Innovation and the region's context.

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1st **ERSA-REGIO Academic Lecture** 2019

7 February 2019, DG REGIO premises, Brussels, Belgium

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Regional Quantitative Analysis Research Group

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Innovation is:

- central to firm performance/competitiveness
- a key ingredient for the growth prospects of a local/regional economy (e.g. Griffith et al, 2006; Rodríguez-Pose and Crescenzi, 2008).

Stimulating innovation is a priority for promoting sustained regional growth and development (EC, 2014).

But innovation is geographically concentrated (Audretsch & Feldman, 1996; Carlino & Kerr, 2015; EC, 2017)

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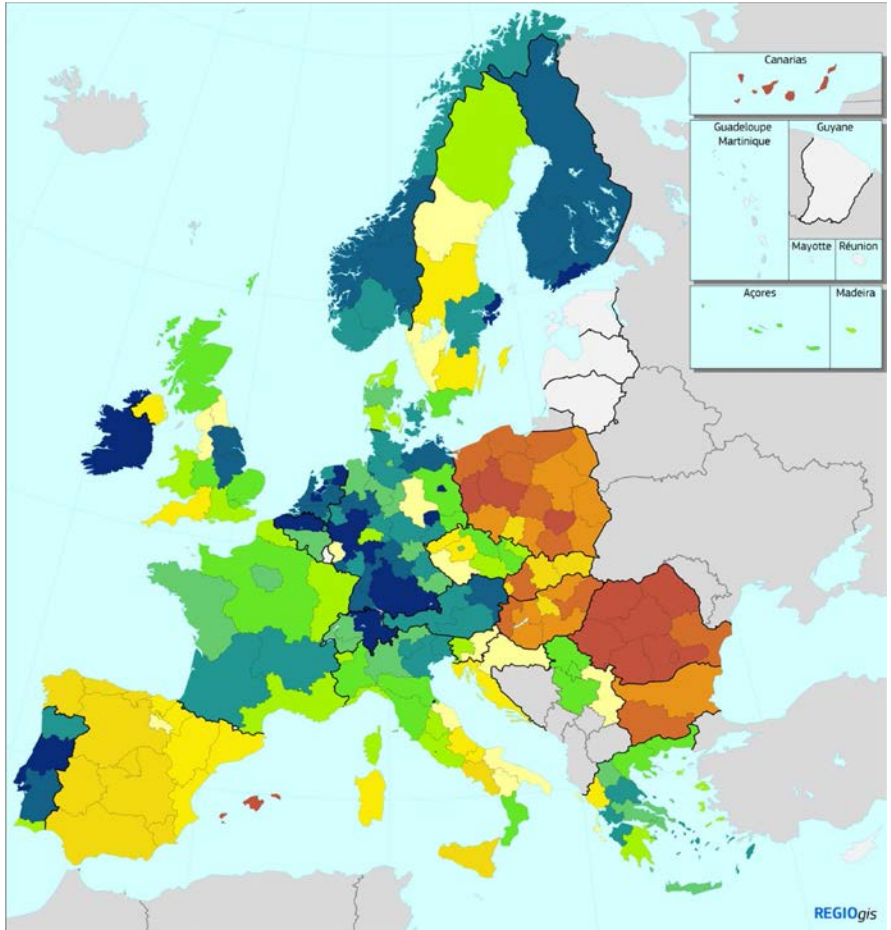
SMEs introducing product or process innovations as percentage of SMEs (RIS 2017)



MOTIVATION

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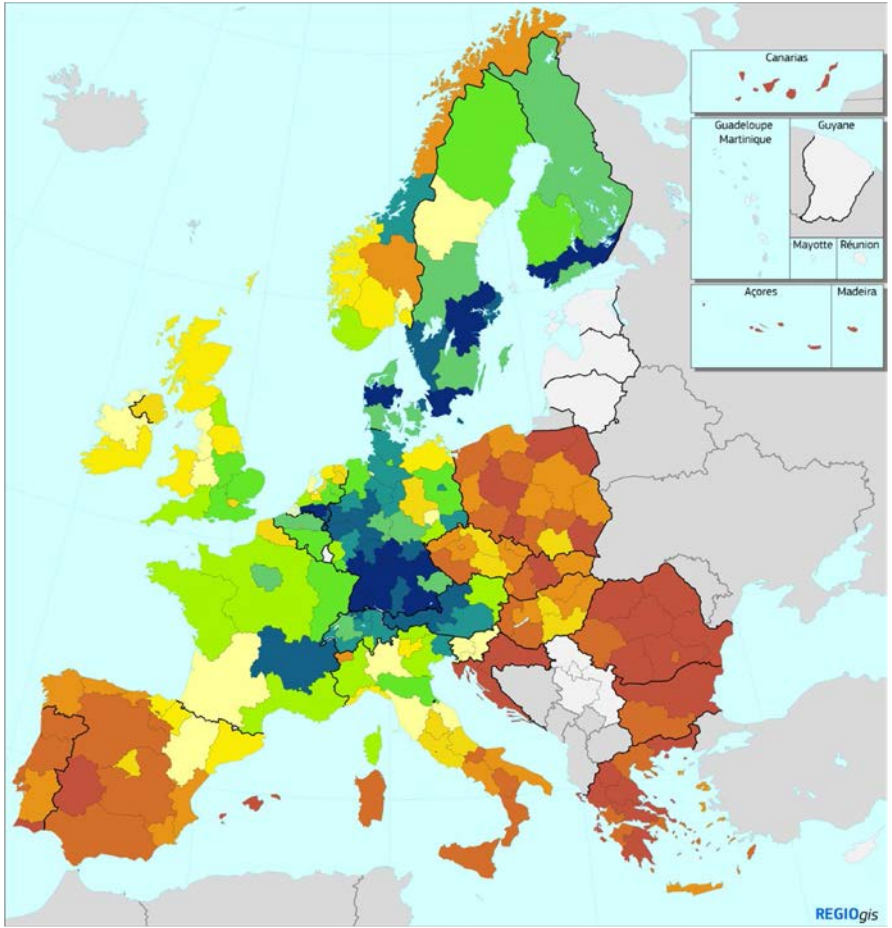
EPO patent applications per billion regional GDP (RIS 2017)



- Bottom one-third low performers
- Middle one-third low performers
- Top one-third low performers
- Bottom one-third moderate performers
- Middle one-third moderate performers
- Top one-third moderate performers
- Bottom one-third strong performers
- Middle one-third strong performers
- Top one-third strong performers
- Bottom one-third high performers
- Middle one-third high performers
- Top one-third high performers

