Determinants of Regional Innovation in Brazil between 1998 and 2018: a Spatial Panel Approach

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Literature Review

- Regional Knowledge Production Function (Jaffe, 1989)
  - Assess determinants of regional innovative performance
  - Using patent fractional counts as a proxy of innovation
- Role of local Human Capital, Industrial and University R&D on innovation
  - (Jaffe, 1989; Audretsch and Feldman, 1996; Acs et al., 2002)
- Urban agglomeration, industrial specialization/diversification, etc.
  - (Carlino et al., 2007; Moreno et al., 2006; Crescenzi et al., 2012)
- Path-dependence, interregional spatial spillovers, co-inventors networks
  - (Miguelez and Moreno, 2013; Charlot et al., 2015; Gonçalves et al., 2020; De Noni et al. 2017)

Literature Review

- Literature Gap:

  Few studies on developing countries;

  Brazil (Gonçalves et al., 2020); China (Ying, 2008; Wang et al., 2016); India (Crescenzi et al., 2012); Russia (Crescenzi et al; 2017)

  Hierarchical-functional regional division and less aggregated areas;

  (REGIC vs. states; provinces; etc.).

  Recent patent data and longer panel (1998-2018);

  (in general data until 2010)

  Explore some heterogeneity from patent data (univ. vs. industrial).

Data

- *Main variable*: patents filled in Brazilian Office (BADEPI)
  - Inventor location and fractional count
- Period: 21 years grouped in 7 triennia (1998-2018)
- 71,177 patents geolocalized (79%)

Data

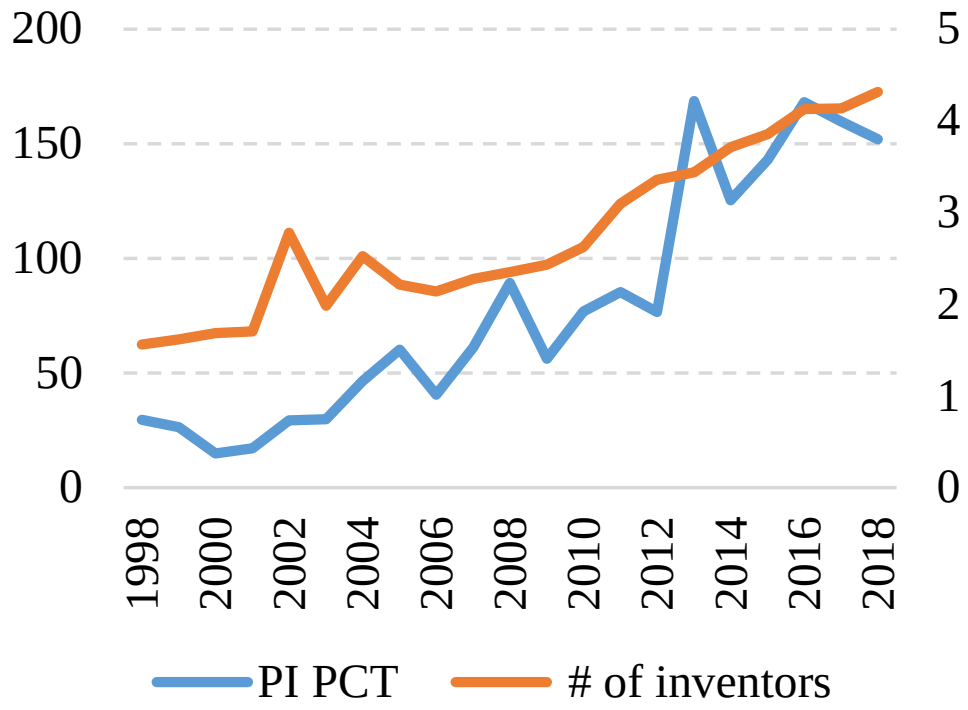
Variable	Description	Source
$PI_{r,t-1}$	Number of fractional patents per 100,000 inhabitants of the region in log form	BADEPI
$R\&DInd_{r,t-1}$	Number of 'technical and scientific personnel' (PoTec) of the region in log form	RAIS
$R\&DUniv_{r,t-1}$	Number of graduate scholarships in STEM per 100,000 inhabitants of the region in log form	CAPES
$HK_{r,t-1}$	Share of higher education personnel for the region employment	BADEPI
$DensPop_{r,t-1}$	Population density for the region	IBGE
$HHI_{r,t-1}$	Hirschman–Herfindahl index for the region employment in manufacturing	BADEPI
$Closeness_{r,t-1}$	Closeness centrality of the region in the co-patenting network	BADEPI
$Betweenness_{r,t-1}$	Betweeness centrality of the region position in the whole network	BADEPI
Dummies UF	Dummies for Federal States	IBGE

