Nonlinear effects
of universities

Dmitrii
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Nonlinear effects of universities' research on innovations in Russian regions: a spatial econometric approach

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Motivation

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- ▶ Universities are generally recognized to play a key role in regional innovation systems, providing opportunities for learning and research that can lead to new ideas, discoveries, developments and innovations.

- ▶ Universities play an important role in creating new technologies because they can attract the best scientists and researchers, as well as provide them with the necessary resources and infrastructure to conduct research.

- ▶ In addition, universities can help create innovative companies by providing the knowledge, experience and connections needed to start a business.

Research gap

- ▶ Literature suggests that universities play an important role in regional innovation systems, but the nature of this role varies depending on the context.
- ▶ Research methods vary greatly from one paper to another.
- ▶ Lack of empirical studies of the impact of the research activities of universities for regional innovations.
- ▶ Russian context requires more detailed consideration.
- ▶ In addition, I consider the non-linear nature of the impact of university research on innovation.

Model

Baseline model:

$$y_{it} = p_{it}\beta_1 + p_{it}^2\beta_2 + C_{it}^{'}\gamma + \alpha_i + \nu_t + u_{it} \qquad (1)$$

Marginal effect:

$$ME_p = \beta_1 + 2\beta_2 p \qquad (2)$$

Estimation strategy

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▶ To take into account the dynamic structure and spatial correlation, quasi-maximum likelihood method is used for estimation, more specifically, the Lee-Yu transformation (Lee, Yu, 2010; Yu, De Jong, Lee, 2008).

▶ Four types of impacts were calculated for statistical inference: direct long-term, indirect long-term, direct short-term and indirect short-term.

▶ The robustness of the results is verified by using various samples, periods, and spatial weight matrices.

▶ SDPDmod package implemented in the R programming language was used for calculations (Simonovska, 2023).

Dataset and sources

Dataset:

- balanced panels
- 2012–2016 and 2012–2019
- 65 regions (after removing outliers and regions with missing values) or 70 regions with outliers

Data sources:

- Regions of Russia (Rosstat, 2022)
- OpenAlex

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Main variables

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► To measure the dependent variable, i.e. innovations, I use the share of innovative goods, works, services in their total volume (*sig*) as the dependent variable.

► As a proxy for university research, I use OpenAlex data on the number of publications and citations. In doing so, I transform the variables and use such relative indicators as works count per faculty member (*works*1) and citation count per work (*cited_by*1).

► As control variables, I use the share of R&D expenditures in GRP, the number of students per 10,000 population, the share of R&D organizations in the total number of organizations, the share of middle-aged population, the share of older population, and the number of women per 1,000 men.

Descriptive statistics

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	mean	sd	min	max
sig	6.24	5.79	0.00	27.50
works1	0.13	0.14	0.00	1.12
cited_by1	3.51	1.96	0.45	14.33
rde_sh	0.01	0.01	0.00	0.06
resorg_sh	0.00	0.00	0.00	0.00
stud10000	303.65	87.41	100.00	585.50
gender	1157.68	42.98	998.50	1237.00
middle	57.32	2.44	51.15	67.40
old	24.71	3.59	11.25	30.90

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Table: Estimation results for models with fixed effects (dependent variable — sig)

	(1)	(2)	(3)	(4)	(5)	(6)
works1	18.942**	5.454	1.360			
	(6.725)	(4.800)	(12.380)			
works1sq	-12.893*	-8.830*	1.500			
	(5.459)	(4.436)	(19.579)			
cited_by1				0.139	0.326	-0.403
				(0.364)	(0.313)	(0.403)
cited_by1sq				-0.007	-0.027	0.025
				(0.021)	(0.026)	(0.036)
N of regions	70	65	65	70	65	65
Years	12–19	12–19	12–16	12–19	12–19	12–16

$+$ p $<$ 0.1, * p $<$ 0.05, ** p $<$ 0.01, *** p $<$ 0.001

Robust standard errors in parentheses

All models include control variables that are not shown for brevity.

All models include year- and region-fixed effects.

