



# The Limits of Lending: Banks and Technology Adoption across Russia

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# Motivation

- Firm innovation drives factor productivity and long-term economic growth ([Romer 1990, Aghion and Howitt 1992](#))
  1. Countries [close to](#) the technological frontier: firms undertake R&D, invent new products and technologies, and patent
  2. Countries [further away](#) from the technological frontier: firms adopt and adapt existing technologies ([Acemoglu, Aghion and Zilibotti, 2006](#))
- Imitative innovation diffuses technologies across and within countries
  - Technological diffusion explains up to 25 per cent of the variation in national income levels ([Comin and Hobijn 2010](#))

# Motivation

- What holds back technological diffusion?
  - Technology adoption is costly ([Mansfield, Schwartz and Wagner 1981](#))
  - Firms, especially smaller ones, may need external funding to imitate
- [Aghion, Howitt and Mayer-Foulkes \(QJE 2005\)](#): Schumpeterian model in which financial constraints prevent countries from exploiting R&D that was carried out in countries closer to the technological frontier
- Empirical challenges to put this theory to the test:
  - ✧ Need firm-level information on *both* credit constraints and imitative innovation (that is, need to go beyond patenting data...)
  - ✧ Need a convincing identification strategy

# Russia

- Two salient characteristics:
  1. Many Russian firms display a very low rate of technological adoption  
[Russia ranks 126<sup>th</sup> out of 148 countries in the World Economic Forum's Global Competitiveness Report on this indicator](#)
  2. Many Russian firms have limited access to bank credit ([EBRD 2013](#))
- We ask:
  - To what extent can characteristic 2 explain characteristic 1?
  - Does better access to credit help firms to innovate and, if so, along which margins?

# Related literature

# Theory: Can banks foster innovation?

No

- Intangible, firm-specific assets difficult to collateralise ([Hall and Lerner 2010](#), [Carpenter and Petersen 2002](#))
- Firms hesitant to disclose sensitive R&D information ([Bhattacharya and Ritter 1983](#))
- R&D too complex to understand for banks ([Ueda 2004](#))
- Banks are technologically conservative ([Minetti 2011](#))

Yes

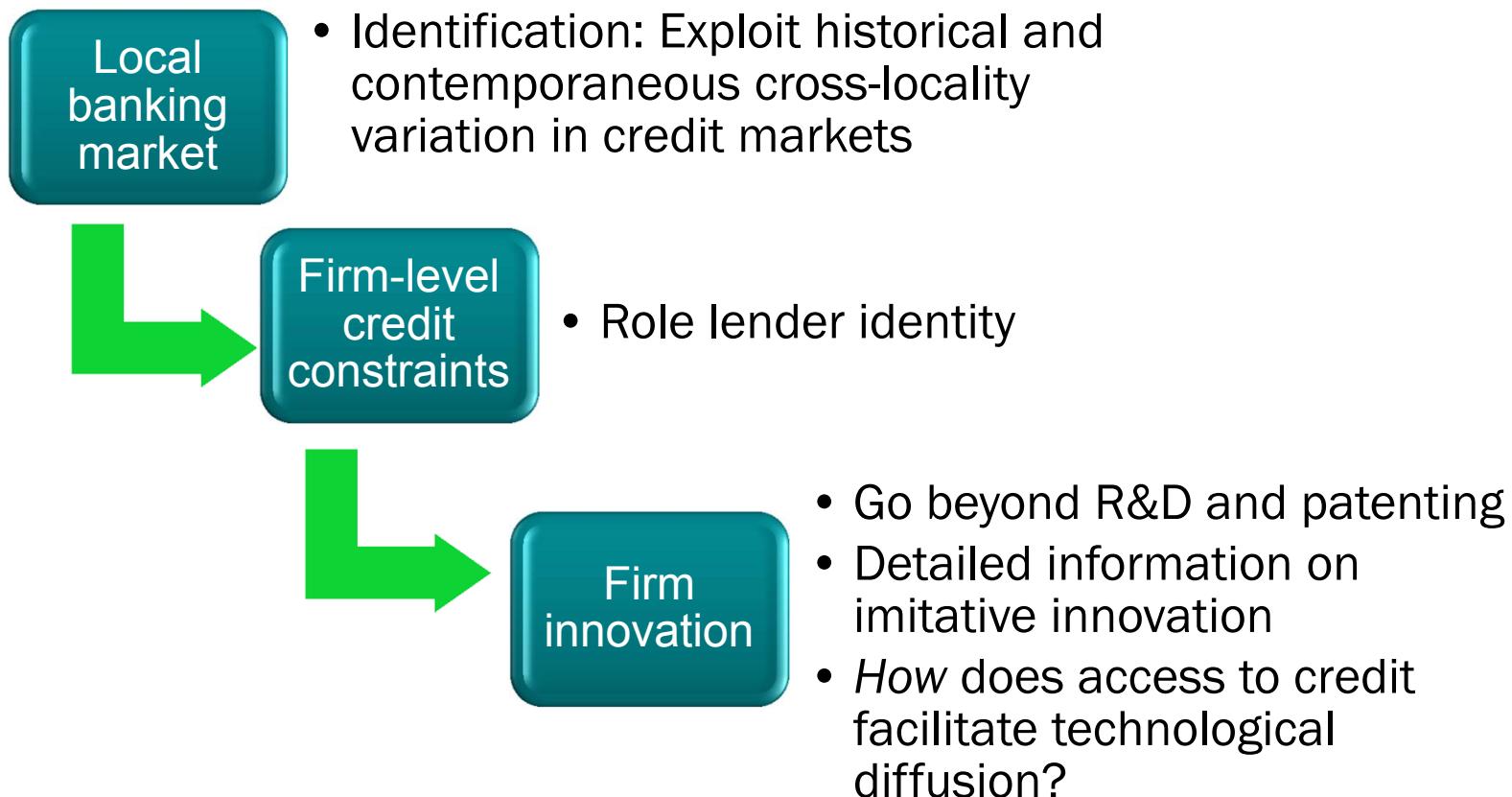
- Banks specialize in building lending relationships with clients and can overcome agency problems ([De la Fuente and Marin 1996](#), [Rajan and Zingales 2001](#))
- Technological upgrading requires better screening technologies by banks ([Laeven, Levine, and Michalopoulos 2013](#))

# Related empirical literature



- Established literature on the role of banks in economic development ([Smith 1776](#), [Schumpeter 1934](#), [Gerschenkron 1952](#), [McKinnon 1973](#))
- More recent ‘finance and growth’ literature ([e.g. Beck, Levine and Loayza 2000](#), [Demirguc-Kunt and Levine 2001](#))
- Emerging work on access to bank credit and innovation:
  - ❖ Cross-country correlations ([Ayyagari, Demirguc-Kunt and Maksimovic 2011](#))
  - ❖ U.S. evidence on inter-state bank deregulation and patenting ([Chava et al. 2013](#), [Amore et al. 2013](#), [Subramanian and Subramanian 2013](#), [Cornaggia et al. 2014](#))
  - ❖ Limited (mainly Italian) firm-level evidence ([Herrera and Minetti 2007](#), [Gorodnichenko and Schnitzer 2013](#), [Benfratello, Schiantarelli and Sembenelli 2008](#), [Alessandrini, Presbitero and Zazzaro 2010](#))

