Types of innovation and firms' economic performance

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CONCORDi, 2019

Objectives

This paper

- uses augmented production function framework, and
- investigates how **the different types of innovation** affect **firms' economic performance**.

The different types of innovation are measured by **patent-based indicators**.

Outline:

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Motivation

- Highly representative firm sample in terms of business R&D spending;
- Firm-level R&D spending and patenting information;
- Innovation type indicators through patents;
  - **Originality and novelty**
  - **Forward citation weights and breakthrough inventions**
  - **Generality**
- Contribution to innovation strategy and policy making.

Conceptual Framework

Research Question

R&D spending $\Rightarrow$ The types of innovation $\Rightarrow$ Firm performance

Patent-based Type Indicators

Ex-ante type indicators	*Ex-post type indicators*
Originality	*Forward citations*
Novelty in recombination	*Breakthrough inventions*
Novelty in tech. origins	*Generality*

Outline:

Data

Firm sample: The EU 2014 Industrial R&D Investment Scoreboard

Information available: Number of employees, Capital expenditure, R&D Expenditure, Operational Profit, Sector and Country.

Period: 2005 - 2013

Patent Data: The European Patent Office (EPO) World-wide Patent Statistical Database (PATSTAT) - Autumn 2016

Information used in the analysis:

- Patent applications at the EPO of type A and kind PI at family-level
- Priority filing dates
- 7-digits IPC technology class information
- Backward and forward citations at the EPO or at least at two IP5 patent offices

Methodology: Backward-looking type indicators

Originality: Hall at al. (2001):

$$Originality_p = 1 - \sum_{j}^{n_p} s_{p,j}^2$$

where $s_{p,j}$ is the percentage of citations made by patent p to patent class j out of the n_p 7-digits IPC contained in the cited patents.

Novelty: Verhoeven et al. (2016) :

Novelty in recombination (NR) : "If a patent contains at least one pair of IPC groups that were previously not connected."

Novelty in technological origins (NTO) : "If a patent makes a novel combination between its own IPC code and an IPC code of cited patents."

Methodology: Forward-looking Type Indicators

Forward citations are normalized levels per technology field and year (Squicciarini et al., 2013).

Breakthrough inventions are the top 1% cited patent applications (Ahuja and Lampert, 2001).

Generality: Squicciarini et al. (2013):
"Let X be the focal patent with y_i citing patents, with $i = 1.....N$:

$$Generality_X = 1 - \sum_{j=1}^{M_i} (1/N \sum_{i=1}^{N} T_{j,i}^n / T_i^n)^2$$

where T_i^n *is the total number of IPC n-digit classes of* y_i*,*
$T_{j,i}^n$ *is the total number of IPC n-digit classes in the* j^th *IPC7-digit classes in* y_i*, and*
$j = 1 \ldots M_i$ *is the cardinal of all IPC7-digit classes in* y_i*."*

Methodology: Econometric Model

The **augmented production function model** proposed by Griliches (1979):

$$Y_{it} = A_t L_{it}^{\beta_1} C_{it}^{\beta_2} K_{it}^{\beta_3} e^{u_i t}$$

Type Premium

Following Jaffe (1988):