Model

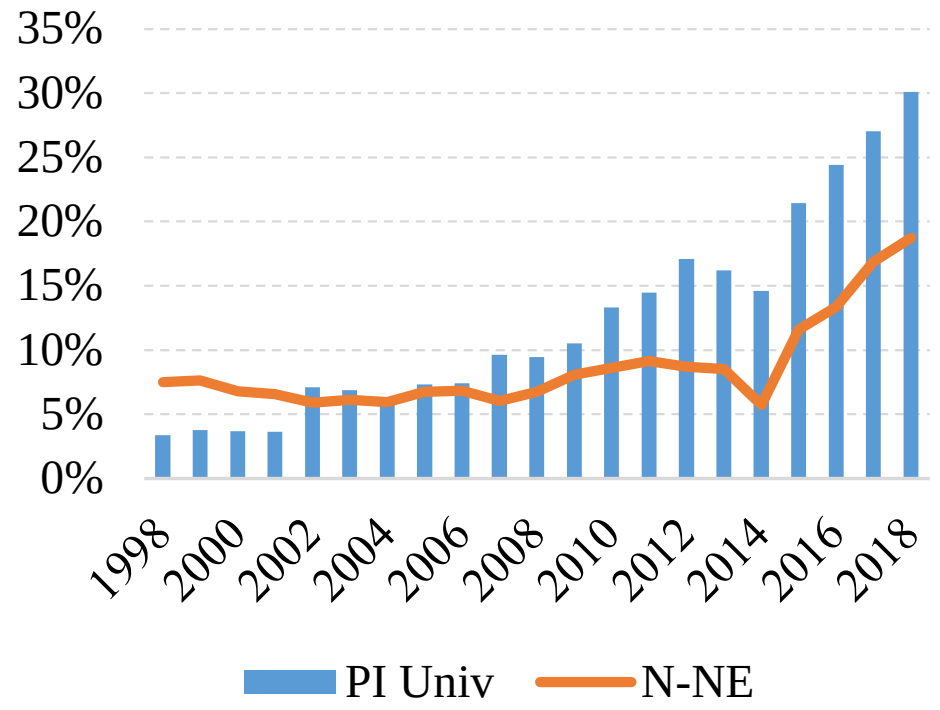
$$I_{r,t} = \beta_0 + \beta_1 R_{r,t-1} + \beta_2 Z_{r,t-1} + \beta_3 N_{r,t-1} + \beta_4 C_{r,t-1} + \beta_5 I_{r,t-1} + \lambda W u_t + \varepsilon_t$$

- Regional units: 133 intermediate regions (REGIC)
- Spatial Panel: tested 4 specifications (SEM, SAR, SDEM, SDM)
- Spatial weight matrix: inverse distance