# Our contribution



# Upfront: Is our story causal?



1. We discuss existing evidence and provide new historical and statistical evidence on the quasi-random geographical distribution of spetsbanks
2. Sorting of banks into localities?
  - ✓ Locality-level regressions show that local banking structures are orthogonal to a large set of *observable* business characteristics
3. Impact of unobservables?
  - ✓ We quantify the relative importance of omitted variables and find that we may in fact underestimate the true effect (cf. Altonji et al. 2005)
4. Exclusion restriction?
  - ✓ Our 2SLS estimates are robust to a substantial relaxation of the strict exogeneity assumption (cf. Conley, Hansen and Rossi 2012)



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# Data

## BEEPS V Survey

- ✧ Conducted in 2011/12 across Russia
- ✧ N = 4,220 firms, precise geographic coordinates
- ✧ Stratified random sample to achieve representativeness across industry, firm size, and region
- ✧ New Innovation Module: Firm managers asked whether they introduced new products, production methods, organisational practices or structures, marketing methods, and/or conducted R&D or spent on consulting services during the past three years.
- ✧ Follows OECD guidelines for collecting technological innovation data ("Oslo Manual")

# Defining credit constraints

- “Did the firm apply for any loans or line of credit?”
  - Yes: What was the outcome of the application?
  - No: What was the reason for not applying?
- If firm answers “No need for a loan”, we classify it as not demanding bank credit
- If loan application was *rejected* or the firm was *discouraged*\*<sup>\*</sup>, then we classify the firm as *credit constrained*

\* “Interest rates were not favourable”; “Collateral requirements were too high”; “Size of loan and maturity were insufficient”; or “Did not think it would be approved”

# Focus on the two relevant groups of firms

	<i>Share of firms with:</i>		
	Any Innovation	At Least 2 Innovations	Observations
Loan	54.65%***	38.32%***	1,010
Private domestic bank	52.94%	35.29%	425
State bank	55.89%	39.83%	467
Foreign bank	55.92%	43.22%	118
No Loan	37.97%	23.04%	2,839
No demand	35.76%	21.61%	1,555
Credit constrained	40.65%	24.77%	1,284
Total	42.35%	27.05%	3,849

