Strategies of industry-science cooperation in the Russian manufacturing sector

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Outline

Research motivation

Background

- The diverse nature of industry-science linkages
  - Motivation behind cooperation
  - Forms of interaction
- Industry-science relations in Russia

Data and Methodology

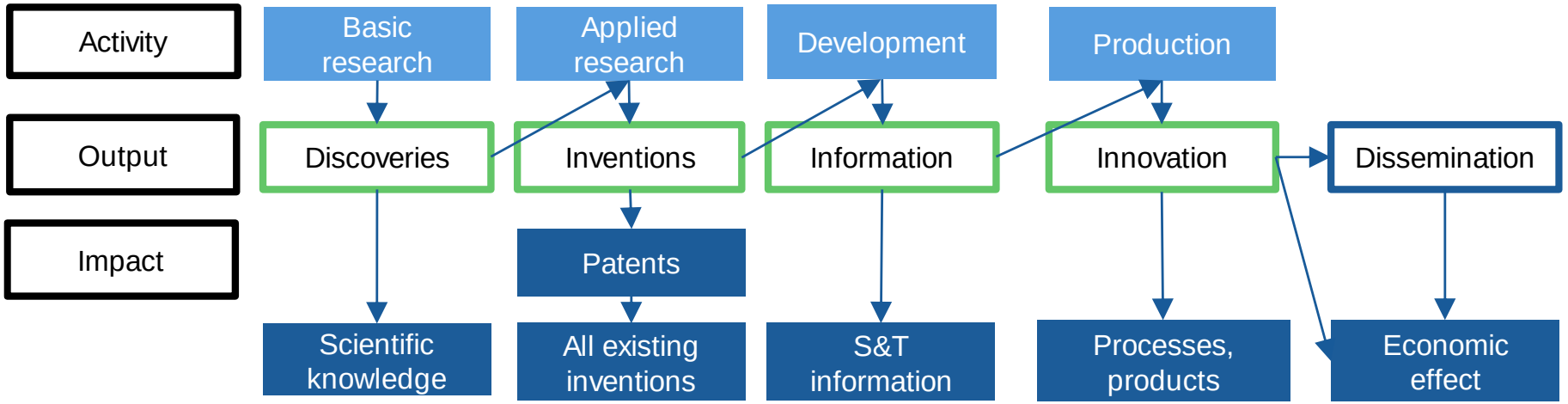
- Econometric model
- Model specification

Results

Conclusion

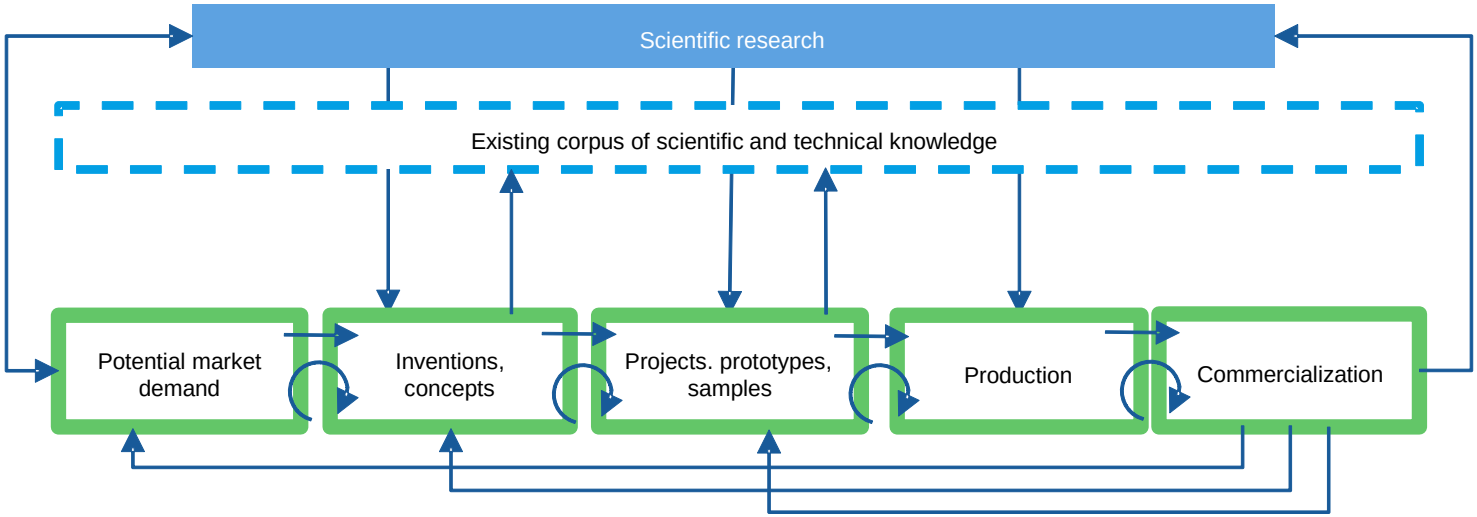
Context: frameworks for empirical analysis of R&D and innovation