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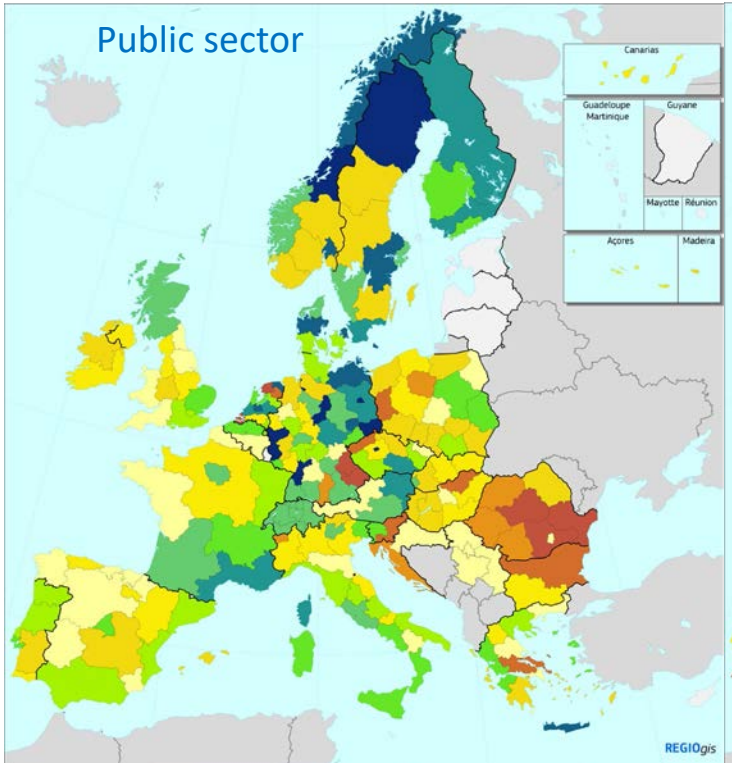
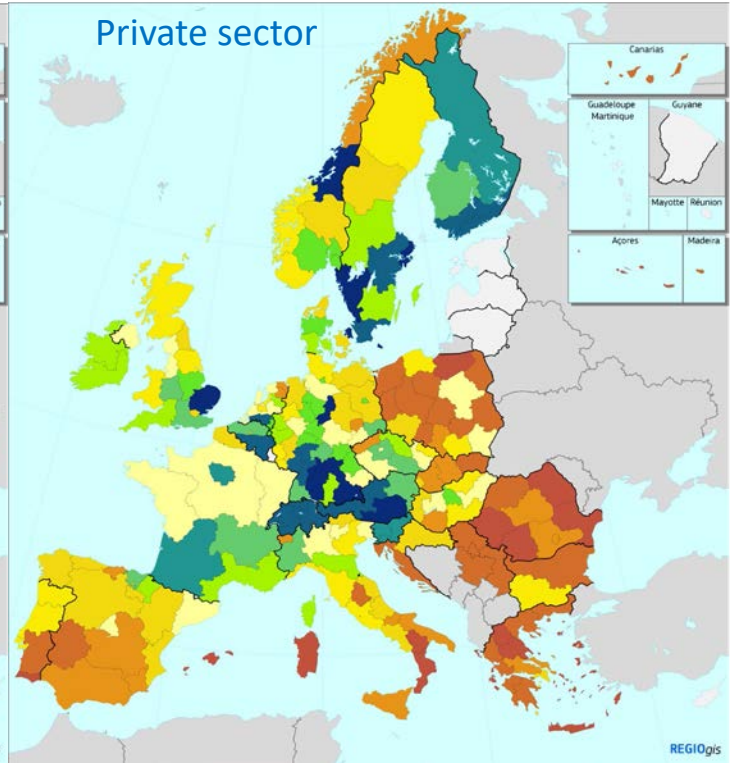
R&D expenditure as percentage of GDP
(RIS 2017)





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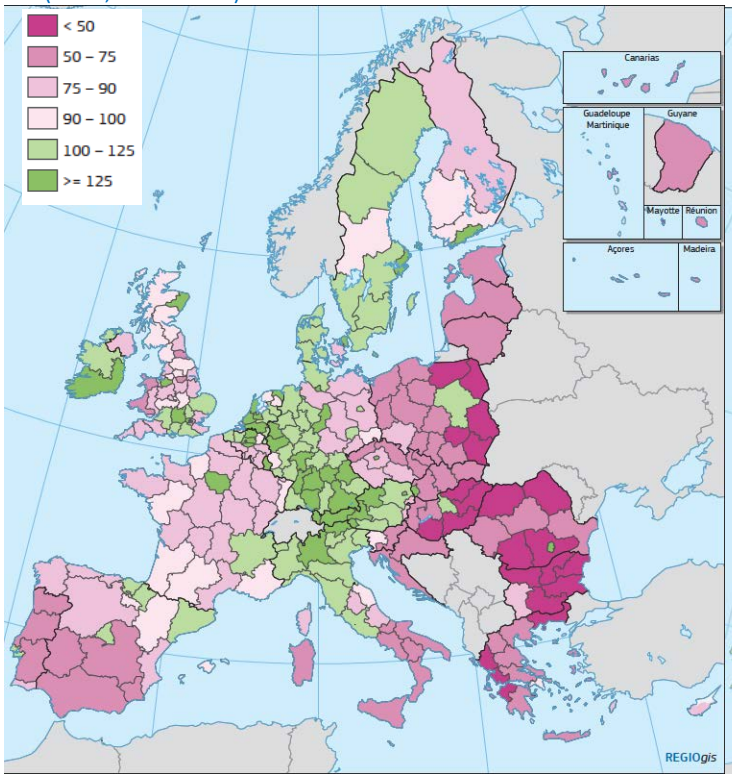
EC (2017) Seveth Report on economic, social and territorial Cohesion

