	Strategic Priorities and Competence development, Linkage building	Weak knowledge for cluster lifecycles High opportunity costs
Micro-based: Behavior-specific approaches	Addressing the heterogeneity, support of specific types of behavior	Weak methodology and missing methodology to link to other levels of analysis

The enterprise-level taxonomies compellingly demonstrate that the heterogeneity of the innovation process participants rules out a satisfactorily efficient verbalization of regulatory measures orientated entirely towards the sectoral level. Within each sector there are various modes. Separate groups of innovators perform basically different but pointedly expressed functions, including generation of new knowledge, innovation transfer and diffusion, creation of demand, and circulation of technological practices.

A working model of the innovation policy should be built on the assumption that the dynamics of the innovation system development is determined by efficiency of interrelationships (and, of course, reciprocal influence) within the framework of the technologically advanced and more traditional sectors. The pioneering role will go to

[6] Decision-takers may use the descriptive results usable for international comparisons, recommendations on potentially effective regulatory tools (with the account of sector-wise distribution of innovation behavior types), as well as systematized motives and limitations in the innovation area. In the long run, viable seems be a discussion of the innovation policy overall architecture and its long-term priorities.

companies of certain types that are especially energetic in development and distribution of novelties in accessible markets and adjacent sectors. For international competitiveness, the innovation system should ensure stimulation of strategic innovators and effective infrastructure support, as well as expansion of the mass production base. Theoretically, mass extracting and processing industries, as well as services, should stimulate the innovation firms by generating demand for new products and technologies, and develop predominantly through strengthening of the innovation sectors.

This logic suggests that extremely important for economy transformation seems to be modernization of the sectoral structure with focus on the leading sectors, which meet emerging requirements and are able to materialize the current complex of general-purpose technologies. This recommendation calls for a thoughtful insight and clear-cut succession in execution of decisions (especially in the future), as well as acumen for a scale-wise and structural assessment of resources. Absorbing the sectoral specifics, the regulatory measures should focus on attaining specific characteristics (parameters), elimination of existing hurdles and promotion of each technological regime implemented in economic sectors.

Within any period, there are companies that lead in the innovation potential and are tightly linked with the new technological paradigms. They require measures to support and enhance their general innovation level (innovation growth rate), to promote interaction with advanced new-technology users and technology *producers*, i.e. top research centers and universities. Competitiveness of sectors handicapped in view of new technology adaptation within the existing technological paradigm should (and must) be stimulated. To this end, central seems to be enhancing cooperation with technologically advanced sectors, possibly with some of their enterprises to begin with. That should give start to the processes of inter-sectoral knowledge diffusion, which, in its turn, makes the basis for expanded technological capabilities and longer life cycles in traditional industries. Such processes could be accelerated by policy initiatives. Within this context, workable seems to be supporting enterprises in purchases of up-to-date equipment, software and technological (external) knowledge from specialized providers. Another feasible measure lies in promoting cooperation between suppliers and producers (works, services). Anyway, an effective regulatory system should be targeted at specific configurations of sectoral interaction (cooperation networks).

Note that inter-sectoral interrelationship balance never remains intact but evolves in step with shifts in the technological paradigm, which makes systematic monitoring and classification of strategies a high-value tool both for researchers and managers. The study of various innovation modes with continuously updated appraisal of interactions between various economic actors (both within and between sectors) seems to provide quite a promising platform for building a convincing new generation policy in the innovation area. However, success along this path undoubtedly requires more empirical research, as well as advancement of the methodological apparatus for analysis of enterprises' innovation behavior.

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