Linear model of innovation



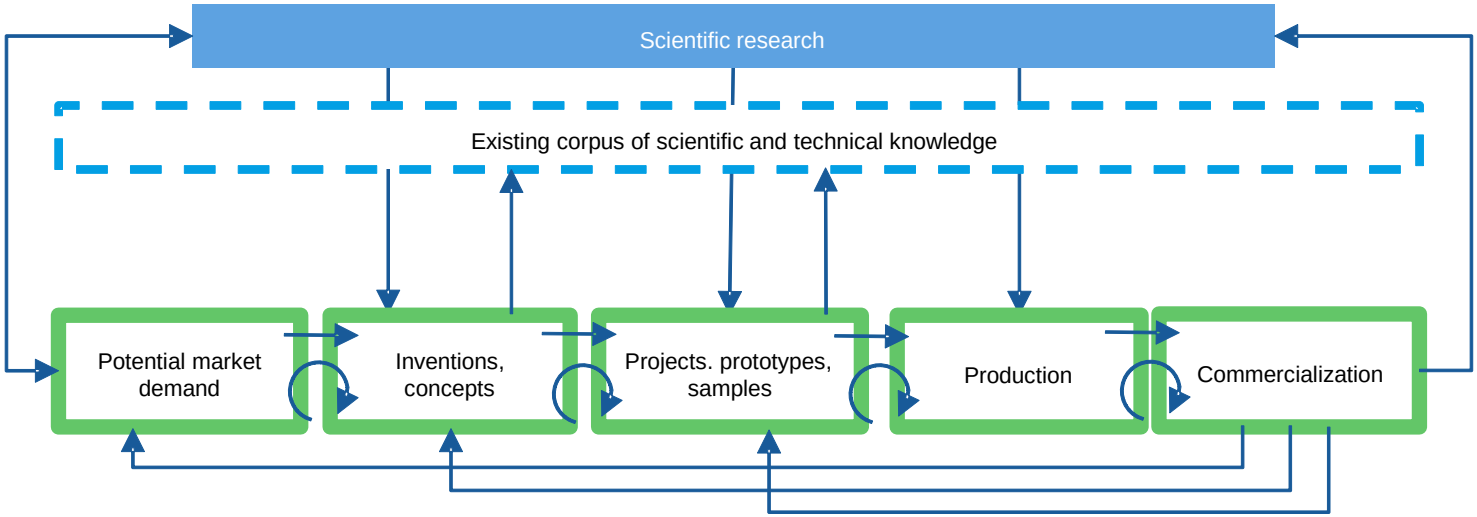
~ V. Bush (1945) and others

Chain-linked model of innovation



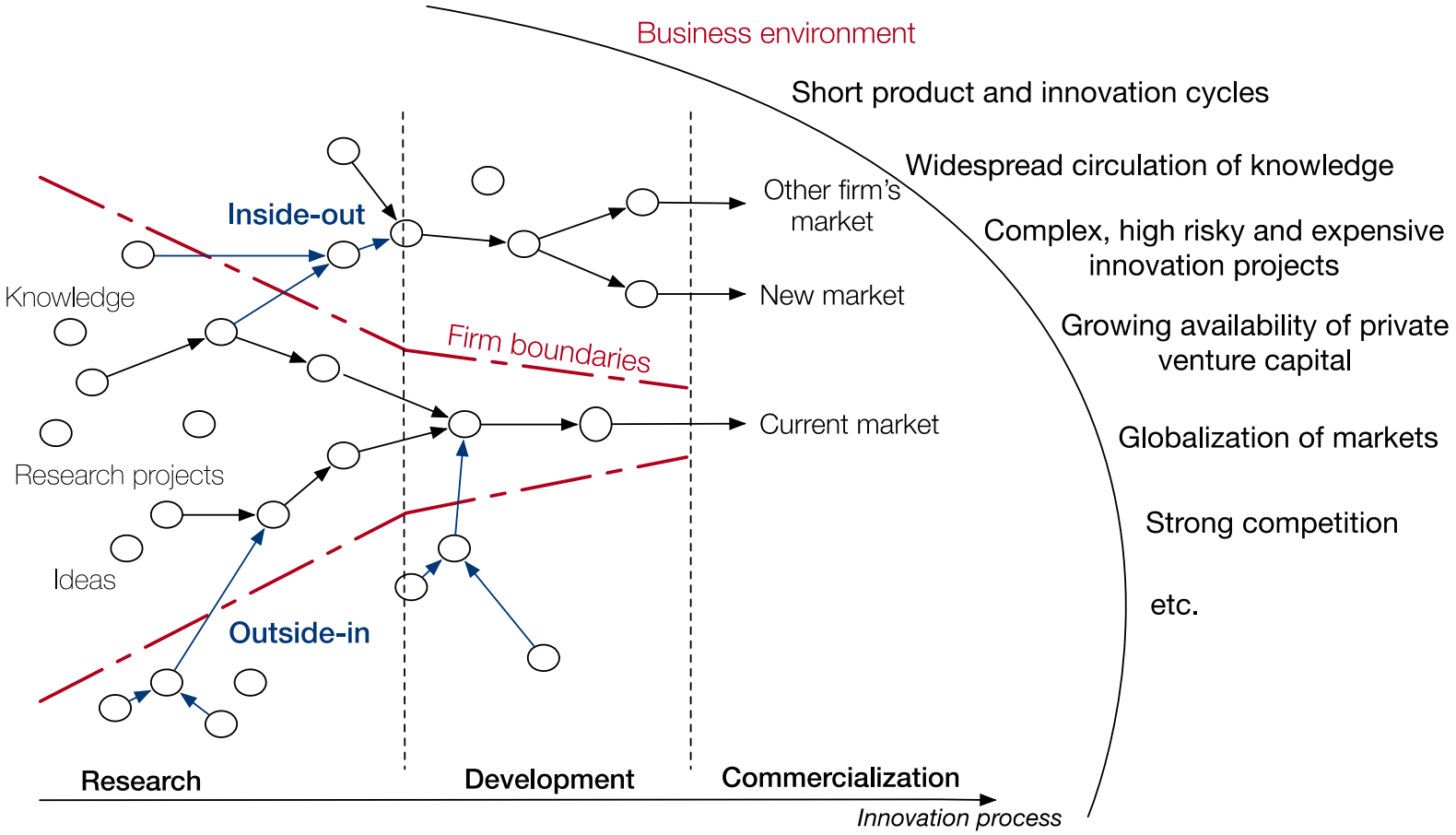
Source: Kline, Rosenberg (1986)