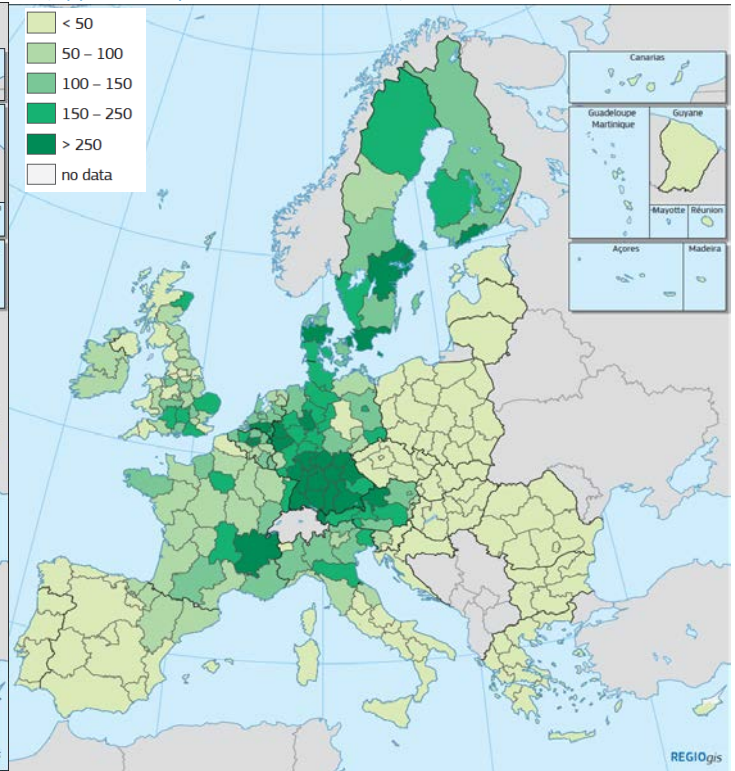
GDP per head (PPS), 2015

(Index, EU-28 = 100)



Patent applications to EPO, average 2010-2011

(Applications per million inhabitants)



MOTIVATION

Prolific literature aiming to identify **factors** likely to increase the propensity of firms to innovate.

Distinction between (Sternberg and Arndt, 2001):

- factors internal to the firm
- regional/environmental/external/contextual factors

Wide consensus on substantive effect of internal factors (R&D activities, firm characteristics)

Inconclusive evidence as regards the contribution of regional factors

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What do we mean by "**regional factors**"?

- institutions and infrastructures conducive to innovation
- availability of highly skilled workers
- innovative-friendly business environment
- social capital
- agglomeration economies
- knowledge spillovers
- …

Roper and Love (2018):

"*Localised knowledge may also have other spatially distinct characteristics, reflecting the presence of specific institutions (typically universities, research labs), clusters of industrial activity, and/or concentrations of specific types of human capital.*"

The point is:

- Two similar firms in two different regions… Do they have the same propensity to engage in innovation activities and, eventually, innovate?

- If the region context improves, will the firm's chances of innovation increase?

Impact of innovation on several economic indicators (productivity, exports, …) has been widely studied from firm-level and regional-level perspectives.

Homogeneous regional impact of innovation is frequently assumed.

But…

- Does an increase in innovation activity stimulates productivity and competitiveness regardless of the characteristics of the region in which the firm is located?

- Or does the region's context moderate the effect of innovation on firm's performance?

Identification of **causal effect** is a great challenge:

- Appropriate empirical strategy
- Data
- Confounding factors
- Spatial sorting
- Reverse causality

OUTLINE

I. Innovation and the region's context. A brief review.

II. Firm's innovation: a subtler role of the region's context

III. Regional heterogeneity in the impact of innovation on exports

IV. Spatial sorting after all?

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Determinants of firm's innovation (Sternberg & Arndt, 2001):

Internal: innovation is the result of incentives and constraints internal to the firm.

Size, internal knowledge / absorptive capacity, sectorial affiliation, organizational status, market position, ...

External: capacity to innovate affected by local conditions and knowledge infrastructures.

Institutions and infrastructures, highly skilled workers, innovation-friendly environment, social capital, agglomeration economies, spillovers…

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Initial evidence supporting effect of external factors based on:

- Case studies
- Regional Knowledge Production Function (RKPF) –Jaffe (1989)

But

- Conclusions from case studies should not be generalised.
- Evidence from RKPF likely to be affected by “Ecological Fallacy”

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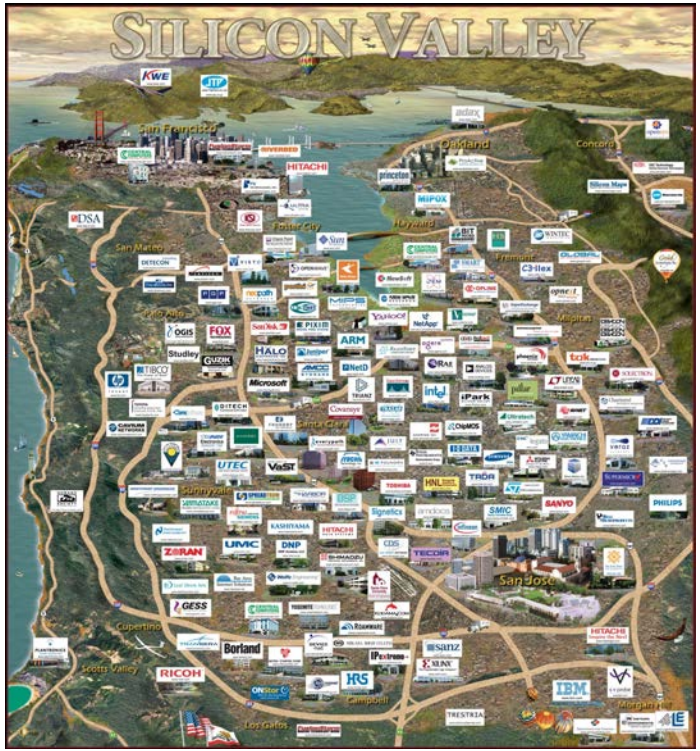
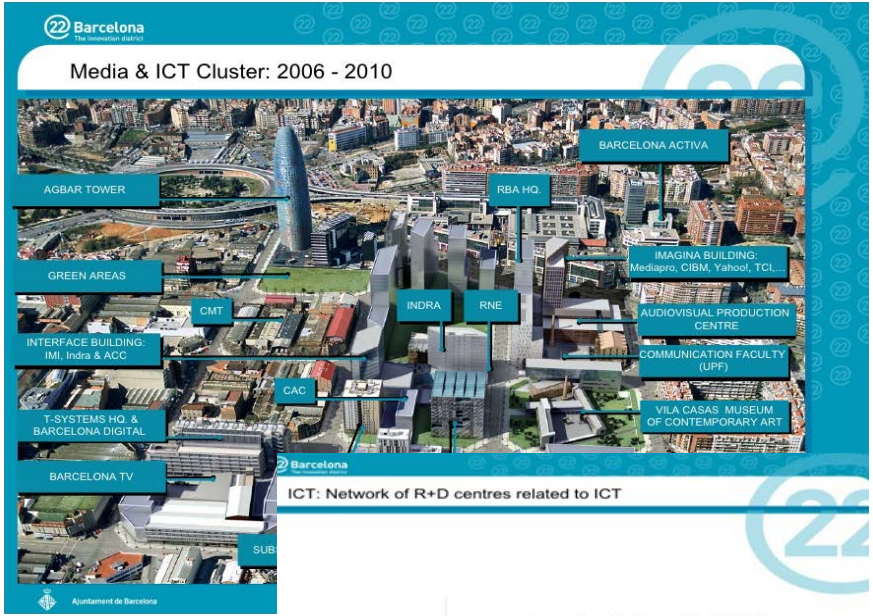
- Case studies "Innovative milieus", *"Industrial districts"*, *"Regional innovation systems"*, *"Innovative clusters"*, *"Learning regions"*





