Does proximity matter in the choice of partners in collaborative R&D projects? An empirical analysis of granted projects in Germany

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Outline



2 Empirical Approach

- Data set
- Spatial Autocorrelation
- Estimation strategy

3 Results & Conclusion



Introduction

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- Different channels through which knowledge can be transferred and measured

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- Proximity is considered as a key determinant for knowledge transfer
- Boschma (2005) five dimensions of proximity
 - geographical, cognitive, institutional, organizational and social proximity

Previous findings on R&D collaborations

- Different applicants between EU FP and national schemes (Brökel & Graf, 2012)
- Public research organizations are overrepresented in EU FP
- SMEs apply for national rather than for EU grants
- Most studies refer to granted R&D collaboration projects from the EU Framework Programmes (e.g. Scherngell and Lata, 2013)
- Spatial interaction model accounting for spatial autocorrelation
- Evidence for the importance of proximity

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Research Gap

National support scheme: Analysis on actors, which have been less prominent in empirical research so far

Description of the Data set

Data Set

- Data: Granted R&D collaboration
- Soucre: Förderkatalog provided by the German Federal Ministry of Education and Research (BMBF)
- Subject of analysis: Cross-regional R&D collaboration intensity
- Regional level: 402 NUTS-3 regions (Kreise)
- Period of investigation: 2006 to 2012
- Collabortion Projects funded: 7,111 with 29,933 pariticipating actors
- Sum of cross-regional linkages: 159,376
- Number of regional pairs with at least one collaboration: 56,807 out of 1,131,228 possible pairs

Top ten regional pairs showing the highest number of collaborations

Region 1	Region 2	Number of collaborations
Munich (city)	Munich (district)	900
Munich (city)	Berlin	382
Hamburg	Berlin	313
Berlin	Potsdam	277
Stuttgart	Berlin	244
Munich (district)	Berlin	237
Stuttgart	Munich (city)	231
Berlin	Dresden	225
Hanover	Berlin	220
Heidelberg	Berlin	209

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Research questions

Does the importance of geographical proximity remain high if other proximity measures are included in the model?

Do proximity measures have linear or non-linear effects?

Data set Spatial Autocorrelation Estimation strategy

Empirical Approach

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Data set Spatial Autocorrelation Estimation strategy

Dependent Variable

Number of cross-region collaborations in granted R&D collaboration projects

- Out of the Förderkatalog, we extract a collaboration matrix for each year, *C* with 402 x 402 elements
- *c_{ij}* represents the amount of granted collaborations with partner from region *i* and *j*
- Symmetric collaboration matrix, with $c_{ij} = c_{ji}$

Empirical equation

$$c_{ij} = a_i^{\delta_1} * b_j^{\delta_2} * \sum_{z=1}^Z \beta_z g_{ij}^{(z)} + \epsilon_{ij}$$

- a_i Origin variables
- b_j Destination variables
- g_{ij} Separation variables

Data set Spatial Autocorrelation Estimation strategy

Determinants of the cross-regoinal collaboration intensity - I

Proximity measures - Boschma (2005)

- Geographical proximity: Euclidean distance between capital cities of two regions
- **Cognitive proximity**: One minus the Pearson correlation coefficient of the vectors of the relative industry shares between region *i* and *j*. (Employment statistics for 60 NACE Rev 1.1 industries provided by the Federal Employment Agency)
- Institutional proximity: One minus the Pearson correlation coefficient of the vectors of the voting shares of poltical parties in the federal elections between region *i* and *j*. (Federal Returning Officer)

Data set Spatial Autocorrelation Estimation strategy

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- Organizational and social proximity are omitted due to the lack of appropriate proxies

Data set Spatial Autocorrelation Estimation strategy

Determinants of the cross-regoinal collaboration intensity - II

Additional proximity measures

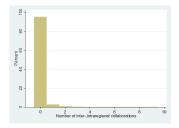
- Border dummy indicating whether one of the regions is located at the German land border with another country
- Neighbor dummy indicating whether region i and region j share a common border
- Intra-regional dummy indicating whether regional pair reflects an intra-regional linkage

Gravity parameters: Origin and Destination variables

- The number of employees in the regions under analysis (Federal Employment Agency)
- The number of establishments in the regions under analysis (Federal Employment Agency)

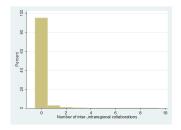
Data set Spatial Autocorrelation Estimation strategy

