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ICRIOS
The Invernizzi Center for Research on Innovation, Organization and Strategy

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Technological regimes and the long-run dynamics of patents' spatial patterns

John von Neumann University
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Motivation

- About 20 years ago, evolutionary economics put the spotlight on the Schumpeterian patterns of innovation (Breschi, Malerba and Orsenigo, 2000)

- Two patterns are identified
  - Schumpeter Mark I - widening
  - Schumpeter Mark II – deepening

- This literature links these patterns to general characteristics of technology, known as:
  - *technological regimes* (opportunity, cumulativeness, appropriability, and property of the knowledge base)

Motivation

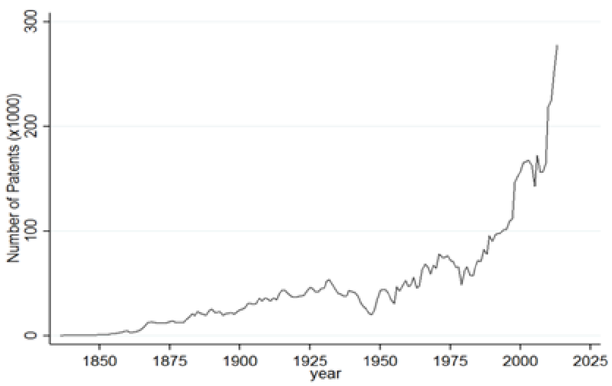
- Today, an emerging literature in the Geography of Innovation is trying to make sense of the complex spatial patterns of innovation

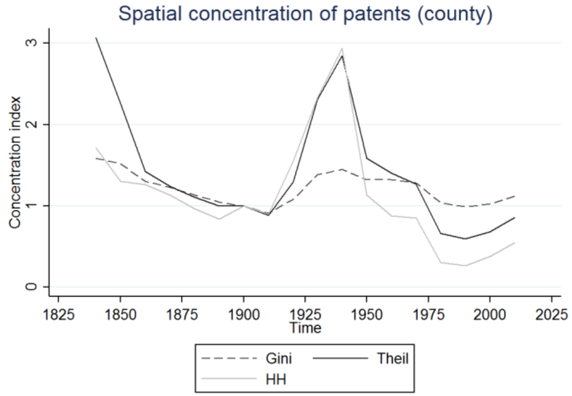
- While economic geography prioritized understanding the regional innovation trajectories through path-dependence, we argue that **technological regimes** can be complementary in explaining spatial patterns of innovation.

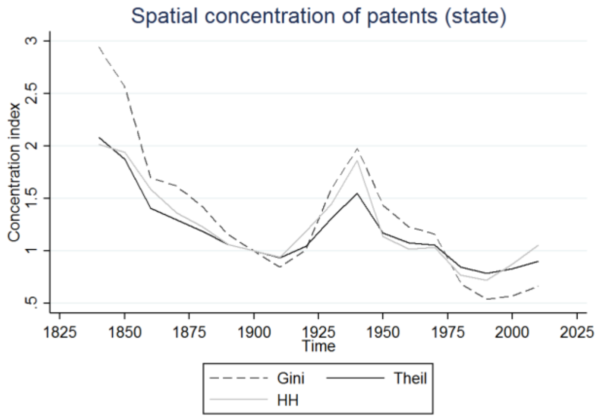
- While the idea is not new (Breschi, 2000; Audretsch and Feldman, 1996), we are able to track the spatial dimension of innovation cycle on the very long run, thanks to the HistPat dataset (Petralia, Balland, and Rigby, 2016)

- In this analysis, we link spatial patterns of innovation to technological regimes to reveal that changes in technological regimes ***within*** technology over the long run are just as important as differences ***between*** technologies