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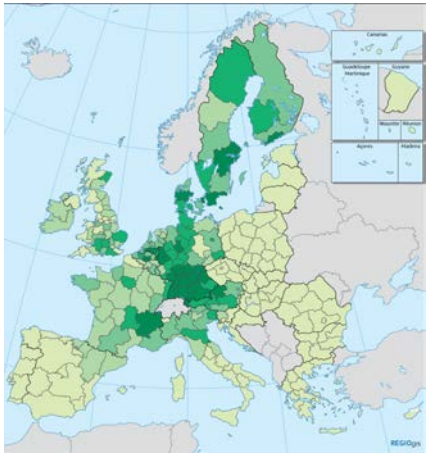
- Regional Knowledge Production Function

shifts the model of the knowledge production function from firms as the unit of observation to geographic units (Malecki, 2010)

Patent applications



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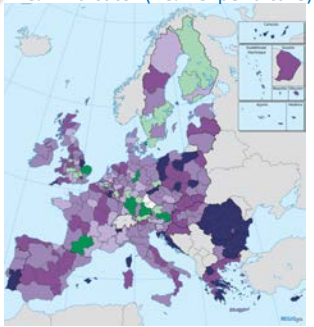
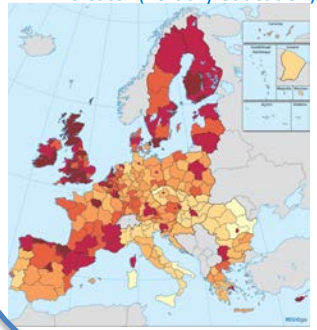
R&D indicator (R&D expenditure)



HK indicator (Tertiary education)



+ Universities & Research Labs

Knowledge Spillovers

+ Agglomeration

Social capital

...

Regional Controls

Unobservables

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Initial empirical evidence supporting effect of external factors based on:

- Case studies
- Regional Knowledge Production Function (RKPF) –Jaffe (1989)

But

- Conclusions of case studies are difficult to generalize
- Evidence from RKPF likely to be affected by “Ecological Fallacy”

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"Ecological Fallacy" John J. Hsieh, *Enciclopædia Britannica*

"(…) *failure in reasoning that arises when an inference is made about an individual based on aggregate data for a group*.

(…) *the aggregation of data results in the loss or concealment of certain details of information. Statistically, a correlation tends to be larger when an association is assessed at the group level than when it is assessed at the individual level. Nonetheless, details about individuals may be missed in aggregate data sets."*

In the specific case of studies about innovation, it results from (Beugelsdijk, 2007):

"*the dissociation between the level that is relevant to the process of innovation (firm) and the level for which the evidence is obtained (region)*"

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Current trend:

Conclusions about effect of external factors on firm's innovation must be drawn by **merging firm-level data** with **aggregate data on regional factors**.

Empirical evidence from a firm-level KPF augmented with regional factors:

$$K_{i\,r} = f(X\_firm_{i\,r}\,,\ X\_Region_{\,r})$$

"**Firm-region knowledge production function**"

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Firm-specific determinants are more important than external regional factors:

- ✓ Sternberg and Arndt (2001). SMEs in some EU regions
- ✓ Beugelsdijk (2007) , Smit et al (2015). Dutch firms
- ✓ Vega-Jurado et al (2008). Spanish manufacturing firms
- ✓ Wang and Lin (2013) for Chinese ICT firms
- ✓ Lee and Rodríguez-Pose (2014) for UK SMEs
- ✓ Backman et al (2017). Swedish firms in hospitality industry

Counteract the tendency to overemphasize the role of the regional context and claim for the importance of accounting for firm heterogeneity in the internal determinants of innovation.

"*Innovative firms tend to be intrinsically similar wherever they are located, though regions differ in the share of innovative firms.*" (Johansson and Lööf, 2008)

Implication: Regional innovation policy should put the emphasis on improving the innovation capacities of firms in the region instead of improving its innovation environment in general.

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However, other recent studies conclude that *geography* also matters:

- ✓ Love and Roper (2001). Firms in Germany, Ireland and UK
- ✓ Czarnitzki and Hottenrott (2009). Flemish firms
- ✓ Srholec (2008). Firms in the Czech Rep
- ✓ Antonietti and Cainelli (2011). Italian firms
- ✓ Laursen et al (2012; 2016). Italian firms
- ✓ Dautel and Walther (2013). Firms in Luxembourg
- ✓ Naz et al (2015). German firms
- ✓ Zhang (2015). Chinese firms
- ✓ Aarstad et al (2016). Norwegian firms.
- ✓ Hervas-Oliver et al (2018). Spanish firms
- ✓ Crescenzi and Gagliardi (2018). Firms in UK
- ✓ Schmutzler and Lorenz (2018). Firms in Latin American regions
- ✓ Tavassoli and Karlsson (2018). Swedish firms

Using as external factors: R&D effort, highly skilled labour force, quality of RIS, socio-cultural characteristics, agglomeration, …

A SUBTLER ROLE OF REGION'S CONTEXT

REGIONAL STUDIES, 2017
https://doi.org/10.1080/00343404.2017.1331296

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Innovation, heterogeneous firms and the region: evidence from Spain

Enrique López-Bazo[a] and Elisabet Motellón[b]

ABSTRACT

Innovation, heterogeneous firms and the region: evidence from Spain. *Regional Studies*. This paper investigates the role of regional factors in innovation performance, controlling for firms' absorptive capacity and other sources of firm heterogeneity. The findings for a sample of firms in Spain support the hypothesis that regional determinants matter, though their role is subtler than is frequently assumed. Rather than exerting a direct influence on firms' innovation, the regional context moderates the effect of internal determinants, particularly of the firms' absorptive capacity. The results indicate that the type of relevant interactions differs for product and process innovation and that they only operate for small and medium-sized enterprises, being negligible for large firms.