Figure: Histrogram of cross-region R&D collaborations



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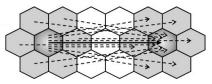


Properties of dependent variable

- Distribution: Count structure with long right tail
- Excess zeros: 95% of regional pairs do not report any collaborations
- Balanced panel structure
- \Rightarrow Longitudinal count model accounting for excess zeros

Data set Spatial Autocorrelation Estimation strategy

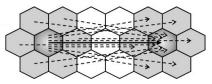
Figure: Spatial autocorrelation in spatial interaction model



Source: Chun & Griffith (2011)

Data set Spatial Autocorrelation Estimation strategy

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Eigenvector Spatial Filter (ESF) suited for spatial interaction data

- Conceptual Approach: Griffith & Chun (2014)
- Application to spatial interaction data: Scherngell & Lata (2013)
- Application to spatial interaction data with a longitudinal structure: Lata, Scherngell & Brenner (2015)

Data set Spatial Autocorrelation Estimation strategy

Eigenvector Spatial Filter

Major purpose of the Eigenvector Spatial Filter approach

Separation of spatially structured random component from the error term

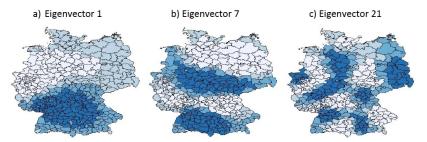
Construction of Eigenvector Spatial Filter

- Transformation of neighborhood matrix W $W^T = (I - 1'1 * 1/n)W(I - 1'1 * 1/n)$
- Eigenvectors $\mathbf{E} = (\mathbf{E}_1, \mathbf{E}_2, ..., \mathbf{E}_n)$ and their corresponding eigenvalues $\boldsymbol{\lambda} = (\lambda_1, \lambda_2, ..., \lambda_n)$ can be extracted from W^T
- Each eigenvector represents a synthetic map of spatial concentration, whose degree of concentration captured by the corresponding eigenvalues (only real values)
- Properties: Independence E*E'=I and zero mean E'*1=0

Data set Spatial Autocorrelation Estimation strategy

Eigenvector Spatial Filter

Figure: Eigenvectors derived from neighborhood matrix W



Data set Spatial Autocorrelation Estimation strategy

Eigenvector Spatial Filter

Selection of Eigenvectors

- $\sum_{o=1}^{O} E_o$ eigenvector spatial filters for the origin regions
- $\sum_{d=1}^{D} E_d$ eigenvector spatial filters for the destination regions
- Only eigenvectors with a Moran's Coefficient above 0.25, $MC_i = n/(\mathbf{1'}W\mathbf{1}) * \lambda_i$ (see Fischer & Griffith, 2008)
- Reduction from 402 to 98 potential eigenvectors
- For each year, we run a regression with all eigenvectors with Moran's Coefficient larger than 0.25.
- For the panel regression, we keep all eigenvectors, which had a significant impact in all cross-sectional regression at the 1%-level. (See Lata, Scherngell, Brenner, 2015)

Data set Spatial Autocorrelation Estimation strategy

Symmetry of the collaboration matrix $\ensuremath{\mathcal{C}}$

- Inclusion of the entire collaboration matrix in the regression
- Equality of coefficient estimates for origin and destination gravity parameters
- The same holds true for the set of eigenvectors, o(1, ..., O)=d(1, ..., D).
- $\sum_{m=1}^{M} E_m$ set of eigenvectors entering the regression for origin and destination regions

Count Regression is based on the following equation:

$$c_{ijt} = \exp\left[\alpha_0 + \delta(\ln(a_{it}) + \ln(b_{jt})) + \sum_{z=1}^{Z} \beta_z g_{ijt}^{(z)} + \theta_m(E_{mi} + E_{mj}) + \varepsilon_{ijt}\right]$$

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Data set Spatial Autocorrelation Estimation strategy

- Each specificatoin estimated twice:
 - i) Linear impact of proximity on collaboration intensity
 - ii) Squared terms of each proximity measure.
- Test for joint significance confirms non-linear relationship

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- Pooled zero-inflated Poisson as a robustness check

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- Panel estimation: Poisson and Nebin regressions
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- Randon-effects specification including Mundlak-group variables of time-variant regressors