Chain-linked model of innovation



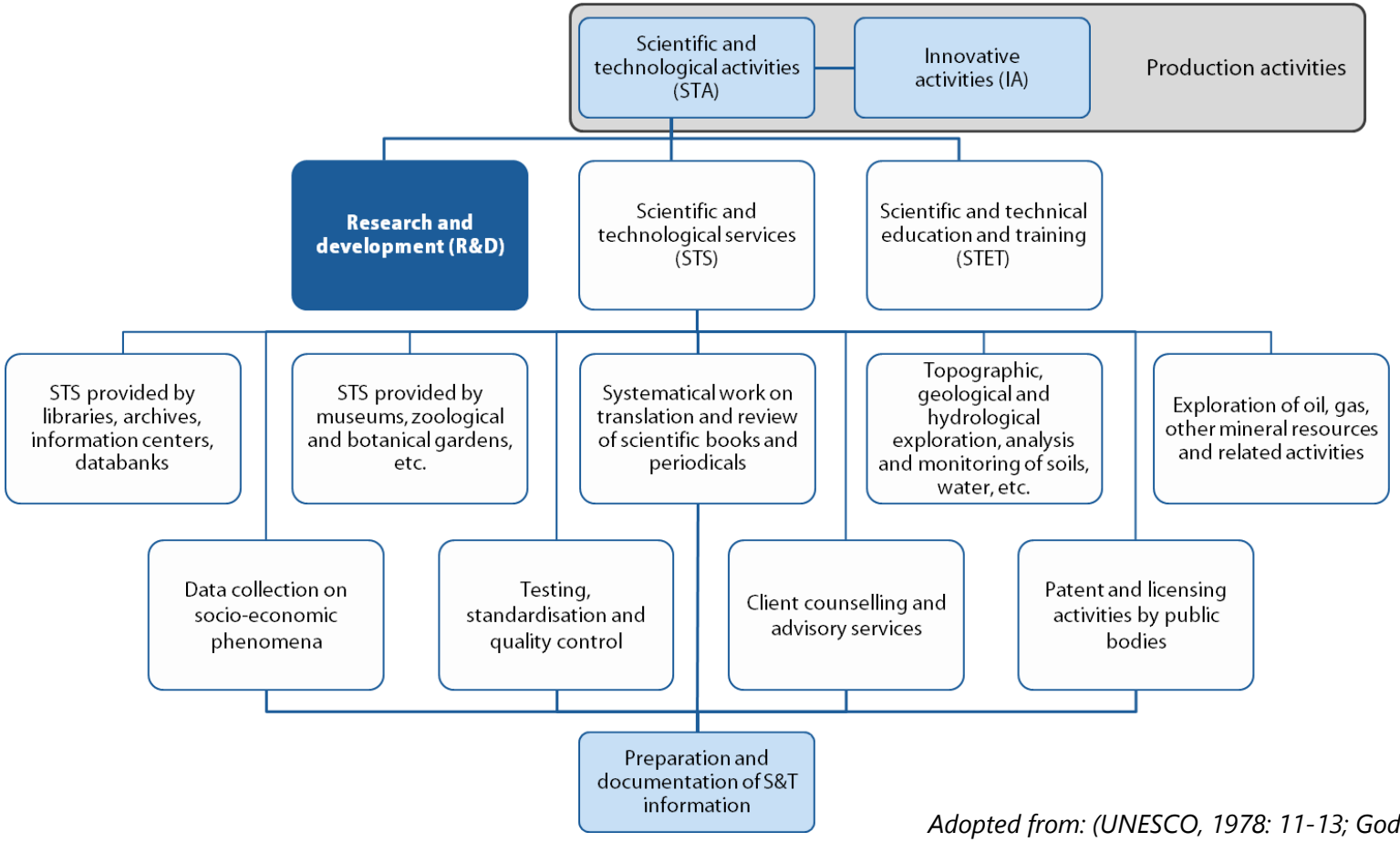
Source: Kline, Rosenberg (1986)

Open Innovation model



Source: Chesbrough (2003)

R&D and other S&T activities



Adopted from: (UNESCO, 1978: 11-13; Godin, 2009: 76)

The aim of the study

To explore the peculiarities of the modes of industry-science interactions

- R&D-oriented cooperation (aimed at acquisition of R&D results that lead to innovation)
- Consulting-oriented cooperation (aimed at purchasing S&T services)

1. What affects the propensity to cooperate with universities and R&D organizations in innovation activities?
2. How firms benefit from cooperation with knowledge producers?
3. What are the barriers to the practical application of R&D results?

Motivation

Innovation is a central process driving sustainable competitive advantages and effective value creation at the enterprise level

Open innovation

- Trend of shifting away from closed systems to new mode of **open systems involving a range of players** distributed up and down the supply chain
- Strong linkage within the innovation process between the external environment of the firm and internal environment

Chesbrough, 2003; Dahlander and Gann, 2010; Laursen and Salter, 2006

Cooperative strategies of enterprises

Dynamic interactions of a diverse set of actors throughout the innovation process

Knowledge (Technology) Transfer

- Between PROs and private sector, and society
- Process of transferring physical assets, know-how, and technical knowledge for the **purpose of further development and commercialization**
- Driver of innovation, economic growth

Bercovitz and Feldmann, 2006; Mowery and Nelson, 2004

Industry-science interactions

Background (1): Diversity of cooperative strategies

Motives:
- Strategic
- Economic
- Intellectual
- Educational
- Political

Innovative company

Barriers:
- External
- Internal

Knowledge
Experiences
Human resources
Tangible assets
Objects of IP

Cooperation partners	Researchers (among other)
Members of the value-chain • Customers/ clients • Suppliers of raw materials	Hagedoorn (1993) Tether (2002)
Market actors • Related value-chain members • Providers of services • Competitors	Fritsch & Franke (2004) Schmidt et al. (2007) Tiwari & Buse (2007) Fiaz & Naiding (2012)
Knowledge producers • Universities • Research organizations	Sánchez-González (2013) Garcia et al. (2015) Un & Asakawa (2015)
• Consulting firms	**Focus of this study**
• Public and local authorities	

For details, see Roud, V., & Vlasova, V. (2016). Firm-Level Evidence on the Cooperative Innovation Strategies in Russian Manufacturing. Higher School of Economics Research Paper No. WP BRP 63/STI/2016.