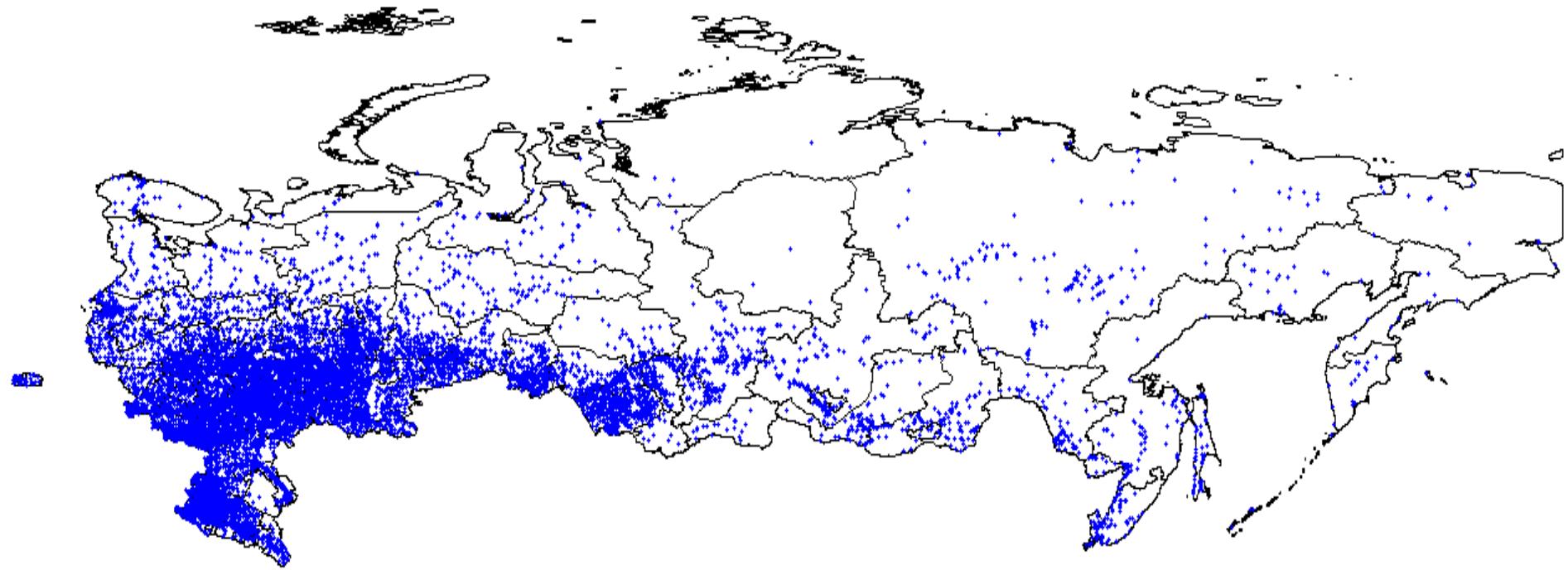
# Local banking markets



## BEPS II survey conducted in 2012

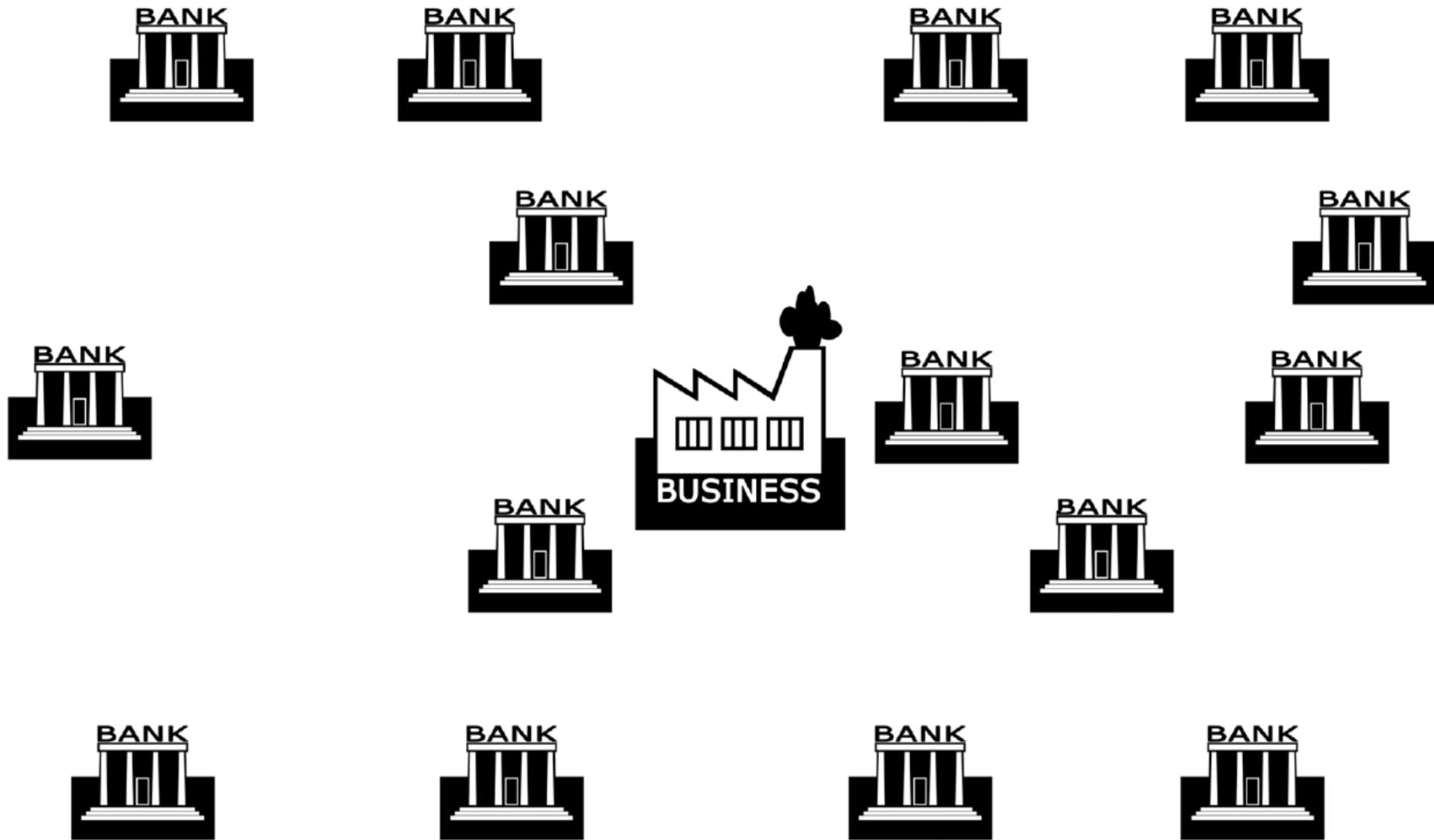
- Geo-coordinates of near universe of bank branches in Russia
- N = 45,728 branches of 853 different banks
- Identify bank ownership (*domestic private, domestic state, foreign*) and match with BankScope
- Use bank CEO responses to BEPS II survey to identify *relationship* and *transaction* banks (cf. Beck, Degryse, De Haas and van Horen 2014)

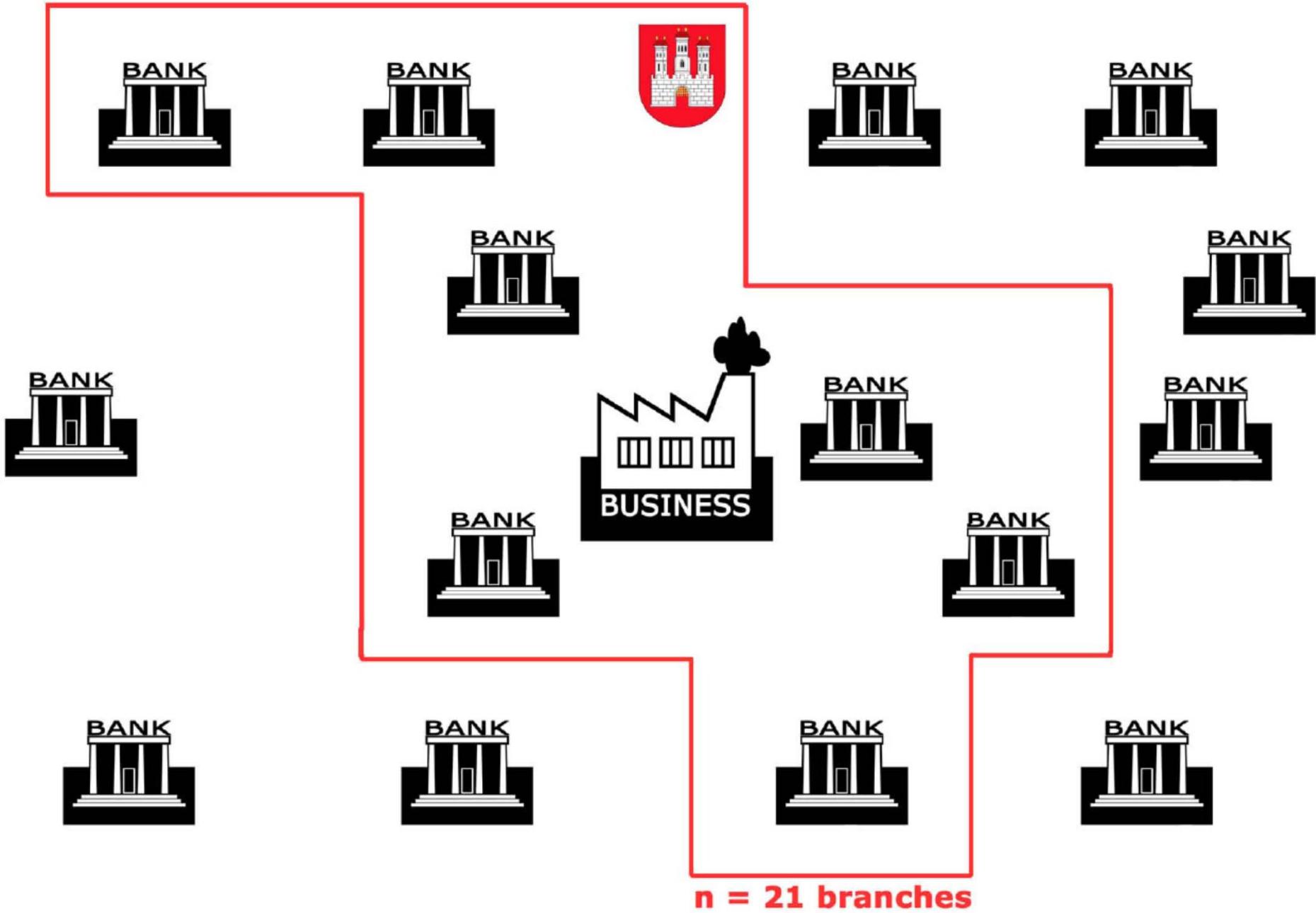
# Local banking markets



Each blue dot represents a bank branch. Source: EBRD BEPS II Survey







# Local banking markets

Locality  $k$ : town or city. 159 localities in BEEPS.