Results & Conclusion

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Cross-Regional	Ne	gbin	Zero-Infla	ted Negbin	
collaborations			Collab.	Probit	
Geo. dist. in km	-0.00175***	-0.00471***	-0.00312***	0.00264***	
Geo.dist.in.km(sq)		4.80e-06***	4.10e-06***	-1.55e-06***	
Cognitive dist	-1.398***	-1.137***	0.114	2.018***	
Cognitive dist (sq.)		-0.298	-2.004***	-3.004***	
Institut dist	-0.352***	-1.098***	-1.110***	0.436***	
Institut dist (sq.)		0.499***	0.396***	-0.322***	
Border dummy	-0.310***	-0.333***	-0.204***	0.165***	
Neighbouring dummy	1.003***	0.688***	0 461***	-0.359***	
Int ra- regional dummy	2.381***	1.893***	1.773***	-0.111	
In(employees)	3.039***	3.056***	2.068***	-1.678***	
In (establishments)	-1.745***	-1.765***	-1.454***	0.532***	
Observations	1,131,228	1,131,228	1,13	1,228	
Log-Likelihood	-247,026.11	-246,447.57	-243,450.40		
Significant eigenvectors	13	13	12		
LR-Test Spatial Filter	17,094.42***	16,679.82***	12,123.3***		
Annual dummies and constant 10%, ** 5%, *** 1%	terms included but	not reported in this	table.Significance	levels * ∢ ≣ ► ≣ ৩৫০	

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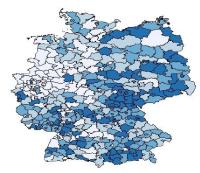
Findings

Determinants of collaboration intensity

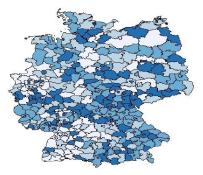
- U-shaped impact of geographical and institutional distance
- Negative impact shrinks after passing a threshold level (380 km or inst. dist. of 1.4)
- Positive impact may not be acheived or be neglected
- Negative impact of cognitive distance. Not as clear as for the other two proximity measures
- Other separation measures in line with expectations
- Regions with large enterprise tend to be more engaged in R&D collaborations
- Eigenvector Spatial Filters reduce the degree of autocorrelation

Figure: Average Error term per region - zero-inflated Negbin

a) Average residuals without spatial filters



b) Average residuals with spatial filters



Outlook and policy conclusion

Policy conclusion

- High share in economic strong regions and clusters
- R&D subsidies are absorped by technological strong actors
- Amplification of economic concentration
- Reduction of regional disparities cannot be aim of R&D subsidies

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Drawbacks and Outlook

- Focus on specific type of actors and collaborations
- Implementation of zero-inflated panel regressions
- Additional insights from collaborations across functional regions
- Identification of proxies for missing proximity measures