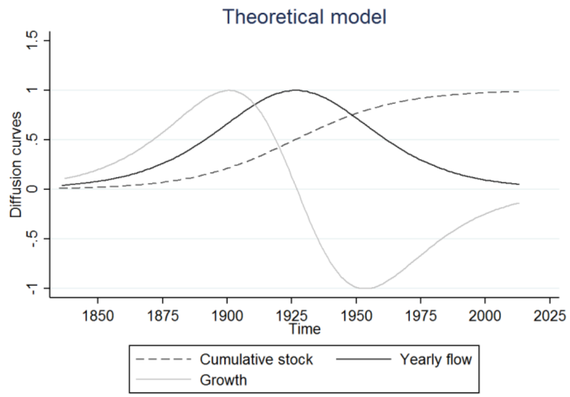
Long run changes

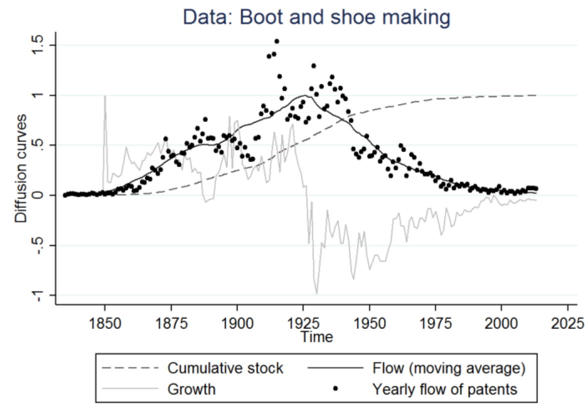


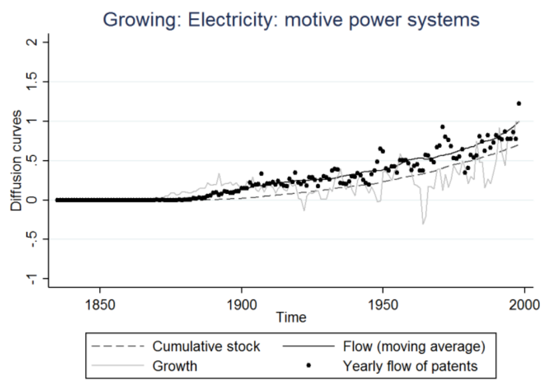


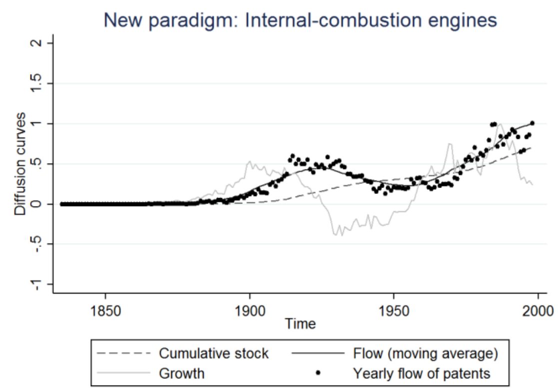


Long run changes









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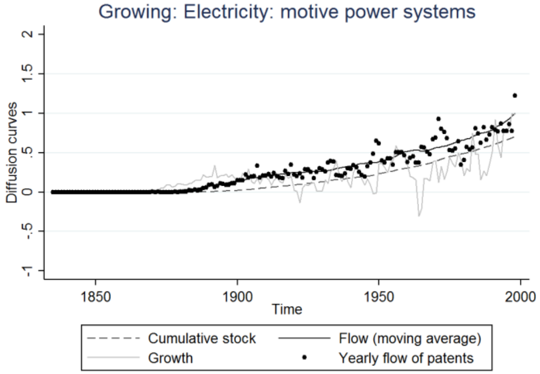