- ① Local concentration: Herfindahl-Hirschman Index (HHI)

$$HHI_{Locality_k} = \sum_{n=1}^{N_b} \left( \#branch_b / \sum_{n=1}^{N_b} \#branch_b \right)^2$$

- ② Local composition: Market share of foreign banks

$$MS_{Foreign_k} = \sum_{f=1}^{F_b} \#branch_b / \sum_{n=1}^{N_b} \#branch_b$$

# Historical variation in credit markets



- ③ Historical variation: ‘Spetsbanks’ per million inhabitants  
(Berkowitz, Hoekstra, Schoors 2014)
- ❖ Created in the last years of the Soviet Union (1988-1991)
  - ❖ Presence uncorrelated with local economic or institutional environment
  - ❖ Location driven by “*high-level Soviet administrators on the basis of their own preferences, which were largely divorced from forces shaping organisations in market economies*”
  - ❖ Lasting impact on local banking markets: Regions with one more spetsbank per million inhabitants, experienced 11 to 22 percent more lending to the private sector in 2002-06



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# Econometric framework

# Main equation: 2SLS

- Sample: firms with credit demand
- Identification: historical and contemporaneous cross-locality variation in credit markets

$$Constrained_{ijk} = \beta_1 Local\ Banking_k + z_{2,ijk}\delta_2 + \gamma_1 IMR_{ijk} + \eta_j + v_{ijk}$$

$$Innovation_{ijk} = \alpha_1 Constrained_{ijk} + z_{3,ijk}\delta_3 + \gamma_2 IMR_{ijk} + \eta_j + u_{ijk}$$

- Standard errors clustered at the industry level

# Selection into credit demand



- Sample: all firms
- Estimate by probit and generate inverse Mill's ratio ( $IMR_{ijk}$ )

$$Demand\ Loan_{ijk} = 1(z_{1,ijk}\delta_1 + \eta_j + w_{ijk} > 0)$$

- Exclusion restrictions: *Leasing fixed assets; Received subsidy*
- Local banking environment should not impact loan demand



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# Results

# Firms' demand for credit

Dependent variable: Loan demand	(1)
Leasing fixed assets (0/1)	0.3126*** (0.0439)
Received subsidies (0/1)	0.1899** (0.0816)
Bank concentration	0.2412 (0.2887)
Share foreign banks	0.6810 (0.8765)
Spetsbanks	-0.0281 (0.0173)
Industry fixed effects	Yes
District fixed effects	Yes
Firm controls	Yes
Observations	3754
Pseudo R-squared	0.04

# Firms' credit constraints

Dependent variable: Credit constrained	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bank concentration	-0.3128** (0.1469)	-1.0155*** (0.2450)	-1.1657*** (0.2951)	-0.3718** (0.1558)	-0.4040** (0.1577)		
Share foreign banks	-1.3780*** (0.3080)	-1.3613*** (0.3061)	-1.3458*** (0.3157)	-1.3564*** (0.3179)	-1.3577*** (0.3026)	-1.3971*** (0.3011)	-1.3831*** (0.3061)
Spetsbanks	-0.0226*** (0.0070)	-0.0218*** (0.0073)	-0.0229*** (0.0070)	-0.0226*** (0.0071)	-0.0219*** (0.0071)	-0.0226*** (0.0071)	-0.0228*** (0.0070)
Bank concentration * (log) Firm size		0.1917*** (0.0591)					
Bank concentration * (log) Firm age			0.3831*** (0.1147)				
Bank concentration * Quality certification (0/1)				0.4464** (0.1840)			
Bank concentration * External audit (0/1)					0.2946* (0.1602)		
Bank concentration * Low-tech industry (0/1)						-0.2966* (0.1526)	
Bank concentration * High-tech industry (0/1)						-0.5301* (0.2814)	
Bank concentration * Low external finance dependence (0/1)							-0.2129 (0.1861)
Bank concentration * High external finance dependence (0/1)							-0.4270*** (0.1223)
Inverse Mills' ratio	0.3987*** (0.1220)	0.3868*** (0.1209)	0.3934*** (0.1208)	0.4105*** (0.1194)	0.3931*** (0.1206)	0.3967*** (0.1223)	0.3961*** (0.1245)
Industry fixed effects	Yes						
District fixed effects	Yes						
Firm controls	Yes						
Observations	2,089	2,089	2,089	2,089	2,089	2,089	2,089
F-statistic on IVs	10.99	14.40	17.71	10.54	8.46	8.52	10.28
Hansen J-statistic (p-value)	0.54	0.56	0.60	0.57	0.60	0.70	0.68

# Credit constraints and firm innovation

Dependent variable:	<i>Extensive margin</i>					<i>Intensive margin</i>			
	Technological innovation	Product innovation	Process innovation	Soft innovation	Aggregate innovation	At least 2 innovation types	At least 3 innovation types	Number of new products	Number of new processes
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Credit constrained (0/1)	-0.5272*** (0.1748)	-0.2117* (0.1279)	-0.3156** (0.1392)	-0.8336*** (0.2917)	-1.3447*** (0.3972)	-0.5174*** (0.1886)	-0.4314*** (0.1371)	-3.5034* (1.8154)	-1.0919*** (0.2880)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,089	2,089	2,089	2,089	2,075	2,089	2,089	2,089	2,089

Firm controls: (log) firm size, (log) firm age, external audit (0/1), training (0/1), technology license (0/1), quality certification (0/1), national sales (0/1), expect higher sales (0/1), purchasing fixed assets (0/1), (log) manager's experience, and state connection (0/1).

# A battery of robustness checks

## ① Alternative variables

- Narrow definition of credit constraints
- Additional firm controls (e.g. foreign-owned, exporter)

## ② Alternative measures of banking competition as instruments

- HHI weighted by bank assets
- Top 3 banks' share of branches
- Avg. Profits/Operating Revenue of banks weighted by branches
- Avg. Lerner index of banks weighted by branches
- Allowing for non-linear effect of HHI

## ③ Sub-sample estimations

- Exclude: young firms; 20 (3) most innovative localities (regions); Moscow & St. Petersburg; localities without foreign banks

## ④ Further checks: more disaggregate locality fixed effects; clustering s.e.'s at different levels; LIML estimator against weak instruments

# How does credit help firms innovate?

## Panel A: Product innovation

Dependent variable:	New to local market	New to national market	Developed with firm's own ideas	Developed with others	Developed with suppliers
	(1)	(2)	(3)	(4)	(5)
Credit constrained (0/1)	-0.1287 (0.1013)	-0.0260 (0.0806)	0.0055 (0.0977)	0.2292** (0.0937)††	-0.0736 (0.0511)

## Panel B: Process innovation

Dependent variable:	New to local market	New to national market	Developed with firm's own ideas	Developed with others	Developed with suppliers
	(1)	(2)	(3)	(4)	(5)
Credit constrained (0/1)	-0.1972* (0.1011)	-0.0509 (0.0563)	0.0270 (0.0896)	-0.3503*** (0.1163)††	-0.1723*** (0.0554)†††

## Panel C: R&D and acquisition of external knowledge

Dependent variable:	Spent on external knowledge	R&D	Applied for a patent or trademark	Hired local consultant	Consulting: business skills improvements
	(1)	(2)	(3)	(4)	(5)
Credit constrained (0/1)	-0.1797*** (0.0672)††	0.0017 (0.0726)	0.0033 (0.0753)	-0.2703** (0.1274)	-0.2723* (0.1508)
Observations	2,089	2,089	2,089	2,082	2,089

