Innovation, heterogeneous firms, and the region.

Enrique López-Bazo
AQR-IREA, Univ. Barcelona

Elisabet Motellón
Open University of Catalonia & AQR-IREA, Univ. Barcelona

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AQR
Regional Quantitative Analysis Research Group
IREA
Universitat de Barcelona

MOTIVATION

Innovation is key for firm performance/competitiveness and a fundamental ingredient for the growth prospects of territories (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).

Prolific literature aiming at identifying factors likely to increase the propensity of firms to innovate. Distinction between factors internal to the firm and regional/environmental/external/contextual factors (Sternberg and Arndt, 2001):

- Wide consensus on substantive effect of internal factors (R&D activities, firm characteristics)
- Inconclusive evidence as regards the contribution of regional factors (institutions and infrastructures conducive to innovation, presence of highly skilled workers, …)

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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*.

Our 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.

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.

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Features of the study:

i) Use of comprehensive sample of firms in **all** Spanish regions. Share of innovative firms largely vary across regions in Spain, as it does internal and external factors.

ii) Firm-level dataset includes rich set of firm characteristics, i.e. controlling for several sources of firm heterogeneity

i) + ii) facilitates identification of effects.

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), although has been rarely used.

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Motivation

Background.

Methodology

Dataset & Descriptive

Results

- Product & Process Innovation
- All firms & by size

Conclusions

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

Internal: innovation is the result of incentives and constraints internal to the firm.
Size, internal knowledge, and absorptive capacity. Others include sectoral affiliation, organizational status, and market position.

External: capacity to innovate affected by local conditions (agglomeration, localization and urbanization economies) and knowledge infrastructures.

"*Regional innovation systems*", "Innovation milieus", "Industrial districts".

Initial empirical evidence supporting effect of external determinants of innovation from case studies or exploiting aggregate regional data through regional KPF.

But

- Conclusions from case studies should not be generalised.
- Evidence from regional KPF likely to be affected by "Ecological Fallacy" (Beugelsdijk, 2007)

Consequently, conclusions about effect of external factors on firm's innovation drawn from firm-level data combined with data on regional factors.

Empirical evidence from a firm-level KPF augmented with regional magnitudes.

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

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

Implication: Regional innovation policy should put the stress on enhancing the innovation capabilities of firms in the region rather than on improving its innovation environment in general.

Other recent studies conclude that geography also matters a lot:

- ✓ Love and Roper (2001). Firms in Germany, Ireland and UK
- ✓ Czarnitzki and Hottenrott (2009). Flemish firms
- ✓ Srholec (2008). Firms in the Czech Rep.
- ✓ Dautel and Walther (2013). Firms in Luxembourg
- ✓ Naz et al (2015). German firms

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

Drawbacks in most of these studies:

- Low number of spatial units and/or just few firm characteristics.
- Only direct effect of external factors on firm innovation.

Regional context may shape effect of R&D activities and other firm characteristics associated with innovation.

- Srholec (2010) was 1st study that accounted for interaction between internal and regional factors.

  Significant effect of interaction between measure of strength of RIS and firm size (no consideration of measures of firm tech activities).

- Fitjar and Rodríguez-Pose (2015) conclude that local R&D expenditures and education have no direct effect on firm's innovation, but they strongly shape returns to collaboration

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Innovation and **firm size**:

Competing arguments support a higher propensity to innovate of both small and large firms. Despite huge number of studies, evidence is mixed, suggesting that there is not an optimal firm size for innovation.

But, recent studies stress that determinants of innovation may differ between large and small firms, particularly for external factors:

- Wang and Lin (2013): small firms more sensitive to regional context than large firms.
- Karlsson and Olson (1998): small firms are locally based and strongly influenced by its environment.
- Rogers (2004) Large firms have means to access updated tech knowledge available worldwide, but small firms depend on local networks that provide economies of scale.
- Evidence in Beugelsdijk (2007) and Naz et al (2015) supports the assumption for Dutch and German firms respectively.