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Table: Estimation results for spatial Durbin models (dependent variable — sig, weights: 8 nearest neighbors, weighted by inverse distance)

	(1)	(2)	(3)	(4)	(5)	(6)
works1	5.129	3.494	0.093			
	(5.443)	(4.767)	(14.336)			
works1sq	-6.181	-6.667	3.644			
	(4.262)	(4.226)	(21.597)			
cited_by1				-0.092	0.769*	0.015
				(0.307)	(0.318)	(0.509)
cited_by1sq				-0.002	-0.064*	-0.016
				(0.018)	(0.027)	(0.046)
W*works1	-1.947	5.502	-12.284			
	(15.038)	(12.648)	(47.022)			
W*works1sq	6.423	-6.511	22.518			
	(11.348)	(12.035)	(62.235)			
W*cited_by1				-0.635	-0.096	-0.343
				(0.818)	(0.867)	(1.613)
W*cited_by1sq				0.027	-0.088	-0.098
				(0.050)	(0.078)	(0.148)
N of regions	70	65	65	70	65	65
Years	12–19	12–19	12–16	12–19	12–19	12–16

$+ \ p < 0.1$, $* \ p < 0.05$, $** \ p < 0.01$, $*** \ p < 0.001$

All models include control variables and their spatial lags that are not shown for brevity.

All models include dynamic and spatial lags of dependent variable, year and region FE.

Marginal effects of publications count per professor

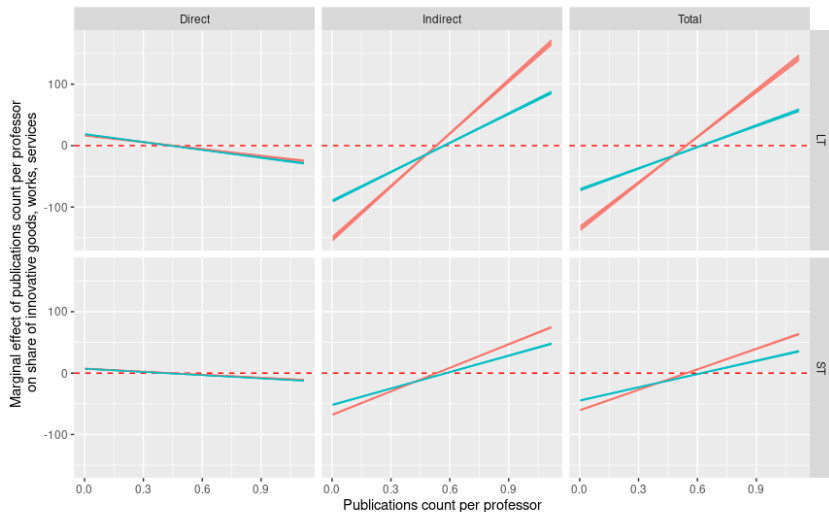Nonlinear effects
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Marginal effects of citations count per publication

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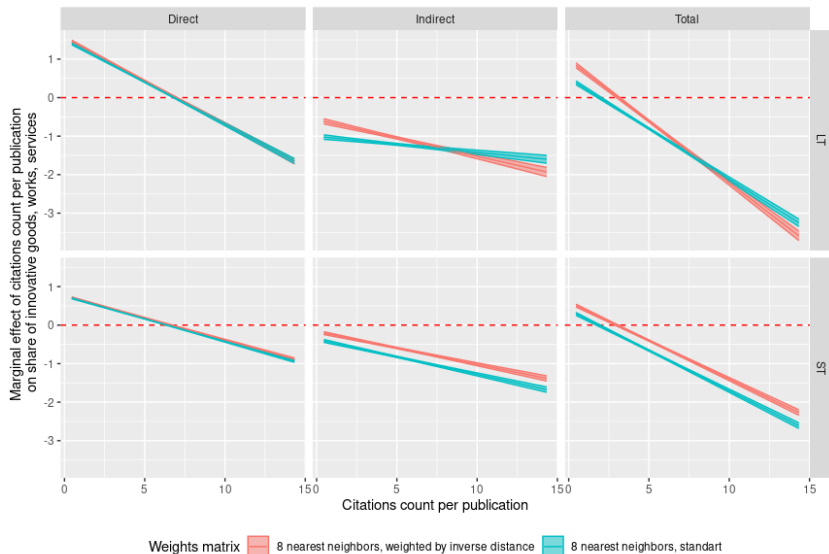**Results**
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Summary of the research results

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- ▶ This paper estimates the nonlinear effect of university research on innovation in the regions of Russia.
- ▶ The results obtained have novelty in view of the formulation of the question of nonlinearity, as well as due to the use of previously unused data sets.
- ▶ The estimation was made using the Durbin model, which takes into account both the dynamic and spatial nature of regional innovations.
- ▶ The results obtained can be used in planning policy in the field of support and stimulation of research activities of university teaching staff.