Background (2): Specificity of industry-science interactions

Contributing factors

- Types of knowledge transferred
- Direction of knowledge flow
- Characteristics of knowledge senders and receivers
- Intensity of personal contacts
- Innovation strategies of firms
- Industry characteristics
- Scientific discipline characteristics
- Policy and framework conditions

1. No cooperation with knowledge producers
2. Cooperation without application of the R&D results and adoption of technologies
3. Cooperation and adoption of technologies → new-to-firm innovation
4. Cooperation and adoption of technologies → new-to-market innovation

Industry-science interaction patterns (based on literature review):

- Research partnerships
- Research services

Perkmann & Walsch, 2007

- R&D-oriented partnerships
- Non-R&D activities

Fischer et al., 2017

- Contract research
- Joint research
- Personnel mobility
- Training and lectures

Schartinger et al., 2002

- Codified output
- Contracted research
- Personnel exchange
- Informal contracts

Bekkers & Bodas Freites, 2008

Determinants of innovation networking strategy

Category	Determinants	Scientific background (empirical studies)
General characteristics	Industry-specific Firm-specific (size, age, ownership, return on sales)	Arvanitis (2012) De Faria et al. (2010) Srholec (2014)
Level of competition	Market structure Markets for future development	Miotti & Sachwald (2003) Sáez et al. (2002)
Technological opportunities	Innovation and R&D intensity, Importance of technological (product, process) innovation, The length of innovation development cycle	Castellacci (2007) Mohnen & Hoareau (2003) Tether (2002)
Absorptive capacity	Staff skills, The recognition of partners' efforts, Importance of cooperation in the corporate culture (intra-firm, external, standard procedures)	Aristei et al. (2016) De Faria & Schmidt (2012) Vonortas & Okamura (2009)
Appropriability conditions	The use of legal (formal) and strategic (informal) mechanisms of intellectual property protection	Badillo & Moreno (2016) Dachs et al. (2008) López (2008)
Public support	Financial support provided by public authorities (horizontal, targeted, networking measures)	Arranz & Fdez. de Arroyabe (2008) Belderbos et al. (2004) Miotti and Sachwald (2003)

Determinant: context of Russia

Category	Analyzing the situation in Russia
General characteristics	• Prevalence of state-owned enterprises and businesses with mixed-ownership (Kudrin and Gurvich, 2015) • Low level of competition in the domestic market (Schwab, 2017)
Level of competition	• **Prevalence of monopolistic markets dominated by large state-owned enterprises in key economic activities** (Yakovlev, 2014)
Technological opportunities	• **Low innovation activity** of manufacturing enterprises (**9.2%** in 2016) • High-tech industries are the most innovation intensive (30.8% in 2016) • Government is the predominant source of funding for R&D (68.2% in 2016)
Absorptive capacity	• Russia is among the world leaders for R&D personnel in absolute figures (722.3 thousand pers.), the share of R&D personnel in the total labor force —1.1% • Among enterprises the **closed innovation behavior is by far the most widespread** (Kratzer et al., 2017)
Appropriability conditions	• **Low institutional quality** , including property rights, intellectual property protection, and judicial independence • The development of intellectual property is largely disconnected from industrial demand and consumer needs (Gokhberg and Kuznetsova, 2015)
Public support	Since 2010 — various policy initiatives to stimulate business R&D and innovation, to improve the legislative framework for IP, to strengthen the institutional infrastructure for technology commercialization and transfer, etc.
	• **Unfavorable framework conditions for entrepreneurship and innovation**, including inadequate law enforcement, government inefficiency in regulation (Polischuk, 2013)

Data

Country: Russia

Source: Monitoring of Innovation behavior of Enterprises (biannually since 2009)

Year: 2015

Sector: Manufacturing

Focus: Innovation-active enterprises

Sample size: 805

Russian branch of the European Manufacturing Survey

Executed by the international consortium of 16 EU countries and beyond and coordinated by ISI Fraunhofer, Germany

Original methodology: compliant with

- Oslo Manual (OECD and Eurostat)
- EU Community Innovation Survey frameworks
- Russian Innovation Survey

Econometric analysis

- Companies take a decision on cooperation with universities and R&D organizations **simultaneously**