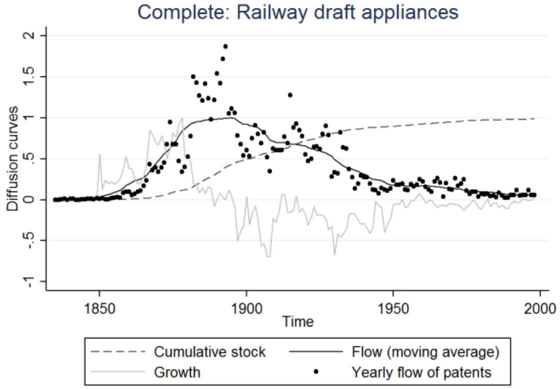

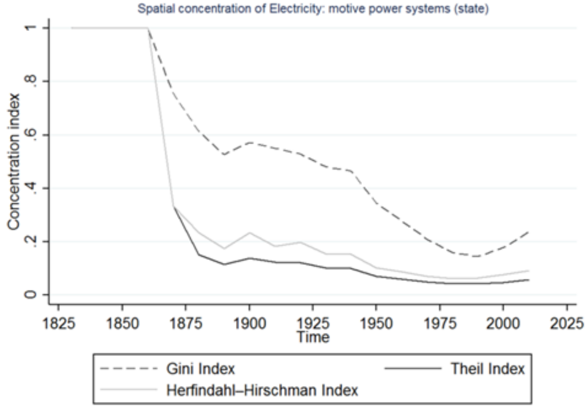

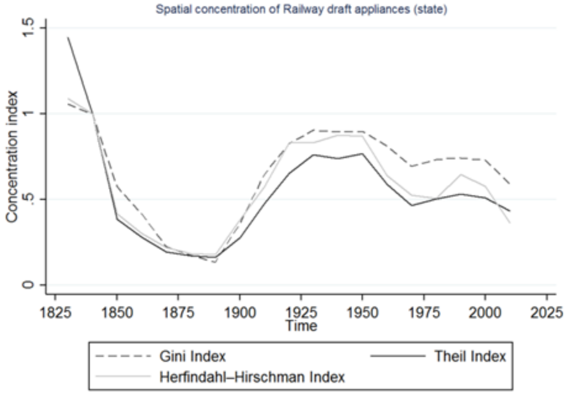

Stylized framework

	Spatial Pattern of Innovation		
Technological Regime	*Expected impact on*		
	Spatial Concentration	*Spatial Entry*	*Stability*
Opportunity	+/-	-/+	+/-
Appropriability	+	-	+
Cumulativeness	+	-	+
Complexity	+	-	+

Empirical design

- In essence, the main aim of the analysis is to attempt to understand empirically the changing spatial patterns of technologies. We estimate

$$SP_{ct} = \beta_0 + \beta_1\, Cumulat_{ct} + \beta_2\, Approp_{ct} + \beta_3\, Complex_{ct} + \varepsilon_{ct}$$

- Where SP is a spatial pattern (spatial concentration, spatial entry, or stability of regions' ranking), *c* are technological classes and *t* is time.

Data

- Data on US patents with geographical information from 1836 to 1975: Petralia, Balland, and Rigby (2016)
- From 1975 to 2010 the data are integrated with NBER patent dataset
- The dataset distinguishes between 438 consistently coded USPTO technological classes
- Similarly, it is uses modern county definition (3240 counties) for historical data to achieve consistency in the spatial classification
- For NBER dataset also inventors and citations are available (used for some analysis)

Definition of variables - Dependent variables

- With c as USPTO class and t as decade. All dependent variables are computed at state and county level.
- **Spatial concentration**
  - We use multiple indicators ($Theil_{ct}$, HH_{ct} , $Gini_{ct}$)
  - Availability: 1830-2010
- **Spatial Entry**
  - Number of regions patenting for the first time in that year
  - Availability: 1830-2010
- **Stability of innovators (regions)**
  - Spearman-rank correlation between two 5-year periods in the decade t
  - Availability: 1840-2010