KEYWORDS

product innovation; process innovation; firm; multilevel modelling; Spanish regions

Beugelsdijk (2007)

" *(…) more empirical analyses for the European Union and the United States are required to confirm or disprove the still inconclusive empirical evidence on the effect of regional factors*."

Fitjar and Rodríguez-Pose (2015)

" (…) *the mechanisms by which the regional context shapes the learning capacity of the firm is still poorly understood*."

Aim: Provide additional evidence on the contribution of regional factors to the firm's innovation performance.

Hypotheses:

i) Internal factors account for most of the variability in the firm's innovation performance. Large impact of the firm's absorptive capacity (internal knowledge).

ii) Regional factors have an effect but subtler than previously assumed in most studies: rather than direct effect, indirect through interaction with firm's absorptive capacity.

iii) Large firms are less sensitive to the regional context than SMEs. Effectiveness of absorptive capacity in large firms is independent of location. Conversely, context intertwine with absorptive capacity in SMEs.

Features of the study:

i) Comprehensive sample of firms in all Spanish regions. Share of innovative firms largely vary across regions in Spain. Large regional disparities in internal and external factors.

ii) Firm-level dataset includes rich set of firm characteristics, i.e. controlling for several sources of firm heterogeneity. But not PD; i.e. no control by unobservables!

iii) Use of multilevel model to accommodate the hierarchical structure of data (level I: firm; level II: region). Claimed as the most appropriate for estimating contribution of regional factors on firm innovation (Srholec, 2010).

A SUBTLER ROLE OF REGION'S CONTEXT
Empirical model

Firm-level KPF with regional context variables: multi-level data structure

Mixed-effects logit specification (fixed and random regional effects) Srholec (2010); Naz et al (2015)

$$\text{prob}\left(Innov_{ir} = 1 \middle| F_{kir}, R_{jr}, u_{0r}, u_{kr}\right) = H(v)$$

where

$$H(v) = \exp(v)/[1 + \exp(v)]$$

$$v = \gamma_{00} + \sum_{j=1}^{J} \gamma_{0j} R_{jr} + \sum_{k=1}^{K} \gamma_{k0} F_{kir} + \sum_{k=1}^{K} \sum_{j=1}^{J} \gamma_{kj} R_{jr} F_{kir} + u_{0r} + \sum_{k=1}^{K} u_{kr} F_{kir}$$

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Identification of effect of regional factors

Assumptions:

- Unobservables that affected the location choice of the firm do not confound the estimate of the impact of external factors
  → Comprehensive set of firm controls minimises sources of independent unobservable factors that may bias the estimate of the effect of external factors

- No "reverse causality"
  → No single firm is important enough to produce a significant modification in the region's innovative environment
  → Measured in t-2

- There is no (perfect) regional stratification of firms that confound effect of internal characteristics and external factors
  → There is enough overlapping in the distribution of firm's characteristics across regions

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Spanish Innovation in Companies Survey

- Produced by INE, following guidelines in Oslo Manual (OCDE). ~ CIS.
- Representative of firms' population of each Spanish NUTS2 region.
- Only firms with 10 or more employees.
- Includes firms in agriculture, manufacturing, construction and services.
- Available for 2000 and from 2002 to 2016 (no panel data). We had access to data for 2005.

Sample of 14,074 on manufacturing firms in 2005.

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Variables. Firm-level

- Innovation:
  - ✓ Product Innovation
  - ✓ Process Innovation

- Absorptive capacity:
  - ✓ R&D exp / sales
  - ✓ Continuous R&D activ.
  - ✓ Cooperation
  - ✓ High-skilled labour

- Other characteristics:
  - ✓ Firm size
  - ✓ Group (Nat/Internat)
  - ✓ Exporting firm
  - ✓ Sector of activity
  - ✓ Foreign ownership
  - ✓ …

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Variables. Region-level

From Eurostat & INE (measured in t-2)

- GERD: total intramural R&D expenditure, % of GDP
- Urban Population: % population living in cities greater than 100K inhabitants
- Human Capital: % of persons aged 25-64 with tertiary education
- GDPpc: Gross domestic product at current market prices per inhabitant

A SUBTLER ROLE OF REGION'S CONTEXT

A flavour of regional disparities…

		Catalonia	Madrid	Andalusia	Extremadura
Innovation	Product	43%	36%	24%	15%
	Process	47%	37%	34%	26%
Absorptive Capacity	R&Dexp / sales	1.6%	3.9%	0.8%	0.8%
	R&D cont.	31%	26%	11%	7%
	Cooperation	16%	16%	7%	10%
	High-skilled	11%	12%	8%	8%
External factors	GERD	1.3%	1.7%	0.9%	0.6%
	Urban Pop.	43%	75%	38%	13%
	Human Cap.	26%	33%	21%	19%
	GDPpc	22.4	24.6	14.2	12.2

A SUBTLER ROLE OF REGION'S CONTEXT

Results for Product Innovation

Internal		External		Interactions	
R&D exp.	-0.10***	**GERD**	0.25*	**R&D exp # GERD**	0.12***
R&D cont.	2.36***	**Urban Pop.**	-0.00	**R&D cont # GERD**	-0.21
Cooper.	1.95***	**Human Cap.**	-0.03	**Cooper # GERD**	-0.60***
High-skilled	0.02***	**GDPpc**	0.01	**High-skill # GERD**	-0.01

Joint significance Wald tests:

All variables	3025***	Internal factor	632***
External factors	4.43	External with interactions	43.06***
Interactions	40.47***		

Random effects:

LR test 0.10 ICC 0.0009

A SUBTLER ROLE OF REGION'S CONTEXT

Large firms vs SMEs

	Product Innovation		Process Innovation	
	LF	SMEs	LF	SMEs
GERD	-0.88	0.26*	0.21	0.22
Urban Pop.	0.00	0.00	-0.00	-0.00
Human Cap.	-0.02	-0.02	0.00	-0.02
GDPpc	0.07	0.01	-0.01	0.03
R&D exp # GERD	-0.25	0.11***	0.12	-0.04***
R&D cont # GERD	0.29	-0.13	0.04	-0.17
Cooper # GERD	-0.60	-0.51**	-0.21	-0.26
High-skill # GERD	0.00	-0.01	-0.01	-0.01**

A SUBTLER ROLE OF REGION'S CONTEXT

Summary of results

- Most of the variability in innovation outcomes is attributable to the firm dimension rather than to differences between regions.
- Strong contribution of firms' absorptive capacity / internal knowledge.
- Once controlling for internal-to-the-firm factors, negligible direct effect of region's context.
- Subtler effect through interaction with absorptive capacity, particularly with tech cooperation.
- This mechanism works for SMEs. Innovation in large firms is independent of the region's context.