Descriptive Analysis

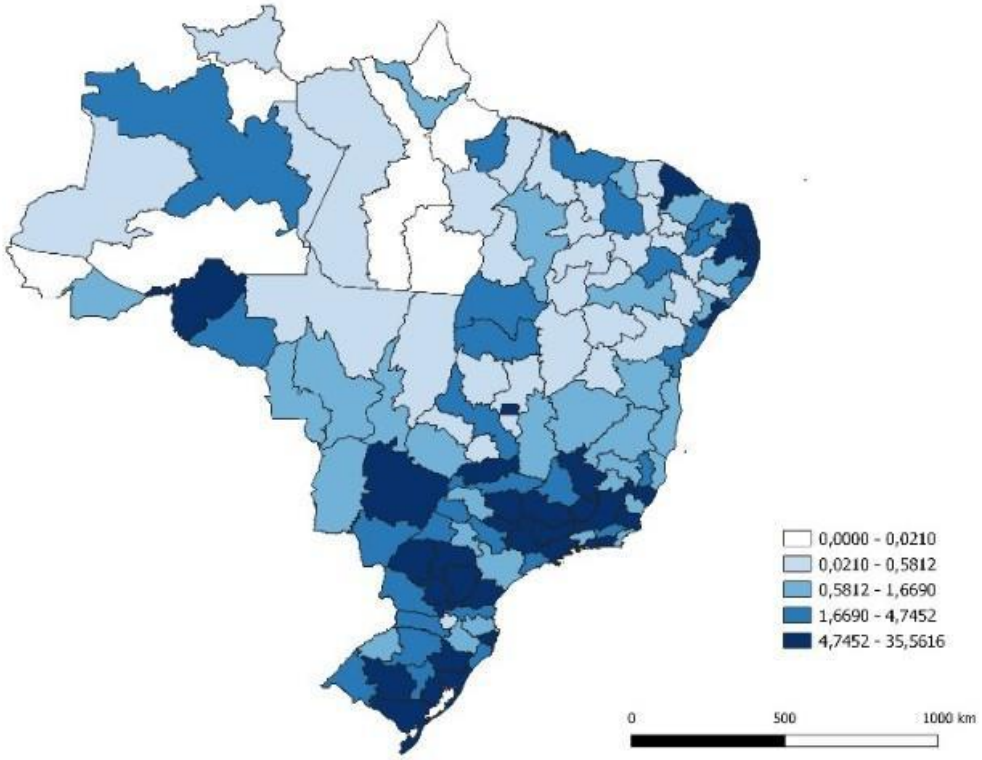


(a) Average number of inventors vs. international patents

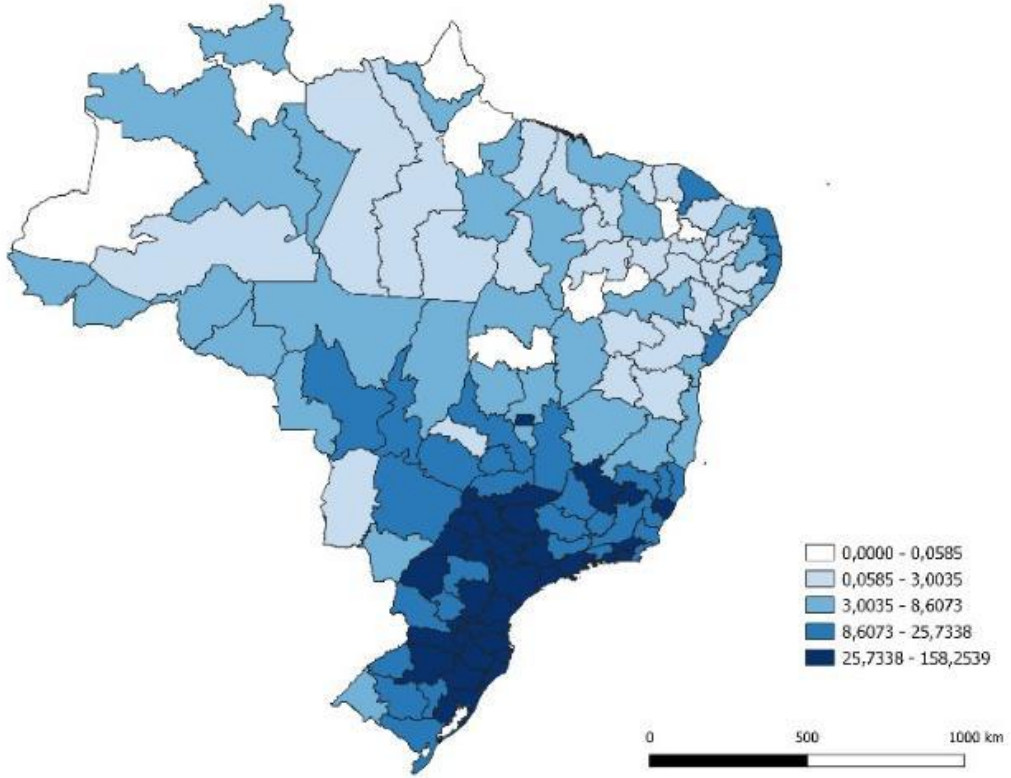


(b) Share of university patents vs. share of patents in North-Northeast region

Descriptive Analysis



(a) University patents



(b) Industrial patents

Results

	(1)	(2)	(3)	(4)
$PI_{r,t-1}$	0.846***	0.683***	0.677***	0.657***
	(0.0218)	(0.0273)	(0.0277)	(0.0283)
$R\&DInd_{r,t-1}$		0.0311***	0.0290***	0.0287***
		(0.00557)	(0.00632)	(0.00660)
$R\&DUniv_{r,t-1}$		0.0275***	0.0260***	0.0214***
		(0.00534)	(0.00577)	(0.00603)
$HK_{r,t-1}$			-0.00956	-0.00502
			(0.0213)	(0.0214)
$DensPop_{r,t-1}$			0.000206	6.83e-05
			(0.000168)	(0.000172)
$DensPop^2_{r,t-1}$			-1.34e-07	-1.29e-07
			(9.10e-08)	(9.04e-08)
$HHI_{r,t-1}$			-0.0453	-0.0351
			(0.0609)	(0.0606)
$Closeness_{r,t-1}$				0.00624
				(0.0466)
$Betweenness_{r,t-1}$				3.092***
				(0.933)
Wu_t	0.826***	0.838***	0.839***	0.845***
	(0.0492)	(0.0563)	(0.0556)	(0.0575)
Constant	0.154***	0.0441	0.0872	0.0815
	(0.0530)	(0.0540)	(0.0781)	(0.0781)
Dummies UF	Yes	Yes	Yes	Yes
N	798	798	798	798
n	133	133	133	133
T	6	6	6	6