# Lender type and firm innovation

**Panel A: Borrowing from a foreign bank**

Dependent variable:	<i>First stage</i> Loan from foreign bank (0/1)	<i>Second stage</i>						
		Technological innovation	Product innovation	Process innovation	Soft innovation	Aggregate innovation	At least 2 innovation types	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Loan from foreign bank (0/1)		0.3506 (0.3926)	0.2928 (0.3157)	0.0578 (0.2407)	1.6647*** (0.5398)	1.9184*** (0.6024)	0.6998** (0.3447)	0.3572 (0.2480)
Closure of banks with regional HQs	0.0147** (0.0066)							
Avg. change in solvency foreign vs. domestic banks	1.4836** (0.6633)							
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,006	1,006	1,006	1,006	997	997	1,006	1,006
F-statistic on IVs	8.08							
Hansen J-statistic (p-value)	0.10							

- Introduction of deposit insurance system in Jan 2004: unexpected closures of domestic banks
- *Closure of banks with regional HQs* measures the number of branches of banks headquartered in a region that were closed between Jan 2004 and Jan 2006, per million population
- Change in *relative solvency* of foreign banks

# To conclude

- Access to bank credit helps firms to reap the low-hanging fruits of imitative innovation...  
... and facilitates the absorption of foreign technologies in developing countries (cf. Aghion, Howitt and Mayer-Foulkes 2005) and helps poor countries to realize their “advantage of backwardness” (Gerschenkron 1952)
- More specifically, access to credit helps firms to innovate by co-operating with suppliers or simply acquiring external know-how
- In contrast, evidence suggests that banks do not play a role in pushing the technological frontier in an emerging market context like ours