A SUBTLER ROLE OF REGION'S CONTEXT

Implications

- Interventions aiming to improve the regional context for innovation should pay attention to the characteristics of the firms in the region.
- Effectiveness of the policy may vary with the firms' absorptive capacity.

→ Same type of intervention may lead to different results in different regions, depending on the firms' composition.

→ The effect of the policy is likely to vary across firms within a region.

- Regions are different as are firms in each region. This must be taken into account when designing and assessing the innovation policy.

REGIONAL HETEROGENEITY IN INNOV → EXPORTS

REGIONAL STUDIES, 2017
https://doi.org/10.1080/00343404.2017.1332406

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Firm exports, innovation and the regional dimension in Spain

Enrique López-Bazo[a] and Elisabet Motellón[b]

ABSTRACT

Firm exports, innovation and the regional dimension in Spain. *Regional Studies*. Firm-level data are used to estimate the effect of product and process innovations on firms' exports in each Spanish NUTS-2 region. Results show that the effect of innovation on exports is far from regionally uniform. The gap in the propensity to export between innovative and non-innovative firms, conditional to other sources of firm heterogeneity, is shown to be particularly wide in regions with a high extensive margin of exports. An immediate implication is that policies aiming at stimulating innovation, which are likely to be effective in increasing the number of exporting firms, will not exert the same effect in all regions.

KEYWORDS

export propensity; product and process innovation; firm heterogeneity; Spanish regions

(New) Trade theory based on firms heterogeneity (Bernard et al., 2003; Melitz, 2003)

Only firms with high enough efficiency, and thus productivity, are able to export

Empirical evidence

Exporting firms are different. With respect to non-exporting firms they are (e.g. Bernard & Jensen, 2004):

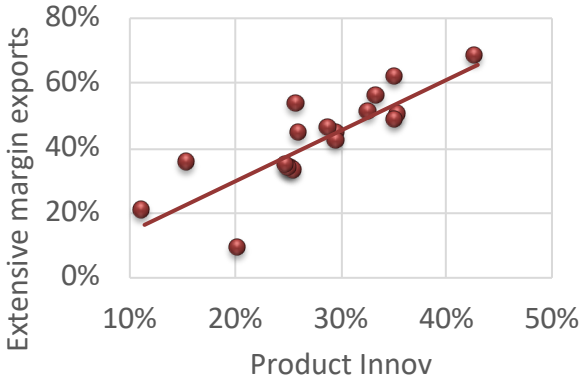
- larger
- more intensive use of physical and human capital
- more likely to belong to a group, particularly an international one
- **more productive**
- **more innovative**

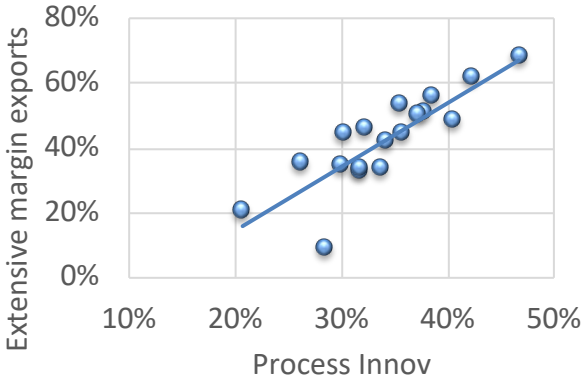
Greater effect of product than process innovations on exports. No significant effect of R&D inputs

Self-selection (Innov→Exports) vs Learning-by-exporting (Exports→Innovation)

REGIONAL HETEROGENEITY IN INNOV → EXPORTS

Introduction





But…

- Relationship could be driven by differences between regions in firm characteristics.
- Impact of innovation on exports can vary between regions

Hypothesis: firm's heterogeneity explains a big deal of regional disparities in export performance (extensive and intensive margin). Particularly, there is a key role played by differences across regions in propensity to innovate.

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Spanish Innovation in Companies Survey

Exports:

- ✓ Extensive Margin: % of exporting firms
- ✓ Intensive Margin: share of exports in total sales

Innovation:

- ✓ R&D expenditures (over sales and over workers)
- ✓ Patents
- ✓ Product Innovation: *significant improvement*. (t, t-1, t-2)
- ✓ Process Innovation : *significant improvement* (t, t-1, t-2)

Productivity and other firm controls

Empirical model

Bivariate probit model to account for endogeneity

$$P(export_{ir} = 1) = \Phi[\beta^r Inn_{ir} + \tau^r \log(Prod_{ir}) + X_{ir}\gamma]$$

$$P(Inn_{ir} = 1) = \Phi[\alpha^r \log(Prod_{ir}) + Z_{ir}\delta]$$

Instruments:

- Obstacles/impediments to firms' innovation (Lachenmaier and Wößmann, 2006; Becker and Egger, 2013)
- Variation across sectors and firm size in the share of firms that received innovation subsidies in each region (Altomonte et al, 2013)

Impacts of innovation and productivity are allowed to vary across regions

REGIONAL HETEROGENEITY IN INNOV → EXPORTS
Results

Table 4. Changes in the extensive margin of exports due to counterfactual innovation.

	Product innovation	Process innovation	Innovation (product/ process)
Spain	4.44***	3.49***	4.24***
Andalusia	8.17***	5.20***	5.96***
Aragon	7.85***	5.55***	6.71***
Asturias	6.55***	5.92***	6.42***
Balearic Islands	11.72***	7.34***	9.30***
Canary Islands	4.28**	3.97**	4.30**
Cantabria	7.77***	7.06***	7.89***
Castile-Leon	6.26***	5.06***	5.71***
Castile-La Mancha	9.21***	8.02***	9.01***

	Product innovation	Process innovation	Innovation (product/ process)
Catalonia	–	–	–
Valencia	4.49***	3.55***	4.34***
Extremadura	12.93***	8.94***	12.48***
Galicia	6.35***	6.63***	7.40***
Madrid	3.22**	4.31***	3.78***
Murcia	7.69***	8.03***	8.03***
Navarra	3.72**	2.44	3.14*
Basque Country	3.34***	1.32	2.05*
La Rioja	8.78***	4.62*	5.59**

Note: Figures are change in percentage points with respect to the actual extensive margin in each region. Figures on the share of innovative firms in Catalonia are used as a benchmark. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$ of a test of equality of the actual and counterfactual margins of exports.