AIC	-384.1	-463.6	-461.1	-468.1

Results – Per capita patents

- *Path dependence*
- Industrial and University R&D
- Co-inventor networks (*Betweenness*)
- Spatial error term

Heterogeneity

	(5) PI Univ	(6) PI Ind
$PI\ Univ_{r,t-1}$	0.871***	
	(0.0419)	
$PI\ Ind_{r,t-1}$		0.673***
		(0.0252)
$R\&DInd_{r,t-1}$	0.00282	0.0270***
	(0.00416)	(0.00597)
$R\&DUniv_{r,t-1}$	0.0306***	-0.00250
	(0.00423)	(0.00540)
$HK_{r,t-1}$	-0.0301**	0.0152
	(0.0140)	(0.0190)
$DensPop_{r,t-1}$	-0.000158	0.000264*
	(0.000111)	(0.000155)
$DensPop^2_{r,t-1}$	2.97e-08	-2.03e-07**
	(5.84e-08)	(8.14e-08)
$HHI_{r,t-1}$	0.00489	-0.0517
	(0.0394)	(0.0545)
$Closeness_{r,t-1}$	0.0216	-0.0278
	(0.0303)	(0.0419)
$Betweenness_{r,t-1}$	1.375**	2.405***
	(0.661)	(0.831)
Wu_t	0.846***	0.779***
	(0.0454)	(0.0745)
Constant	0.165***	-0.0447
	(0.0506)	(0.0691)
Dummies UF	Yes	Yes
N	798	798
n	133	133
T	6	6
AIC	-1152.7	-639.3

University patents vs. Industrial patents

- Path-dependence (both)
- Industrial R&D → Industrial patents
- University R&D → University patent
  - (Lissoni, 2008)
- Agglomeration effects (ind)
- Network effects (both)
- Spatial error term (both)