1

Decision on cooperation

Bivariate probit model

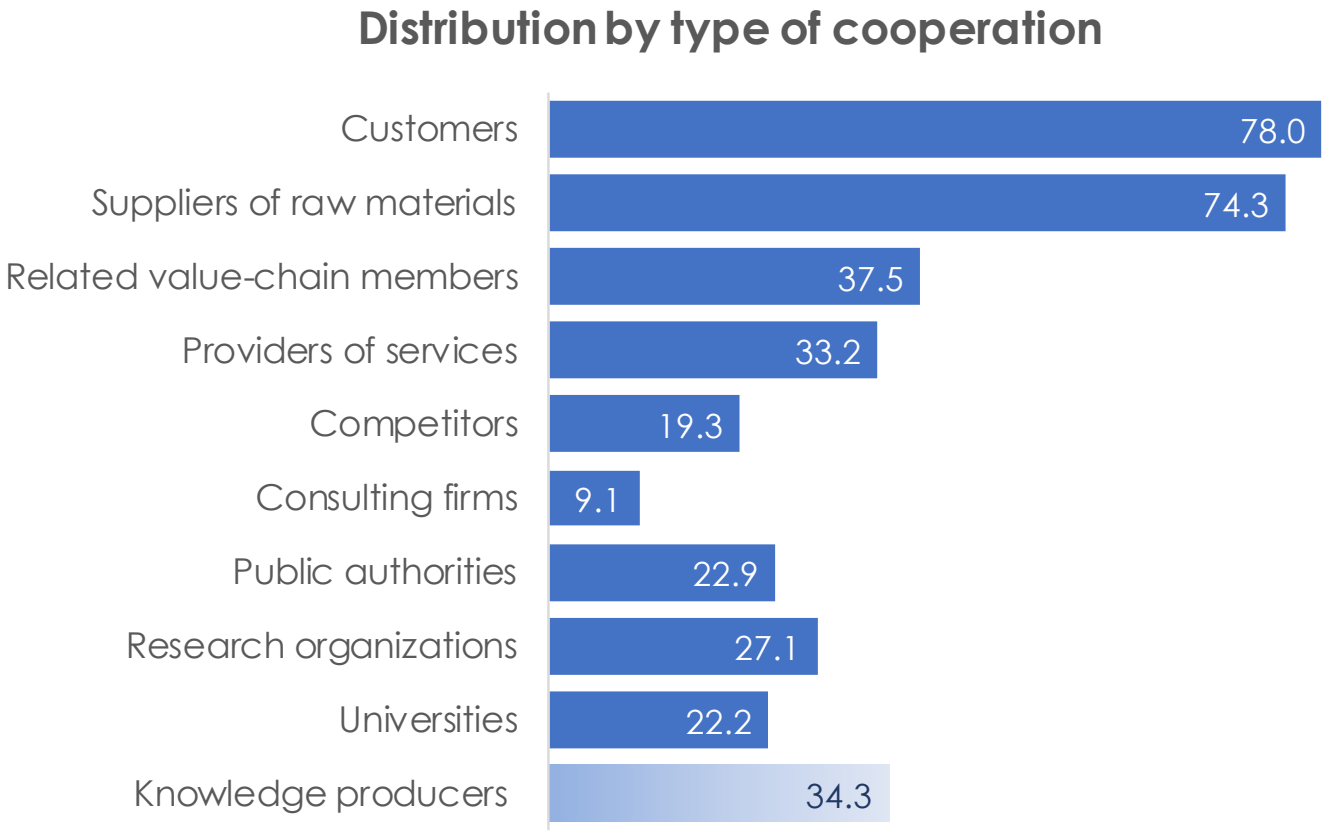
2

Application of R&D results

Multinomial logit model

- Focus on **factors preventing** the application of S&T results developed by the R&D organizations and universities

Cooperative innovation strategies in Russian manufacturing



* Data is weighted by population characteristics derived from the Federal State Statistics Service (Rosstat)

Who cooperates with PROs (1)

		Universities	Research organizations
General characteristics	Size	**0.101****	**0.096****
		(0.044)	(0.045)
	Age_less5	-0.495	**-1.031*****
		(0.305)	(0.395)
	Foreign ownership	-0.241	-0.171
		(0.227)	(0.231)
	State ownership	**0.300***	0.166
		(0.167)	(0.166)
	Return on sales:		Baselevel: Negative
	ROS (0-5%)	0.160	-0.0739
		(0.158)	(0.160)
	ROS (more than 5%)	0.127	0.0515
		(0.147)	(0.147)
	Industry:		Baselevel: Low-tech industries
	High-tech	**0.742*****	**0.892*****
		(0.186)	(0.186)
	Medium high-tech	**0.518*****	**0.438*****
		(0.157)	(0.158)
	Medium low-tech	**0.357****	0.0390
		(0.160)	(0.168)
Level of competition	Market structure:		Baselevel: Competitive market
	Monopoly	0.0649	-0.128
		(0.149)	(0.156)
	Oligopoly	0.0547	0.129
		(0.126)	(0.128)
	Markets for future development:		Baselevel: Local markets
	Regional	0.0167	0.341
		(0.261)	(0.313)
	National	0.322	**0.769*****
		(0.243)	(0.295)
	Foreign	0.415	**0.684****
		(0.266)	(0.315)

Large and experienced firms

U: State-owned innovative enterprises

Enterprises from high-, medium high- and low-tech manufacturing industries

RO: Orientation towards national and international markets promotes more intensive cooperation

Who cooperates with PROs (2)

		Universities	Research organizations
Technological opportunities	Share of development and implementation costs in the total turnover:		
	High	0.110	0.0760
	(more than 10%)	(0.192)	(0.200)
	Medium	0.0468	**0.291***
	(2.5-10%)	(0.153)	(0.156)
	Low	-0.0008	0.0154
	(less than 2.5%)	(0.155)	(0.162)
	Continuous R&D	-0.0022	-0.0784
		(0.123)	(0.127)
	Product innovation	-0.159	-0.161
		(0.156)	(0.160)
	Process innovation	-0.0306	-0.0818
		(0.158)	(0.158)
	Long product innovation	0.0968	-0.114
		(0.151)	(0.159)
	Long process innovation	0.154	0.208
		(0.160)	(0.162)
Absorptive capacity	High qualification of the staff	0.003	0.002
		-0.0024	-0.0024
	Culture - external cooperation	**0.288****	0.191
		(0.121)	(0.125)
	Culture - procedures for cooperation	0.170	-0.191
		(0.122)	(0.129)
	Culture - internal cooperation	-0.026	-0.023
		(0.115)	(0.117)
	Own effort	**-0.663*****	**-0.358*****
		(0.111)	(0.114)
Appropriability conditions	Methods of intellectual property protection:		
	Formal	**0.365*****	0.153
		(0.128)	(0.130)
	Informal	**0.301****	**0.431*****
		(0.124)	(0.129)