Appendix

Datase coparation valuation Comparation valuation Comparation valuation Constraint Constraint <thconstraint< th=""> Constraint <</thconstraint<>	, ,	0	,	Poisson		sson	Negative binomial		
Datase coparation valuation Comparation valuation Comparation valuation Constraint Constraint <thconstraint< th=""> Constraint <</thconstraint<>		Poi	sson	Negative	binomial	Count	Probit	Count	Probit
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Distance (separation variables)								
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Geographical distance (km)	-0.00135***	-0.00378***	-0.00175***	-0.00471***	-0.00237***	0.00207***	-0.00312***	0.00264***
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		(8.82e-05)	(0.000253)	(6.66e-05)	(0.000224)	(0.000306)	(0.000263)	(0.000325)	(0.000370)
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Geographical distance squared (km)		4.01e-06***		4.80e-06***	2.67e-06***	-1.79e-06***	4.10e-06***	-1.55e-06***
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $			(3.61e-07)		(3.16e-07)	(4.53e-07)	(3.91e-07)	(4.93e-07)	(5.43e-07)
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Cognitive distance	-1.545***	-0.817***	-1.398***	-1.137***	-0.342	1.906***	0.114	2.018***
		(0.0833)	(0.273)	(0.0542)	(0.179)	(0.298)	(0.269)	(0.289)	(0.426)
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Cognitive distance (squared)		-0.978***		-0.298	-1.198***	-2.101***	-2.004***	-3.004***
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$			(0.330)		(0.212)	(0.405)	(0.384)	(0.416)	(0.651)
	Institutional distance	-0.492***	-1.156***	-0.352***	-1.098***	-0.774***	0.851***	-1.110***	0.436***
$ \left(\begin{array}{cccccccccccccccccccccccccccccccccccc$		(0.0278)	(0.0767)	(0.0202)	(0.0647)	(0.0810)	(0.0752)	(0.0882)	(0.109)
	Institutional distance (squared)		0.464***		0.499***	0.314***	-0.420***	0.396***	-0.322***
International conductor (0.022) (0.027) (0.021) (0.027) (0			(0.0445)		(0.0380)	(0.0480)	(0.0458)	(0.0528)	(0.0660)
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Border region (dummy)	-0.332***	-0.298***	-0.310***	-0.333***	-0.147***	0.0962***	-0.204***	0.165***
Construction (0.0095) (0.0025) (0.0057) (0.0053) (0.0078)		(0.0322)	(0.0316)	(0.0211)	(0.0210)	(0.0429)	(0.0337)	(0.0341)	(0.0375)
Ibra regiond collocation (amp) 13.06 ⁿ⁺¹ 13.06 ⁿ⁺¹ 13.08 ⁿ⁺¹ 14.08 ⁿ⁺¹ 0.40 ⁿ⁺¹ 0.11 ¹ Atgin and domination variables (massem) 0.151 0.0114 0.0120 </td <td>Neighbouring region (dummy)</td> <td>0.984***</td> <td>0.755***</td> <td>1.003***</td> <td>0.688***</td> <td>0.533***</td> <td>-0.311***</td> <td>0.461***</td> <td>-0.359***</td>	Neighbouring region (dummy)	0.984***	0.755***	1.003***	0.688***	0.533***	-0.311***	0.461***	-0.359***
0.125 0.115 0.136 0.0379 0.0877 0.0877 0.0170 0.0170 0.0120 0.00270 0.0270		(0.0695)	(0.0632)	(0.0621)	(0.0653)	(0.0988)	(0.0642)	(0.0799)	(0.0931)
Xign ad dominion variables (mass unit) Namber of exactlements) 1.80*** 3.271*** 3.050*** 1.50*** 1.720*** 2.06*** 1.675*** Namber of exactlements 0.0454)* 0.0257** 0.0379** 0.026** 0.	Intra-regional collaboration (dummy)	1.360***	1.018***	2.381***	1.893***	1.408***	-0.408***	1.773***	-0.111
Number of engloyces (bp) 3.199*** 3.09*** 1.09*** 1.29*** 1.09*** 0.05** <td></td> <td>(0.125)</td> <td>(0.151)</td> <td>(0.134)</td> <td>(0.139)</td> <td>(0.0987)</td> <td>(0.102)</td> <td>(0.123)</td> <td>(0.142)</td>		(0.125)	(0.151)	(0.134)	(0.139)	(0.0987)	(0.102)	(0.123)	(0.142)
Namber of extallibutions (b) 0.0053 0.00750 0.00760 0.00870 0.0	Origin and destination variables (mass terms)								
Number of scatabinisments (p) 1397*** 2.139*** 1.739*** 1.769*** 1.600*** 0.000** <	Number of employees (log)	3.190***	3.271***	3.039***	3.056***	1.720***	-1.797***	2.068***	-1.678***
00179 00.0609 0.00170 0.02710 0.02570 0.02570 0.06270 Consum 4.312*** 4.30*** 2.24*** 2.28*** 3.28*** 3.28*** 5.27*** 5.37**		(0.0645)	(0.0726)	(0.0375)	(0.0376)	(0.0621)	(0.0541)	(0.0542)	(0.0637)
Small 4312*** 439*** 2.264*** 2.264*** 3.300*** 13.00*** 7.24*** 5.573*** Small 0.050 0.250 0.050 0.050 0.054 0.355 0.553 0.553 0.553 0.554 0.554 0.555 0.553 0.555 0.553 0.554 0.555<	Number of establishments (log)	-1.937***	-2.032***	-1.745***	-1.765***	-1.060***	0.861***	-1.454***	0.532***