REGIONAL HETEROGENEITY IN INNOV → EXPORTS
Summary and Implications

- Innovative firms are more prone to export in all Spanish regions

- However, the effect of innovation is far from being regionally uniform. The regional gap in propensity to export is partly explained by different impact of innovation.

- Geography, agglomeration, and certain regional endowments might be causing differences across regions in export sunk costs. As a result, the benefits of innovation would allow the entry exporting costs to be covered by firms in some regions but not in others.

- Policies aiming to stimulate innovation, which are likely to be effective in promoting exports by increasing the number of exporting firms, will not exert the same effect on exports in all the Spanish regions.

  Geography and certain locational endowments can affect the particular impact of these policies in each region.

- Coordination between innovation and export policies.

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Knowledge and the region's innovative context.

Spatial sorting after all!

Enrique López-Bazo

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SPATIAL SORTING AFTER ALL?
Features of the study

i) Firm-level dataset includes rich set of firm characteristics, i.e. allows control by several sources of **observed firm heterogeneity**.

ii) **PD** allow **control unobservable characteristics**, that are likely to correlate with observables

i) + ii) allow to account for **spatial sorting** when estimating effect of region innovative context.

iii) Consideration of **persistence in innovation** and impact on identification of effect of the region's environment.

iv) (Attempt to) Control **endogeneity** of the region's innovative context indicators.

v) Evidence from **inputs and outputs** of innovative activity.

vi) Effect of external factors **before/after crisis**.

Introduction

Spatial sorting → hot topic (e.g. effect of agglomeration/urbanization on wages/productivity – Combes et al, 2008; Eeckhout et al, 2014; Behrens et al, 2014).

Correlation between firm's innovation and variables of the region's innovative context because of:

i. Causal effect of regional context on firm's innovative activity: the innovative context boosts the propensity to innovate of firms in the region. For instance, facilitating knowledge acquisition, learning, and overcoming some internal-to-the-firm barriers.

ii. Firms most prone to innovate sort into specific regions (e.g. denser and more productive) in which the innovative context is also better. Therefore, the regional gap in the firms propensity to innovate is explained by innovative firms being more prone to locate in certain regions (spatial sorting)

Importance of disentangling both mechanisms: policies focusing on improving innovation infrastructures, facilitating supply of high-skilled workers, etc., have effect only under i. (~ Crescenzi & Gagliardi, 2018)

Empirically → control by observed & unobserved characteristics that affect firm's location decision.

Innovation persistence → state dependence over time of innovation activities

Due to several reasons (e.g. Raymond et al, 2010):

- Risk of losing market share for incumbents if stop innovating
- Profits of past successful innovations finance current innovation activities
- Technological trajectories in the evolutionary theory (radical innovs → succession of incremental innovs)
- Learning by innovating / Knowledge accumulation
- Sunk cost in innovation activities

Empirical evidence supports persistence in R&D activities and different types of innovation.

Assumption: Indicators of the region's innovative context can absorb (part of) the effect of persistence in innovation. Neglecting persistence may lead to confounding the effect of the regional innovative context.

Survey on Business Strategies (ESEE)

- Produced by SEPI foundation since 1990, under auspices of Spanish Gov.
- ~1800 firms surveyed each year from manufacturing firms 10+ employees (random sampling 10-200; exhaustive +200).
- Firm identifier → PD.
- Comprehensive information about firms' strategies and features that affect their decisions, including own characteristics and those of the market.
- Information about R&D activities and innovation (product, process, organizational and marketing, patents).
- Data available since 1990(91). But focus on years before and after financial and debt crisis → 2000 to 2015.

Survey on Business Strategies (ESEE)

- Identifies the NUTS 2 region in which each productive establishment of the firm is located.
  - Information reported for most indicators (e.g. those for innovative activities) corresponds to the firm, i.e. it is not disaggregated by establishment.
  - Multi-plant firms can have establishments in more than one region.

→ Issue of assigning firms to regions

- Single-plant firms & firms with 2 plants in same region

✓ Almost no effect for firms 10-200 employees (93% of single-plant firms in this category). Higher impact for large firms (62% single-plant).

✓ Selection does not seem to bias the sample attending to innovation indicators & firm characteristics.

Eurostat Regional Database

- It provides information on a comprehensive list of key magnitudes for the NUTS 2 Spanish regions, in a way that guarantees consistency with the entire set of EU regions.
- Homogeneous data for the innovative context variables are available in Eurostat for period under analysis.

Firm-level variables

- Knowledge:
  - R&D activity: Total / External (Knowledge acquisition)
  - Product Innovation; Process Innovation

- Firm characteristics: Size, Age, Use of highly skilled workers, Export activity, Product diversification, R&D subsidies, Tech cooperation; R&D intensity; Advertising intensity, Belonging to a group, Foreign ownership, Capacity utilization.

- Market characteristics: Degree of competition, Market dynamics, Appropriability, Market share, Capital intensity.

- Others: industry, extraordinary events.

Regional innovative context

- Input-based indicators:
  - R&D intensity (GERD/GDP) –total, BES, GOV, HES–
  - R&D stocks –total, BES, GOV, HES– (PIM; depreciation 10%)
  - Highly skilled labour: Tertiary educ, Univ. empl. in Sci & Tech

- Output indicators:
  - Patent applications per million inhab. per year
  - Stock of patents (PIM, depreciation 10%)

Static version

Probability that firm *i* in region *r* carries out innovation activity in time *t*:

$$p(Inn_{irt} = 1 | fi_{irt}, fe_{rt}, R_r, T_t, \mu_{ir}) = \Phi(\alpha \cdot fi_{irt} + \beta \cdot fe_{rt} + R_r + T_t + \mu_{ir}) \qquad (1)$$

fi_{irt} : set of internal to the firm determinant of innovation

μ_{ir} : effect of unobservable characteristics that do not vary over time, or evolve very smoothly (e.g. quality of management)

→ fi_{irt} & μ_{ir} : account for spatial sorting

fe_{rt} the measure of region's innovative context

R_r and T_t region and year unobserved effects

Non-lineal CRE model: accounts for correlation between unobserved heterogeneity (μ_{ir}) and the firm's observed characteristics.