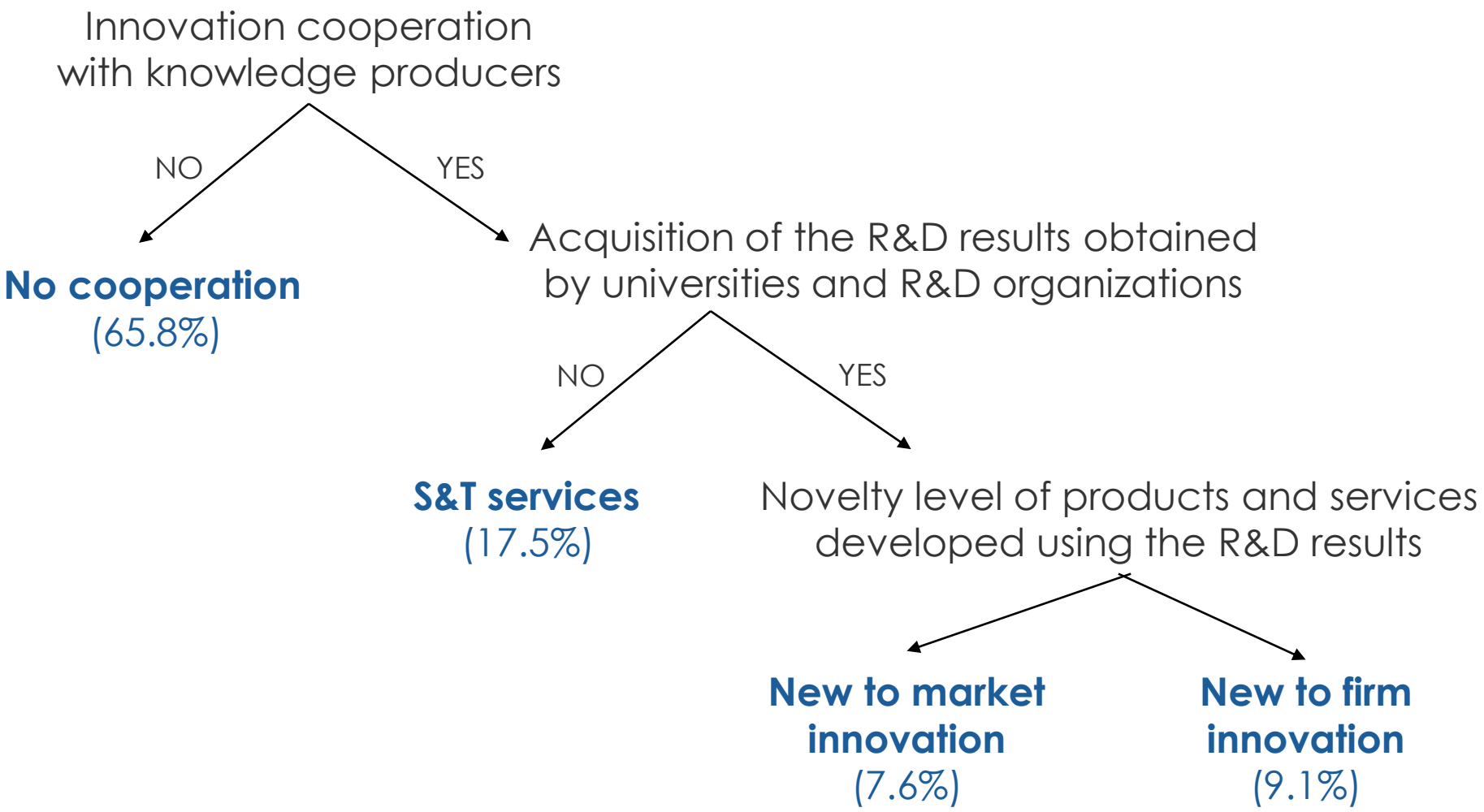
RO: Enterprises with relatively high intensity of innovation

U: Company management welcomes the involvement of external parties in innovation activities

Enterprises highly appreciate the contribution of PROs in innovation process

Availability of effective IP protection mechanisms (both legal and strategic)

Interaction strategies with PROs



Modes of interaction with PROs (1)

		No cooperation with R&D sector	Cooperation-S&T services	Cooperation-Application_ New to the firm	Cooperation-Application_ New to the market
General characteristics	Size	**-0.035*** **	0.016	**0.016*** **	0.002
		(0.013)	(0.011)	(0.006)	(0.002)
	Age_less5	**0.133** **	-0.073	**-0.0480*** **	-0.012
		(0.053)	(0.049)	(0.017)	(0.008)
	Foreign ownership	**0.116*** **	**-0.088** **	-0.0272	-0.001
		(0.045)	(0.036)	(0.018)	(0.009)
	State ownership	-0.061	0.065	-0.005	0.001
		(0.060)	(0.054)	(0.019)	(0.008)
	Return on sales:				*Baselevel: Negative*
	ROS (0-5%)	-0.019	-0.026	0.043	0.003
		(0.048)	(0.039)	(0.028)	(0.009)
	ROS (more than 5%)	-0.049	0.055	-0.002	-0.004
		(0.044)	(0.037)	(0.021)	(0.008)
	Industry:				*Baselevel: low-tech*
	High-tech	**-0.320*** **	**0.155** **	**0.087***	**0.077***
		(0.074)	(0.069)	(0.047)	(0.044)
	Medium high-tech	**-0.203*** **	**0.149*** **	0.019	0.036
		(0.057)	(0.051)	(0.027)	(0.023)
	Medium low-tech	-0.0905	0.009	0.015	**0.066***
		(0.056)	(0.043)	(0.026)	(0.035)
Level of competition	Market structure:				*Baselevel: competitive*
	Monopoly	0.032	**-0.062***	0.008	0.023
		(0.044)	(0.032)	(0.022)	(0.015)
	Oligopoly	-0.017	0.007	-0.003	0.013
		(0.038)	(0.032)	(0.017)	(0.010)
	Markets for future development:				*Baselevel: local*
	Regional	-0.073	0.096	-0.021	-0.002
		(0.093)	(0.089)	(0.032)	(0.020)
	National	**-0.182** **	**0.131***	0.025	0.026
		(0.078)	(0.071)	(0.037)	(0.025)
	Foreign	**-0.238** **	**0.192***	0.017	0.029
		(0.109)	(0.110)	(0.046)	(0.042)

S&T services:

- High- and medium high-tech companies, planning to enter national and international markets
- Negative impact: lack of competition and foreign business ownership

New to firm innovation:

- High-tech, large, experienced (5-year-old or more) enterprises

New to market innovation:

- High-tech, large-sized, experienced (5-year-old or more) enterprises

* Marginal effects after multinomial logit model

Modes of interaction with PROs (2)