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# Thank you

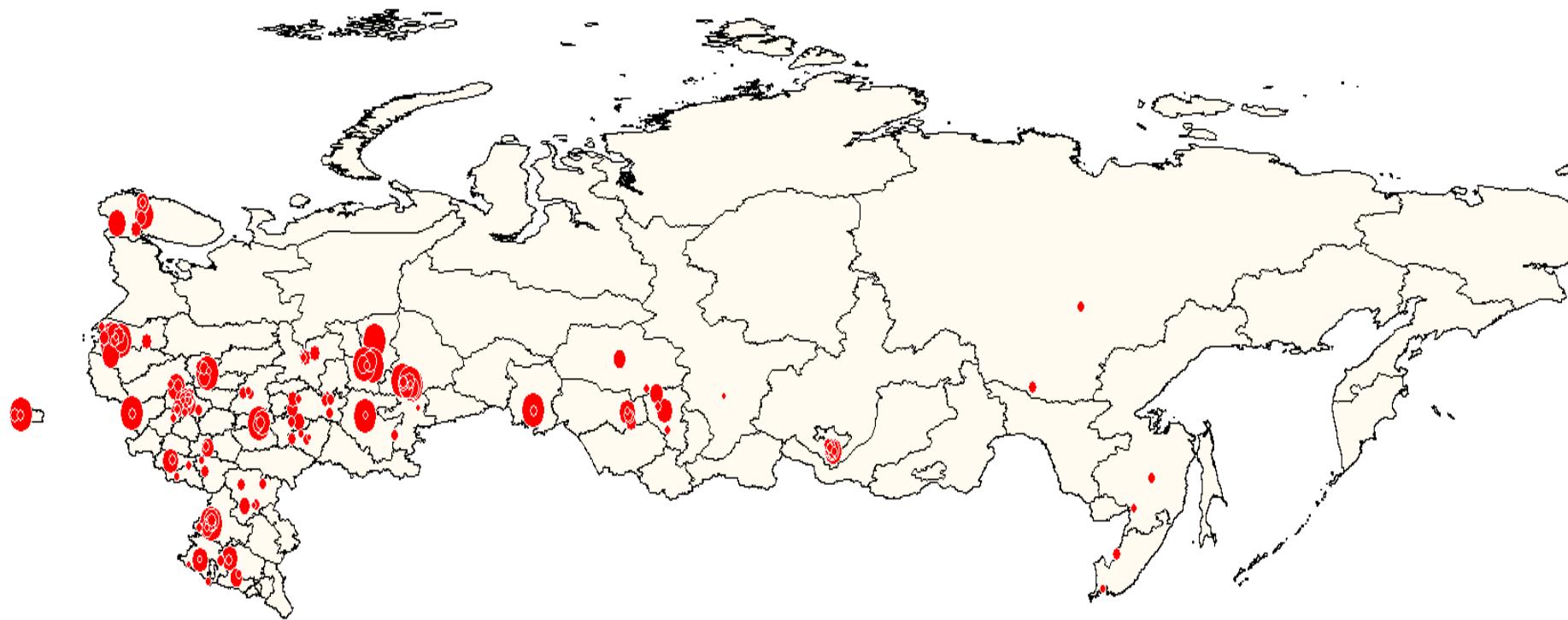


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# Appendix

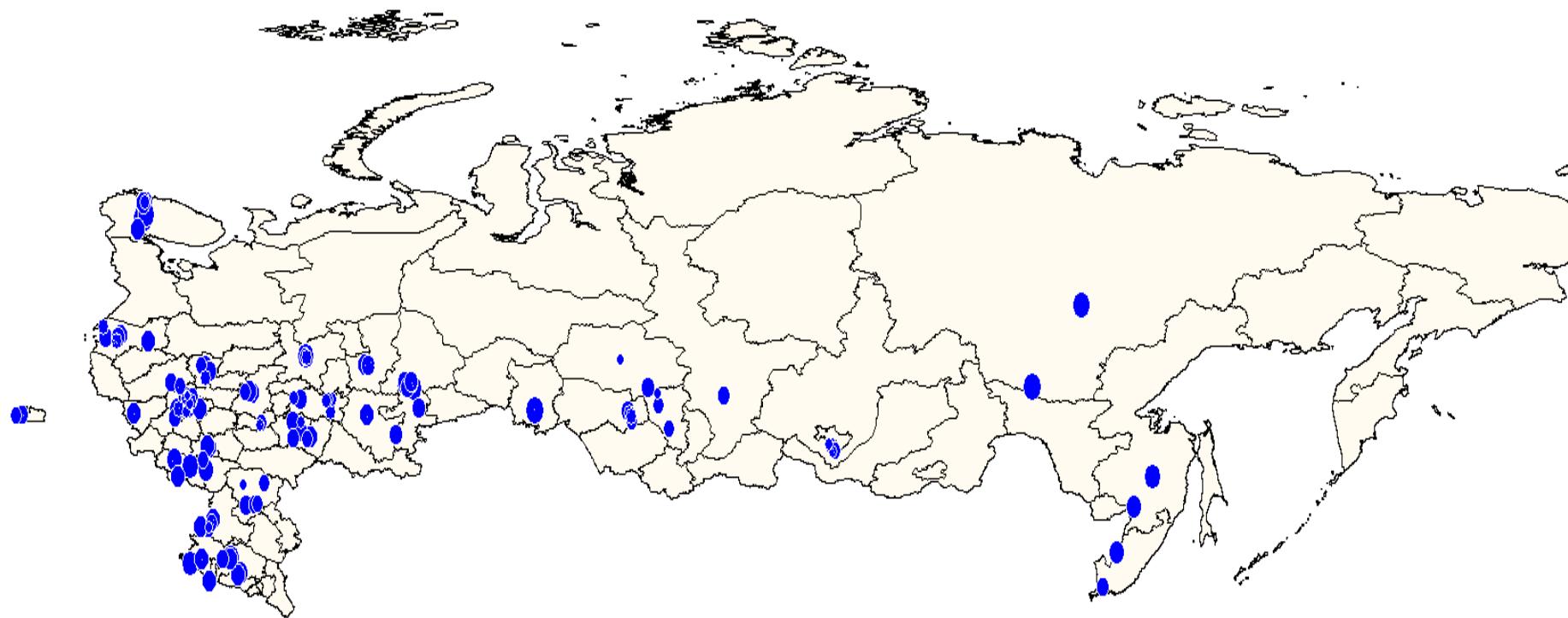
# Geographical variation in competition



- Higher circles indicate higher levels of HHI -> more concentrated markets.

Source: EBRD BEPS II Survey

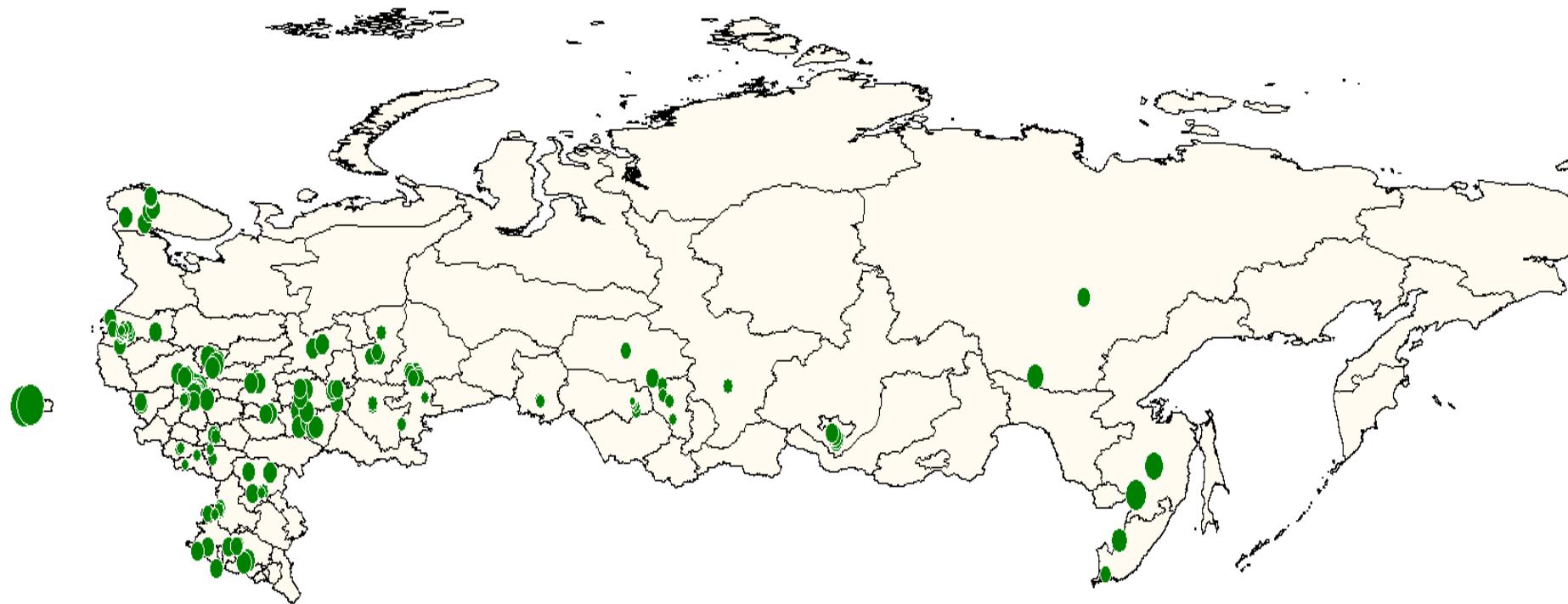
# Geographical variation in foreign banks



- Higher circles indicate higher shares of foreign bank branches.

Source: EBRD BEPS II Survey

# Geographical variation in Spetsbanks



- Higher circles indicate greater number of Spetsbanks per population.

Source: EBRD BEPS II Survey

# Spetsbanks: luminosity diff-in-diff



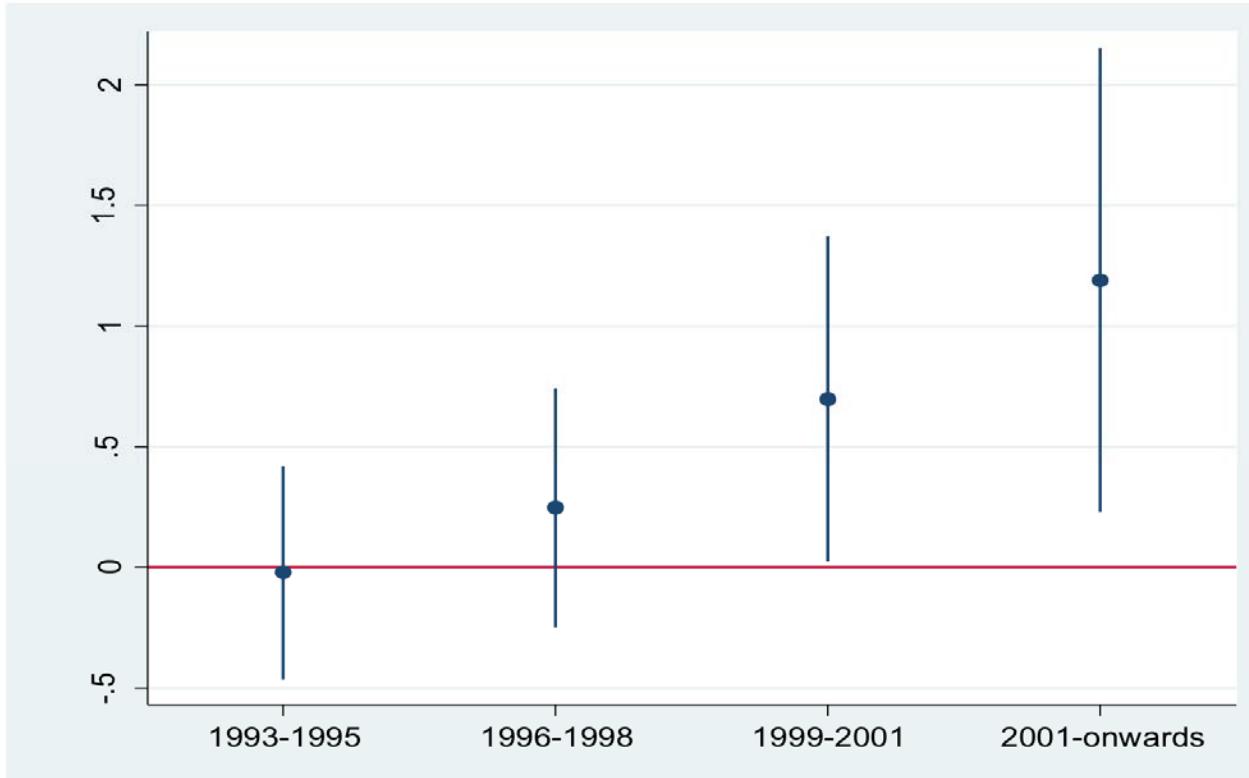
## Local presence of spetsbanks and night-time light intensity, 1993-2013