Wooldridge–Mundlack–Chamberlain & controls for unbalanced panel → consistent estimation of APE.

Dynamic version

Probability that firm *i* in region *r* carries out innovation activity in time *t*:

$$p(Inn_{irt} = 1 | Inn_{irt-1}, fi_{irt}, fe_{rt}, R_r, T_t, \mu_{ir}) = \Phi(\gamma \cdot Inn_{irt-1} + \alpha \cdot fi_{irt} + \beta \cdot fe_{rt} + R_r + T_t + \mu_{ir}) \quad (2)$$

Non-lineal CRE model: accounts for correlation between unobserved heterogeneity (μ_{ir}) and i) the firm's observed characteristics, ii) lagged innovation activity

Additional *Wooldridge controls* → consistent estimation of APE

Unbalanced panel → Cautious interpretation of results

SPATIAL SORTING AFTER ALL?
Results for Product Innovation

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Static	GERD Total	GERD BES	GERD GOV	GERD HES	Tertiary Ed.	Univ. Emp. Sci & Tech	Patents
Region Context Indicator	0.0479**	0.0118	0.0359**	0.0788***	-0.0006	0.0031	0.0244
	(0.0201)	(0.0204)	(0.0175)	(0.0228)	(0.0022)	(0.0027)	(0.0233)
Signif. Firm Controls	61.58***	61.38***	61.82***	61.79***	94.12***	93.53***	60.53***
Signif. Market Controls	3.092	3.179	3.084	3.131	3.131	3.321	3.331
Signif. Regional Controls	36.10***	31.76**	32.60***	38.20***	25.89*	29.21**	26.34**

Dynamic	GERD Total	GERD BES	GERD GOV	GERD HES	Tertiary Ed.	Univ. Emp. Sci & Tech	Patents
Region Context Indicator	0.0441**	0.0100	0.0319**	0.0739***	-0.0002	0.0029	0.0326
	(0.0200)	(0.0187)	(0.0149)	(0.0199)	(0.0020)	(0.0023)	(0.0199)
Persistence	0.1400***	0.1401***	0.1398***	0.1401***	0.1451***	0.1450***	0.1402***
	(0.0074)	(0.0074)	(0.0074)	(0.0074)	(0.0073)	(0.0073)	(0.0074)
Signif. Firm Controls	20.05	19.91	20.16	20.52	32.18***	32.30***	19.75
Signif. Market Controls	1.965	1.873	1.970	1.998	2.219	2.305	1.822
Signif. Regional Controls	27.20**	23.41	26.07**	32.69***	19.15	21.35	23.79*

*** p<0.01, ** p<0.05, * p<0.1 from robust s.e.

Size of the effect

Change in probability to innovate in Product / Process when the region's context indicator increase by 1 s.d.

			Effect size	
	mean	**s.d.**	**Product Innov**	**Process Innov**
GERD Total	9624.3	8445.6	0.0357	0.0420
GERD GOV	1691.2	2083.7	0.0341	0.0471
GERD HES	2582.4	1683.4	0.0474	0.0310

SPATIAL SORTING AFTER ALL?

Endogeneity

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Control by observed & unobserved firm heterogeneity, and unobserved region characteristics that may affect firms knowledge, does not exclude reverse causality, e.g. regions with more innovative firms attracting more GERD.

More evident in the case of GERD BES: firms prone to innovate decide to locate in territories with already highly innovative firms.

Also a possibility for GERD GOV and HES: if R&D investments in most innovative regions of these institutional sectors counterbalance investments to stimulate innovation in the less innovative territories.

Although evidence from the ”agglomeration-productivity” literature suggests that effect of spatial sorting on estimates is far more important than controlling for endogeneity.

Difficult to find appropriate instruments. I’ve been *playing* with historical data…

AQR

I've been *playing* with historical data…

- Patents by region from 1871 to 1910
- Literacy rate by region from 1860 to 1900

Interacted with year dummies.

Assumptions:

- Historical data correlate with current indicators of the innovative context.
- Shocks that affect the firm's propensity to innovate in a region today do not correlate with region characteristics at the end of XIX century.

Estimation: Static CRE with CF (as suggested by Wooldridge)

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Product Innovation

	GERD Total	GERD BES	GERD GOV	GERD HES
Region Context Indicator	0.1204	0.0564	0.0330	0.1275
	(0.1540)	(0.0696)	(0.1472)	(0. 2972)

SPATIAL SORTING AFTER ALL?
Discussion

Evidence from firms in Spanish regions suggests that:

- Size of the effect of local innovative context is moderate (at best) and limited to stocks of knowledge of the GOV and HES sectors.
- Spatial sorting of firms is far more important than region's innovative context.

		Current values all variables	Counterfact. Firm & Mkt Current values Reg. context	Counterfact. Reg Context Current values Firm & Mkt
Product Innov.	**GERD Total**	-0.50	-31.58	1.18
	GERD BES	-0.50	-35.48	-1.05
	GERD GOV	-0.56	-31.45	1.61
	GERD HES	-0.50	-24.94	4.47
Process Innov.	**GERD Total**	0.35	-9.31	1.08
	GERD BES	0.35	-10.35	0.45
	GERD GOV	0.35	-9.41	1.56
	GERD HES	0.31	-10.17	0.87

% change deviation of predictions with respect actual probability in the sample (16.12% for product innovation; 28.8% for process innovation). Using estimates from the static CRE with full set of Firm & Market charact. & region FE.

SPATIAL SORTING AFTER ALL?
Discussion

- Studies aiming at identifying the effect of regional factors on firm's innovation should account for observable & unobservable characteristics that affect the location choice of the firm → i.e. firms' *spatial sorting*

- Controlling by persistence in innovation activities does not seem to affect the estimate of the effect of the regional innovative context.

- Results support innovation policies that take into account specificities of firms in each territory and address barriers to innovation of local firms → improve the innovation capabilities of firms in the region rather than just improving the innovative context (infrastructures and facilities).

Thanks for your attention

Innovation and the region's context.

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1st **ERSA-REGIO Academic Lecture** 2019

7 February 2019, DG REGIO premises, Brussels, Belgium

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