		No cooperation with R&D sector	Cooperation-S&T services	Cooperation-Application_New to the firm	Cooperation-Application_New to the market
Technological opportunities	Share of development and implementation costs in the total turnover:				
	High	0.028	-0.046	-0.010	0.028
	(more than 10%)	(0.056)	(0.043)	(0.024)	(0.021)
	Medium	-0.081	0.051	0.033	-0.003
	(2.5-10%)	(0.049)	(0.042)	(0.025)	(0.008)
	Low	-0.013	0.019	-0.002	-0.005
	(less than 2.5%)	(0.048)	(0.042)	(0.021)	(0.008)
	Continuous R&D	0.035	**-0.062****	0.002	**0.024****
		(0.037)	(0.031)	(0.017)	(0.011)
	Product innovation	0.062	-0.063	0.009	-0.008
		(0.052)	(0.047)	(0.020)	(0.011)
	Process innovation	0.0005	0.003	-0.006	0.004
		(0.047)	(0.039)	(0.023)	(0.009)
	Long_product innovation	0.014	-0.019	0.003	0.003
		(0.046)	(0.037)	(0.020)	(0.008)
	Long_process innovation	-0.042	0.045	0.005	-0.008
		(0.053)	(0.046)	(0.022)	(0.007)
Absorptive capacity	High qualification of the staff	-0.0005	0.0007	-0.0002	0.0001
		(0.001)	(0.0006)	(0.0003)	(0.0001)
	Culture_external cooperation	**-0.084****	0.035	**0.033***	**0.016***
		(0.039)	(0.033)	(0.019)	(0.009)
	Culture_procedures for cooperation	-0.007	0.011	-0.002	-0.002
		(0.038)	(0.033)	(0.016)	(0.007)
	Culture_internal cooperation	0.016	0.011	-0.025	-0.002
		(0.035)	(0.030)	(0.015)	(0.006)
	Own effort	**0.156*****	**-0.067****	**-0.064*****	**-0.024****
		(0.038)	(0.031)	(0.021)	(0.011)
Appropriability conditions	Methods of intellectual property protection:				
	Formal	-0.056	0.034	0.007	**0.015***
		(0.037)	(0.031)	(0.017)	(0.008)
	Informal	**-0.129*****	**0.105*****	0.012	**0.012***
		(0.037)	(0.030)	(0.015)	(0.007)

S&T services:

- Firms carrying out continuous in-house R&D
- Highly appreciate the contribution of PROs
- Effective strategic (informal)methods of IP protection

New to firm innovation:

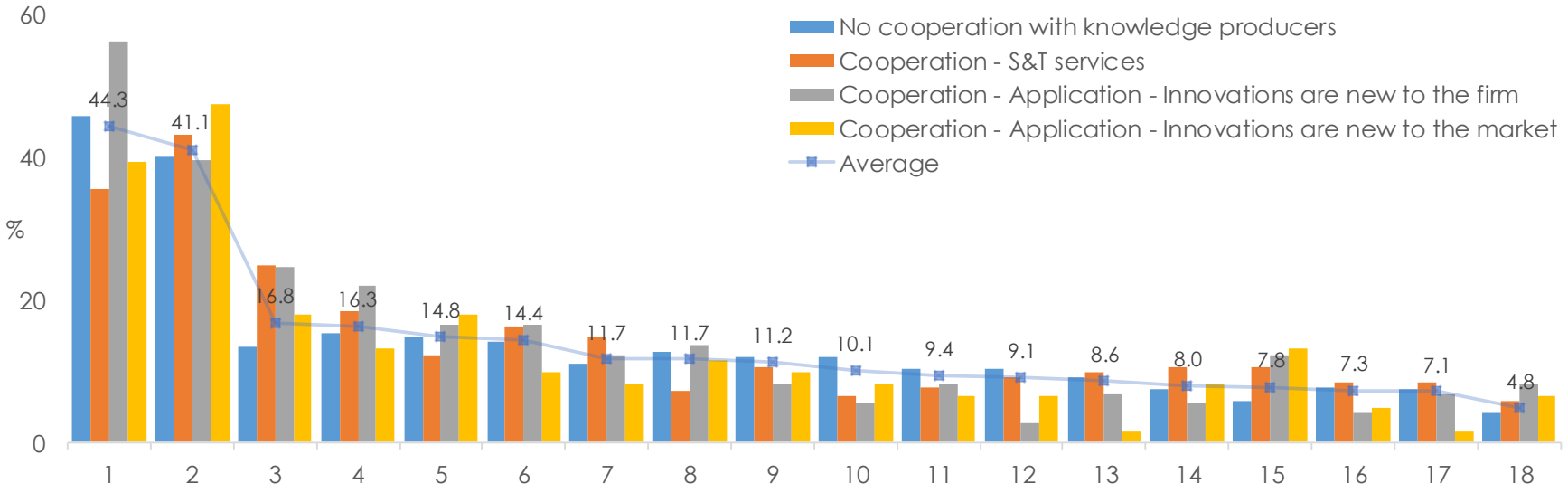
- Firms appreciate cooperation with external parties and their contribution to the innovation process

New to market innovation:

- Firms carrying out continuous in-house R&D
- Firms appreciate cooperation with external parties and their contribution to the innovation process
- IP protection is effective

* Marginal effects after multinomial logit model

Barriers to the application of R&D results



1 Lack of financial resources
2 High economic risks of new technologies adoption
3 S&T results are not ready for practical introduction in innovation processes
4 Greater competitiveness of foreign technologies
5 Lack of qualified personnel (engineers, technologists)
6 Strong competition from imported goods and services
7 Technological risks related to the application of R&D results
8 Strong competition from other on domestic producers of goods and services
9 Other
10 Poor innovation infrastructure
12 Lack of information on new technologies in the company
13 Lack of cooperative ties with research organizations
14 Lack of qualified specialists to ensure the transfer of S&T results (economists, lawyers)
15 The disparity between the level of pilot research projects and the latest S&T achievements
16 Poor management in research organizations
17 Poor management in firms
18 General insufficient innovation legal and normative support
19 Legal and administrative barriers to the transfer and adoption of S&T results