	(7) S-SE-CO	(8) N-NE
$PI_{r,t-1}$	0.659***	0.347***
	(0.0365)	(0.0700)
$R\&DInd_{r,t-1}$	0.0454***	0.0156**
	(0.0120)	(0.00774)
$R\&DUniv_{r,t-1}$	0.0138	0.0477***
	(0.00842)	(0.00992)
$HK_{r,t-1}$	0.0573	-0.00234
	(0.0476)	(0.0205)
$DensPop_{r,t-1}$	-0.000145	0.000703
	(0.000240)	(0.000552)
$DensPop^2_{r,t-1}$	-9.16e-09	-1.24e-06
	(1.24e-07)	(1.30e-06)
$HHI_{r,t-1}$	-0.134	-0.00862
	(0.111)	(0.0614)
$Closeness_{r,t-1}$	0.000862	0.00514
	(0.0740)	(0.0552)
$Betweenness_{r,t-1}$	1.736	7.529***
	(1.198)	(1.692)
Wu_t	0.743***	0.801***
	(0.0909)	(0.0657)
Constant	0	0.179**
	(0)	(0.0710)
Dummies UF	Yes	Yes
N	414	384
n	69	64
T	6	6
AIC	-137.4	-381.6

North vs South

- Path-dependence (both)
- Industrial R&D → both
- University R&D → North
- Network effects → North
- Spatial error term (both)

Robustness check

	(9) PI PCT	(10) PI CoInv	(11) UM
$PI\ PCT_{r,t-1}$	0.504***		
	(0.0541)		
$PI\ CoInv_{r,t-1}$		0.770***	
		(0.0311)	
$UM_{r,t-1}$			0.767***
			(0.0215)
$R\&DInd_{r,t-1}$	0.00280***	0.0145***	0.0173***
	(0.00108)	(0.00506)	(0.00542)
$R\&DUniv_{r,t-1}$	-0.00128	0.0278***	0.00263
	(0.000991)	(0.00483)	(0.00500)
$HK_{r,t-1}$	-0.000946	-0.0216	0.0148
	(0.00316)	(0.0170)	(0.0176)
$DensPop_{r,t-1}$	7.16e-05**	-0.000110	3.97e-06
	(2.99e-05)	(0.000136)	(0.000143)
$DensPop^2_{r,t-1}$	-4.57e-08***	-2.01e-08	-2.12e-08
	(1.57e-08)	(7.17e-08)	(7.47e-08)
$HHI_{r,t-1}$	-0.00533	-0.00289	-0.0105
	(0.00998)	(0.0479)	(0.0506)
$Closeness_{r,t-1}$	-0.0113	-0.0116	-0.0176
	(0.00700)	(0.0368)	(0.0389)
$Betweenness_{r,t-1}$	0.756***	2.354***	0.113
	(0.153)	(0.758)	(0.762)
Wu_t	0.730***	0.854***	0.789***
	(0.0886)	(0.0481)	(0.0680)
Constant	-0.00156	0.103*	-0.0354
	(0.0126)	(0.0614)	(0.0636)
Dummies UF	Yes	Yes	Yes
N	798	798	798
n	133	133	133
T	6	6	6
AIC	-3564.8	-840.5	-761.5

Robustness check

- International Patents (PCT)
  - (Rodriguez-Pose et al., 2008; Rassenfosse and Jaffe, 2021)
- Co-invented patents
  - (Rassenfosse and Jaffe, 2021)
- Utility models
  - Ying (2008)
- Other: queen Spatial Weigth Matrix

Conclusions

- Confirm important determinants of regional innovation
  - Industrial and University R&D;
  - Path-dependence, spatial effects;
  - Urban agglomeration and co-inventors networks.
- Evidence with new data and focused in Brazil
  - University vs Industry innovation works on different ways;
  - North vs. South regimes.

Next steps

- Deal endogeneity issues (GMM)
- Include additional controls
- Explore more heterogeneity
  - Patent/Inventors data

- Comments? Suggestions?

Thanks

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