Annual hulphan biomatar hulphan Series functional for a state of the state of the state state of the state of the state state of the state of the state of the state state of the state of the state of the state state of the state of the state of the state state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state of the state state of the state of the state of the state of the state state of the state of the state of the state of the state of the state state of the state of the state of the state of the state of the state state of the state of the		(0.0719)	(0.0806)	(0.0369)	(0.0371)	(0.0576)	(0.0492)	(0.0523)	(0.0629)
Jamma halpha 1.42*** 1.41*** 0.55*** Baveratami 1.11.228 1.11.228 1.11.228 1.11.228 Jambard Mark 1.15.228 1.11.228 1.11.228 1.11.228 1.11.228 Jack Test Space Mark 3.156.200 2.702.51 3.64.4175 2.754.4175 2.754.4175 2.754.4175 JAC Test Space Mark 4.202.64*** 7.155.44** 1.070.4175 2.754.4175 2.754.4175 2.754.4175 2.754.4175 2.754.4175 2.754.4175 2.754.4175 2.754.4175 7.754.7165 1.212.33** 1.212.33** 1.212.33** 1.212.21 1.212.23 1.212.23 1.212.23 1.212.23 1.212.23 1.212.23 1.212.23 1.212.23 1.212.23** 1.212.33** 1.212.33** 1.212.33** 1.212.33** 1.212.33** 1.212.33** 1.212.33** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** 1.212.23** </td <td>Constant</td> <td>4.312***</td> <td>4.988***</td> <td>2.204***</td> <td>2.887***</td> <td>3.809***</td> <td>1.816***</td> <td>7.274***</td> <td>5.873***</td>	Constant	4.312***	4.988***	2.204***	2.887***	3.809***	1.816***	7.274***	5.873***
Instructions 1,11,228 1,11,228 1,11,228 1,11,228 1,11,228 1,11,228 Log Lakihood -1,15,21,33 -1,11,228 1,11,228		(0.693)	(0.230)	(0.268)	(0.270)	(0.459)	(0.346)	(0.353)	(0.454)
Jaccrustam 1.13.1228 1.33.1238 1.33.1238 1.33.1238 1.33.1238 1.33.1238 1.23.138* 0.75.167.167.167.167.167.167.167.167.167.167	Constant Inalpha			1.432***	1.417***			0.586***	
				(0.0192)	(0.019)			(0.0156)	
Xi, Tari, Squand Tahra 42.00.44*** 71.51.54*** 10.69.32*** SQu100*** 12.12.33** VCS for (pint squand diance measure decar). I with optial filters 20.1*** 71.09.42*** 16.07.32*** SQu100*** 12.12.33** Mean I, with optial filters 0.944 0.99 -0007 -0008 0.27.9 0.097 Mean I, without optial filters 0.954 0.242 -00007 -00008 0.27.9 0.097 Maner I without optimum 0.24 24.25 -00007 -00008 0.27.9 0.097 State of anglicant cigenvector 1.9 1.6 1.3 1.3 8 1.2 Gate or consultacionation 0.512*** 0.512*** 0.512*** 0.598*** 0.52*** 0.598***	Observations	1,131,228	1,131,228	1,131,228	1,131,228	1,131,228		1,131,228	
V7-free for significance of squared distance messares 226. ¹¹⁹⁷ 475.560 ¹⁹⁸ 77.41 ¹⁹⁷⁸ 170.39 ¹⁹⁷⁸ doma's l without qualifilation. 0.914 0.199 -0.0008 527.99 0.097 doma's l without qualifilation. 0.024 -0.00040 -0.0008 527.99 0.097 under of significant eigeneeuton 0.19 16 13 13 8 12 clar on endiperson 0.523 ¹⁹⁷⁸ 0.523 ¹⁹⁷⁸ 0.523 ¹⁹⁷⁸ 0.523 ¹⁹⁷⁸ 0.6996 ¹⁹⁷⁸	Log-Likelihood	-315,921.83	-316,420.69	-247,026.11	-246,447.57	-275,442.1		-243,450.40	
Mean's Humb quaid filters 0.944 0.959 -0.0007 -0.0008 0.279 0.047 Mean's Humber quaid filters 0.243 0.245 -0.0008 -0.003 0.020 -0.024 Mather of adjufficant digenvecture 1.9 1.6 -1.3 -8 -1.2 -1.2 Factor consulprised 0.532*** 0.532**** 0.592*** 0.522*** 0.592***	LR-Test Spatial Filter	41,200.84***	77,515.4***	17,094.42***	16,679.82***	30,410.0***		12,123.3***	
Mean's l'vishour parial filters .0243 .0245 .00040 .00033 .033 .0324 Sumér d'ajuficant digenectors 19 16 13 13 8 12 Enfo orcedigenectors 0.5213*** 0.9272*** 1.1512*** 0.6905***	X2-Test for joint significance of squared distance measures		236.1***		475.56***	77.41***		170.39***	
Momin' hither spinia filters .024 .0245 .0000 .0003 .033 .0324 Samber of significant eigencetors 19 16 1 13 8 12 Factor sendigregences 0.523*** 0.528*** 0.9272*** 1.512*** 0.6965***	Moran's I with spatial filters	.0194	.0159	00007	00008	.0279		.0197	
Number of significant eigenvectors 19 16 13 13 8 12 Fest for overdispersion 0.5233*** 0.5129*** 0.9308*** 0.9272*** 1.1512*** 0.6905***	Moran's I without spatial filters	.0243	.0245	00040	00033	.0330		.0324	
Test for overdispersion 0.5233*** 0.5129*** 0.9308*** 0.9272*** 1.1512*** 0.6905***	Number of significant eigenvectors	19	16	13	13	8			
	Test for overdispersion	0.5233***	0.5129***	0.9308***	0.9272***				
	Vuong-Statistes for model without clustered error terms		1		1	49.47***		32.74***	