Barriers for application of the R&D results

	No cooperation with R&D sector	Firms that cooperate with R&D sector in innovation activities		
		S&T services	Application_ New to the firm	Application_ New to the market
Lack of financial resources	-0.033	-0.014	**0.051*** **	-0.004
	(0.038)	(0.031)	(0.019)	(0.006)
High economic risks of new technologies adoption	0.016	0.004	-0.022	0.002
	(0.036)	(0.031)	(0.015)	(0.006)
S&T results are not ready for practical introduction in innovation processes	**-0.095***	0.047	**0.052***	-0.004
	(0.054)	(0.043)	(0.031)	(0.007)
Greater competitiveness of foreign technologies	0.036	-0.044	0.013	-0.005
	(0.042)	(0.033)	(0.022)	(0.007)
Lack of qualified personnel (engineers, technologists)	-0.011	-0.011	0.014	0.007
	(0.051)	(0.042)	(0.025)	(0.011)
Strong competition from imported goods and services	-0.009	0.028	-0.009	**-0.011***
	(0.049)	(0.044)	(0.018)	(0.007)
Technological risks related to the application of R&D results	-0.013	0.028	-0.007	-0.008
	(0.053)	(0.047)	(0.020)	(0.007)
Strong competition from other on domestic producers of goods and services	0.036	-0.059	0.018	0.005
	(0.052)	(0.039)	(0.029)	(0.012)
Other	-0.015	0.015	0.007	-0.007
	(0.062)	(0.053)	(0.031)	(0.007)
Poor innovation infrastructure	**0.110****	**-0.077****	-0.029	-0.003
	(0.043)	(0.036)	(0.018)	(0.009)
Lack of information on new technologies in the company	0.020	-0.015	-0.001	-0.004
	(0.057)	(0.048)	(0.027)	(0.009)
Lack of cooperative ties with research organizations	0.059	-0.010	**-0.045*****	-0.004
	(0.053)	(0.048)	(0.016)	(0.009)
Lack of qualified specialists to ensure the transfer of S&T results (economists, lawyers)	0.036	0.004	-0.022	**-0.018****
	(0.059)	(0.053)	(0.020)	(0.007)
The disparity between pilot research projects and the latest S&T achievements	-0.023	0.045	-0.028	0.006
	(0.069)	(0.062)	(0.020)	(0.015)
Legal and administrative barriers to the transfer and adoption of S&T results	-0.123	0.052	0.045	0.026
	(0.076)	(0.059)	(0.042)	(0.022)
Poor management in research organizations	0.025	0.012	-0.022	**-0.015****
	(0.061)	(0.055)	(0.023)	(0.006)
Poor management in firms	-0.042	0.058	0.0002	**-0.016****
	(0.070)	(0.064)	(0.029)	(0.007)
General insufficient innovation legal and normative support	-0.172	0.083	0.081	0.009
	(0.107)	(0.087)	(0.064)	(0.017)

* Derived from full marginal effects estimation for the multinomial logit model

Barriers for application of the R&D results

- Main complaints include the lack of financial resources (44.3%) and high economic risks of new technologies adoption (41.1%)
- **Non-cooperators** often reference to insufficient innovation infrastructure
- **Enterprises focusing on purchasing S&T services** as opposed to adopting the technologies less frequently complain about the lack of developed innovation infrastructure
- **Firms that adopt technologies to create new-to-firm innovation** most often complain about the lack of financial resources and insufficient readiness of S&T results for practical implementation
- **Firms that adopt technologies to create new-to-market innovation** consider poor management in companies and research bodies and strong competition from imported products and services as the main constraints in applying R&D results

Impact of public support

		No cooperation with R&D sector	Cooperation - S&T services	Cooperation - Application - New to the firm	Cooperation - Application - New to the market
Public support	Public support measures:				
	Horizontal	**-0.0901****	0.060	0.024	0.006
		(0.047)	(0.039)	(0.021)	(0.008)
	Targeted	0.021	-0.036	0.009	0.005
		(0.040)	(0.033)	(0.019)	(0.008)
	Networking	-0.094	0.011	**0.089***	-0.007
		(0.071)	(0.052)	(0.047)	(0.006)

Horizontal state support measures

- increase the propensity to cooperate with knowledge produces in innovation activities

Targeted support measures:

- no significant effect

Networking support measures

- facilitate the application of R&D results, that lead to the creation of products new to the firm
- positively influence the duration of cooperation with knowledge producers

Conclusions

- The scale of industry-science linkages is generally hampered by low propensity of business to the R&D-based innovation strategies (dominance of imitation and borrowing of ready-made solutions). However, those that cooperate, praise the contribution of research organizations and universities

- The firm-level innovation effort is mainly conditioned by the general level of technological opportunities within the country

- S&T services acquisition comprises important share of industry-science cooperation

- Support to general theory: Higher likelihood of cooperation and technology adoption for
  - Large and technologically advanced companies with higher absorptive capacity and effective IP management systems;
  - Focus on global markets as opposed to local niches (in case of universities and for S&T services strategy)

- The main obstacle to successful cooperation is the general belief that academia is unfit to produce applicable outcomes

- Given the developing context, a general public support design (such as indirect or direct financial assistance for innovation activities) is ineffective for triggering new industry-science interactions

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Sample characteristics

Manufacturing sector	Innovation -active	Has at least one cooperation partner	Cooperation with knowledge producers
Food and Beverages	83	81	16
Textiles, clothing and shoes	58	58	11
Wood and paper	50	47	9
Printing and Publishing	47	46	6
Petrochemistry, coal and nuclear fuel	21	20	6
Rubber, plastics and nonmetallic goods	55	53	12
Chemical production	54	53	29
Pharmaceuticals	41	40	23
Metallurgy	51	50	20
Metallic products	60	60	19
Machinery and Equipment	94	93	51
Precision instruments and computers	44	44	29
Railway transport and shipbuilding	43	43	11
Automobiles	27	27	12
Aircraft and space	23	22	17
Other manufacturing	54	53	5
Total	**805**	**790**	**276**