This table reports difference-in-differences regressions to estimate the impact of the presence of spetsbanks in 1995 across different localities in Russia on the change in night-time light intensity of these localities' during various periods.

Dependent variable: Luminosity

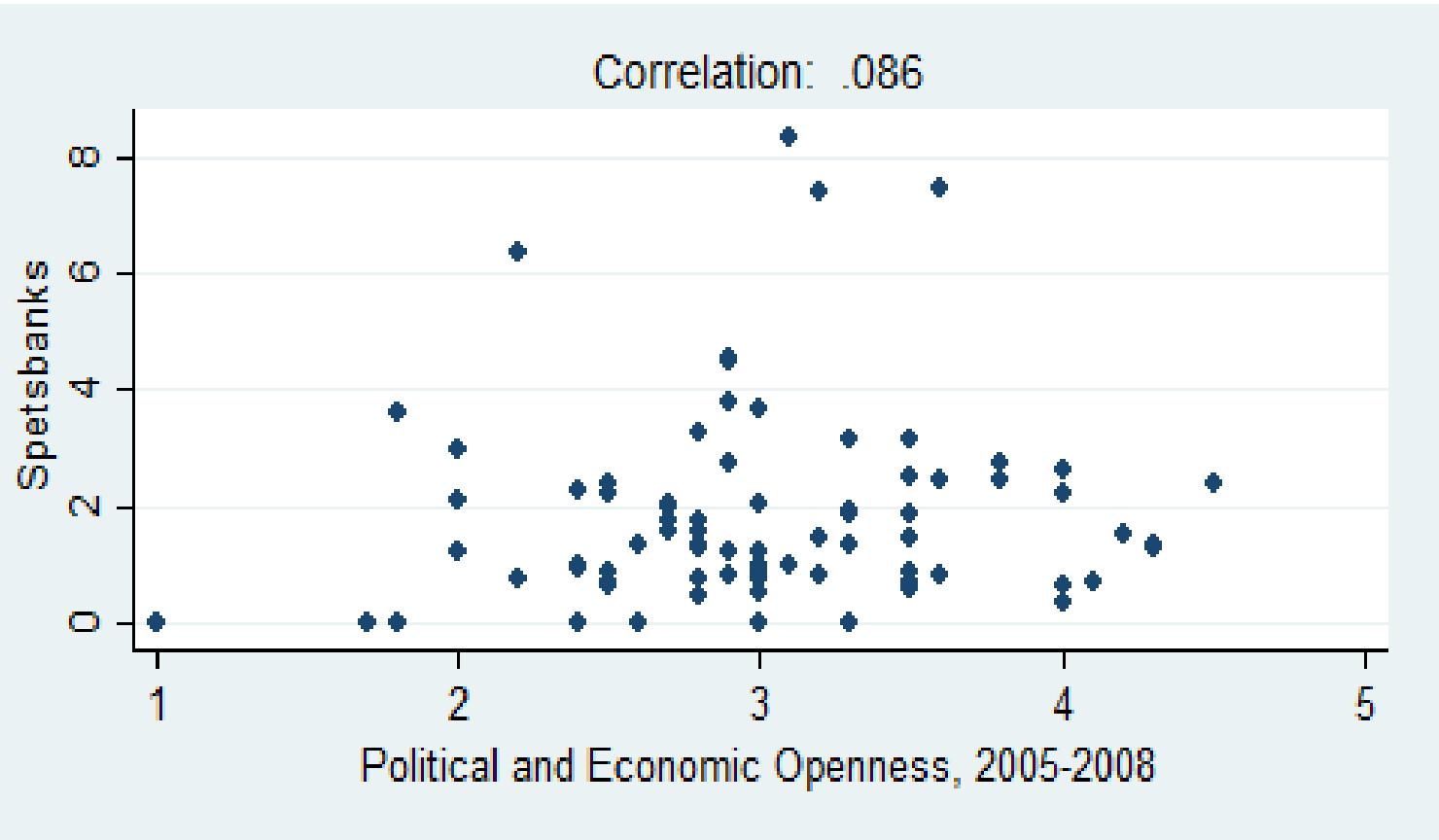
	(1)	(2)	(3)	(4)	(5)
Spetsbanks x post-1995	0.5992** (0.2329)		0.3416* (0.2040)		
Spetsbanks x post-1993 (placebo)		-0.0832 (0.1709)			
Spetsbanks x 1993-1995				-0.0912 (0.2412)	-0.0245 (0.2231)
Spetsbanks x 1996-1998				0.0770 (0.2648)	0.2440 (0.2509)
Spetsbanks x 1999-2001				0.4293** (0.1801)	0.6964** (0.3414)
Spetsbanks x 2001-onward				0.6696* (0.3648)	1.1872** (0.4869)
Locality fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Locality trends			Yes		Yes
R-squared (within)	0.5066	0.0042	0.6417	0.5083	0.6433
Observations	3,498	636	3,498	3,498	3,498