Table 4. Estimation results for the pooled regressions - non-inflated and zero-inflated specifications

Notes: Standard errors in parentheses. - The dependent variable is the number of cross-regional collaborations between region i and j. – Annual dummies and constant terms included but not reported in this table. – Significance levels * 10%, ** 5%, *** 1%, – The coefficients of the origin and destination region are identical.

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Source: Authors' own calculation.

	Peisson	Negative binomial
VARIABLES	(9)	(10)
Distance (senaration variables)		
Geographical distance (km)	-0.00520***	-0.00344***
	(0.000177)	(0.000150)
Geographical distance squared (km)	5.20e-06***	3.10e-06***
	(2.63e-07)	(2.25e-07)
Cognitive distance	3.521***	2.485***
	(0.288)	(0.382)
Cognitive distance (squared)	-4.561***	-3.138***
	(0.337)	(0.443)
Institutional distance	-0.0993	0.0374
	(0.0448)	(0.0597)
Institutional distance (squared)	0.0922***	0.0287
	(0.0236)	(0.0315)
Border region (durnmy)	-0.248***	-0.235***
	(0.0173)	(0.0148)
Neighbouring region (dammy)	0.730***	0.285***
	(0.0502)	(0.0374)
Intra-regional collaboration (dummy)	1.818***	-0.378***
	(0.0960)	(0.0611)
Origin and destination variables (mass terms)		
Number of employees (log)	-0.901***	0.0527
	(0.192)	(0.264)
Number of establishments (log)	1.440***	1.408***
	(0.181)	(0.248)
Mundlak: Group Variables		
Cognitive distance	-5.134***	-3.791***
	(0.323)	(0.401)
Cognitive distance (squared)	5.103***	3.548***
	(0.382)	(0.465)
Institutional distance	-1.115***	-1.103***
	(0.0838)	(0.0843)
Institutional distance (squared)	0.492***	0.501***
	(0.0494)	(0.0485) 2.539***
Number of employees (log)	3.736***	
N 1 6 111 - 6 1	(0.195) -2.933***	(0.265)
Number of establishments (log)	-2.933****	-2.858****
Constant	(0.154)	1.784***
L OEM2PE		
e	(0.237) 0.937***	(0.193) 1.102***
Constant Inalpha	(0.0110)	(0.0120)
on		(0.0120)
Observations	1,131,228	
Log-Likelihood	-251,970.82 7,276.96***	-230,528.56 7.234.96***
LR-Test Spatial Filter	20	7,234.96***
Number of significant eigenvectors Hausman Test between fixed-effects and random-effects	20 89.8***	13 5939.42***
Hausman Test between fixed-effects and random-effects	89.8***	5939.42***

Table 5. Estimation results for the panel regressions (random effects with Mundlak group variables)

Notes: Z-values in parentheses. The dependent variable is the number of cross-regional collaborations between region 1 and j. - Annual dummies and constant term included but not reported in this table. - Significance levels * 10%, ** 5%, *** 1%, - The coefficients of the mass terms (or the origin and desinition region are identical.

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Source: Authors' own calculation.