Empirical model

- Firm-level KPF with regional context variables: multi-level data structure (for firm *i* in each region *r*).
- Mixed-effects logit specification (fixed and random regional effects). Srholec (2010); Naz et al (2015)

$$
\begin{cases}
Innov_{ir}^{*} = \beta_{0r} + \sum_{k=1}^{K} \beta_{kr} F_{kir} + \varepsilon_{ir} \\
\beta_{0r} = \gamma_{00} + \sum_{j=1}^{J} \gamma_{0j} R_{jr} + u_{0r}\,, \quad u_{0r} \sim N\left(0, \sigma_{u_{0r}}^{2}\right) \\
\beta_{kr} = \gamma_{k0} + \sum_{j=1}^{J} \gamma_{kj} R_{jr} + u_{kr}\,, \quad u_{kr} \sim N\left(0, \sigma_{u_{kr}}^{2}\right)
\end{cases}
$$

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

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Empirical model

- Firm-level KPF with regional context variables: multi-level data structure (for firm *i* in each region *r*).
- Mixed-effects logit specification (fixed and random regional effects).

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

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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Strategy

1) Estimation of most parsimonious version (intercept and random regional components) → assess contribution of regional and firm dimensions to variability in firm's propensity to innovate.

2) Estimation of models including, separately, internal and external factors → to obtain preliminary evidence of their *raw* contribution

3) Estimation of model including, simultaneously, internal and external factors. Without and with interactions.

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Spanish Innovation in Companies Survey

- Produced by INE, following guidelines in Oslo Manual (OCDE). It is used to produce the Spanish sample of the 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 2014 (no panel data). We had access to data for 2005.

Sample of 14,074 on manufacturing firms in 2005.

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

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A flavour of regional disparities…

		Catalonia	Madrid	Andalusia	Extremadura
Innovation	Product	43%	36%	24%	15%
	Process	47%	37%	34%	26%
Absorptive Capacity	R&D exp.	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%	0.85%	0.62%
	Urban Pop.	43%	75%	38%	13%
	Human Cap.	26%	33%	21%	19%
	GDPpc	22.4	24.6	14.2	12.2

RESULTS. Product Innovation.

Internal		External		Interactions	
R&D exp.	0.91***	**GERD**	1.29*	**R&D exp # GERD**	1.13***
R&D cont.	10.6***	**Urban Pop.**	1.00	**R&D cont # GERD**	0.81
Cooper.	7.05***	**Human Cap.**	0.98	**Cooper # GERD**	0.55***
High-skilled	1.02***	**GDPpc**	1.01	**High-skill # GERD**	0.99

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

RESULTS. Process Innovation.

Internal		External		Interactions	
R&D exp.	1.08***	**GERD**	1.26*	**R&D exp # GERD**	0.96***
R&D cont.	4.59***	**Urban Pop.**	0.99	**R&D cont # GERD**	0.86
Cooper.	7.34***	**Human Cap.**	0.98*	**Cooper # GERD**	0.74*
High-skilled	1.01***	**GDPpc**	1.03	**High-skill # GERD**	0.99**

Joint significance Wald tests:

All variables	2173***	Internal factor	550***
External factors	7.16	External with interactions	41.52***
Interactions	38.88***		

Random effects:

LR test 2.89** ICC 0.0014

RESULTS. Large vs Small firms.

	Product Innovation		Process Innovation	
	LF	SMEs	LF	SMEs
GERD	0.41	1.30*	1.23	1.25
Urban Pop.	1.00	1.00	0.99	1.00
Human Cap.	0.98	0.98	1.00	0.98
GDPpc	1.07	1.01	1.00	1.03
R&D exp # GERD	0.78	1.12***	1.13	0.96***
R&D cont # GERD	1.33	0.88	1.04	0.85
Cooper # GERD	0.55	0.60**	0.81	0.77
High-skill # GERD	1.00	0.99	0.99	0.99**

CONCLUDING COMMENTS.

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CONFIRMED

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.

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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.

CONFIRMED

CONCLUDING COMMENTS.

Interventions aiming at increasing R&D in the region should take into account:

- In general, they will not have and effect *per se*
- They will affect the effectiveness of absorptive capacity of firms in the region, in particular the return to firm R&D, and the effect of cooperation and high-skilled workers

→ The net regional effect will depend on the composition (firm demography), i.e. the same intervention may lead to different results in different regions

→ Reaction to intervention (in terms of innovation) is likely to vary across the firms of the region, depending on firm characteristics and, particularly, on absorptive capacity

Regions are different as are firms in each region. This should be taken into account when innovation policy is designed and assessed

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