# Spetsbanks: luminosity diff-in-diff



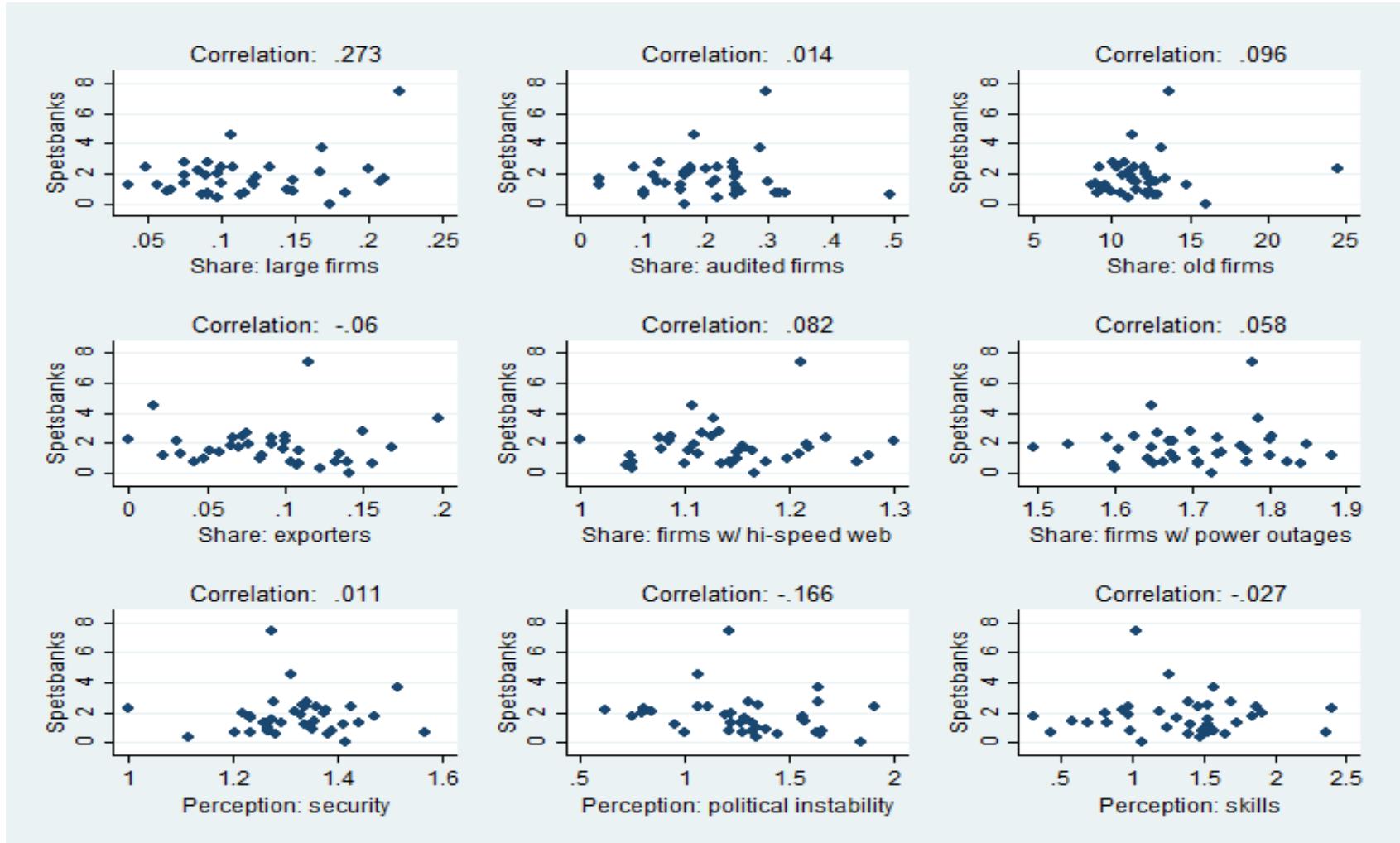
**Fig. 1.** This figure visualizes the locality-level difference-in-differences estimates (Table 6) of Spetsbank presence in 1995 on the change in night-time light intensity during various periods.

# Spetsbanks and institutions

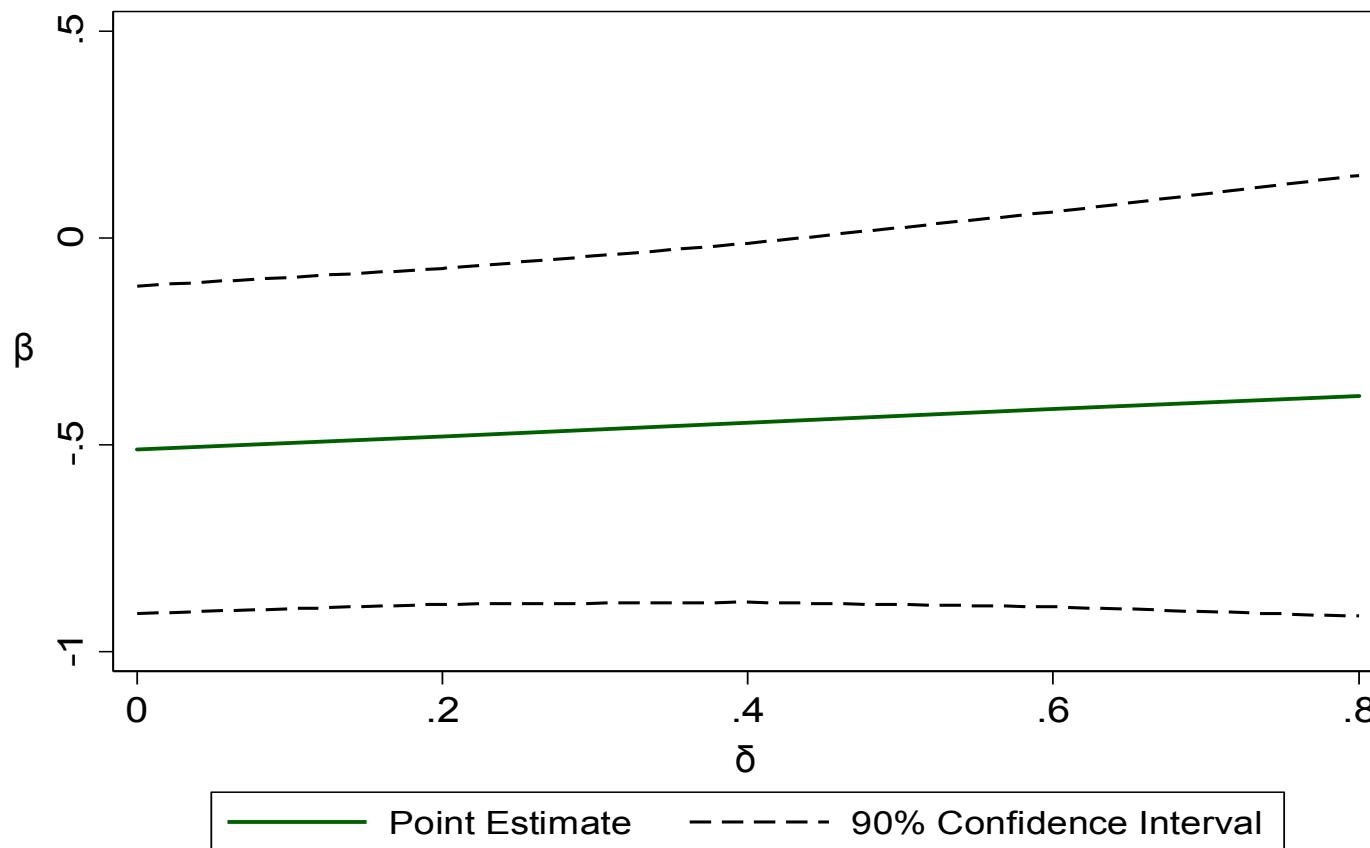


Political and economic openness data sourced from Bruno et al (2013).

# Spetsbanks and the business environment



# Sensitivity to relaxing the exclusion restriction



- We follow the local-to-zero approach of Conley et al (2012) using the prior that the direct effect of local bank concentration and foreign-bank ownership on innovation is weakly positive.  $\delta = \text{zero}$  corresponds to the strict exogeneity case.