Definition of variables - independent variables

- **Opportunity**
  - Measured as number of patents in c, t (Park and Lee, 2006)
  - Availability: 1830-2010
- **Cumulativeness**
  - Share of innovators that have registered more than 4 patents in both 5-year periods within the decade (Park and Lee, 2006)
  - Availability: **1970-1990**
- **Appropriability**
  - Measured as self-citation over total citations of (c, t) (Park and Lee, 2006)
  - Availability: **1960-1990**
- **Complexity**
  - Measured as average number of secondary classifications for primary class c (in t)
  - Availability: 1830-2010

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Stylized framework

	Spatial Pattern of Innovation		
	Concentration	*Entry*	*Stability*
Technological Regime			
Opportunity	+/-	-/+	+/-
Appropriability	+	-	+
Cumulativeness	+	-	+
Complexity	+	-	+

Baseline model

VARIABLES	(1) **Concentration**	(2) **Entry**	(3) **Sability**
l_opportunity	-0.352***	0.619***	0.108***
	(0.0318)	(0.0344)	(0.0134)
l_approp	-0.0493**	0.0552**	-0.0160
	(0.0224)	(0.0236)	(0.0120)
l_cumulat	0.0578***	-0.0267	0.0238***
	(0.0158)	(0.0172)	(0.00791)
l_complex	0.0603	0.181**	-0.0550
	(0.0771)	(0.0833)	(0.0336)
Constant	-2.413***	-0.111	-0.970***
	(0.237)	(0.278)	(0.0986)
Observations	1,262	1,262	1,254
R-squared	0.465	0.694	0.346
Number of c	426	426	422

Interaction term

VARIABLES	(1) Concentration	(2) Entry	(3) Stability
l_opportunity	-0.541***	0.532***	0.114***
	(0.0126)	(0.0131)	(0.00477)
l_approp	0.308***	-0.415***	-0.0261**
	(0.0482)	(0.0358)	(0.0110)
l_cumulat2	0.420***	-0.250***	0.0260***
	(0.0258)	(0.0207)	(0.00740)
l_complex	0.136***	0.101***	0.0374***
	(0.0404)	(0.0384)	(0.0122)
Apprcumu	0.101***	-0.106***	-0.00935***
	(0.0120)	(0.00960)	(0.00329)
Constant	-0.206	-0.348***	-1.137***
	(0.133)	(0.119)	(0.0397)
Observations	1,262	1,262	1,254
R-squared	0.745	0.808	0.767

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Lagged variables

VARIABLES	(1) **Concentration**	(2) **Entry**	(3) **Stability**
l_L_opportunity	-0.595***	0.536***	0.115***
	(0.0179)	(0.0225)	(0.00511)
l_L_approp	-0.106***	-0.0354	-0.000793
	(0.0351)	(0.0389)	(0.00964)
l_L_cumulat2	0.235***	-0.0482**	0.0442***
	(0.0152)	(0.0191)	(0.00465)
l_L_complex	0.124**	0.00463	0.0511***
	(0.0614)	(0.0689)	(0.0162)
Constant	-0.696***	0.266	-1.100***
	(0.153)	(0.189)	(0.0429)
Observations	1,262	1,262	1,254
R-squared	0.642	0.602	0.686

Findings

- **Opportunities** is positively linked with Entry as expected, but surprisingly also with Stability

- Results for **appropriability** are less straightforward
  - Increase in rents, but also competition effect
  - expected sign when Apprcumu interaction is included

- **Cumulativeness** works as expected: more concentration, less entry, higher stability

- In line with expectations, **complexity** is positively linked with concentration and stability, but also with entry
  - this association however fades when lagging the independent variables. This reveal the reverse causality between entry and complexity: entry of new regions - with presumably different technological background - makes technology more complex!

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Conclusion

- We link the evolution of spatial patterns of innovation to four technological regimes
- We find evidence that all four regimes (opportunity, cumulativeness, appropriability, complexity) influence spatial patterns
- The effect of opportunity is the strongest
- Since generally opportunity grows and the declines during the life cycle, spatial concentration first falls and then rises again
- Complexity, appropriability and cumulativeness appear - with some exceptions - to coherently push towards a deepening pattern.

Thanks for your attention

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