$$Premium_{it}^{k} = stype_{i,t}^{-k} + (1+\gamma) stype_{i,t}^{k}$$

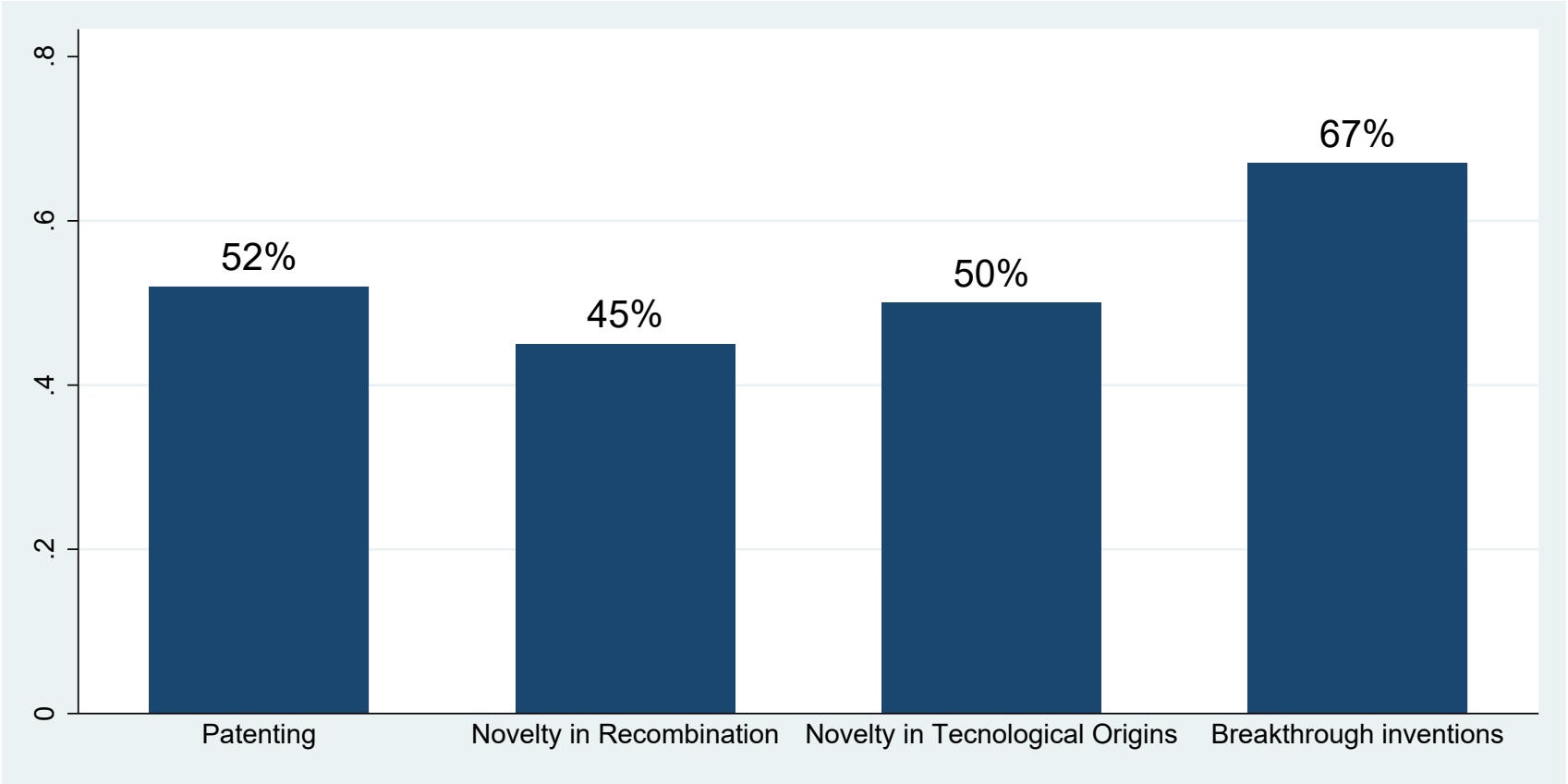
Taking logarithm, our estimation equation is following:

$$y_{i,t} = c + \beta_1 c_{i,t} + \beta_2 l_{i,t} + \beta_3 k_{i,t} + \beta_4 \gamma stype_{i,t}/K_{i,t} + \tau_t$$

Outline:

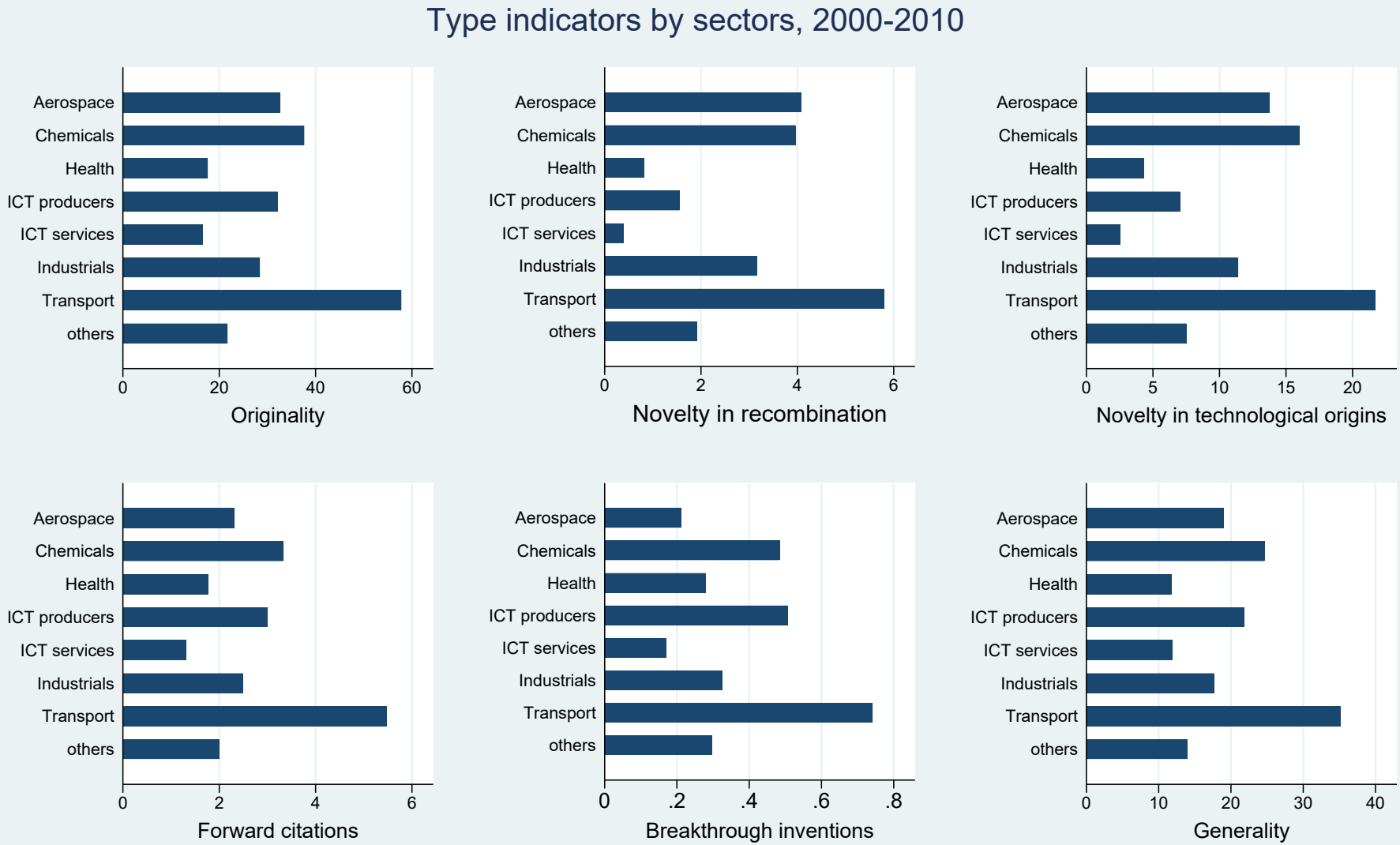
Descriptive Results:Type indicators at the EPO

- The Scoreboard firms' R&D spending constitute the 90% of global industrial R&D (The 2014 EU Industrial R&D Investment Scoreboard).
- The Scoreboard firms' patenting and innovation types at the EPO:



Source: Authors' own elaboration

Descriptive Results:Type indicators by sectors



Source: Authors' own elaboration

Econometric Results: Fixed-Effects Estimation

VARIABLES	(1) Originality	(2) NR	(3) NTO	(4) Forward Cit.	(5) Breakthrough	(6) Generality
Number of Employees - Log	0.576***	0.576***	0.576***	0.576***	0.576***	0.576***
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
Physical capital stock - Log	0.182***	0.182***	0.182***	0.181***	0.182***	0.182***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
R&D stock - Log	0.143***	0.136***	0.143***	0.144***	0.142***	0.144***
	(0.043)	(0.042)	(0.043)	(0.043)	(0.043)	(0.043)
Type stock/R&D stock - Lagged	0.003***	-0.692*	0.005***	0.034**	0.324*	0.004***
	(0.001)	(0.390)	(0.002)	(0.016)	(0.177)	(0.002)
Constant	0.375	0.427	0.377	0.371	0.380	0.374
	(0.404)	(0.404)	(0.405)	(0.403)	(0.404)	(0.404)
Year dummy				YES		
R-squared	0.499	0.499	0.499	0.499	0.499	0.499
Hausman test				0.000		
Observations	4,699	4,699	4,699	4,699	4,699	4,699
Number of id_new	1,146	1,146	1,146	1,146	1,146	1,146

Robust standard errors in parentheses:
*** p<0.01, ** p<0.05, * p<0.1
Hausman test results favors the fixed-effects estimator relative to random effects estimator.

Outline:

Conclusions

What is the impact of an innovation type on firm performance?

- **Originality and novelty of an invention:**
  - *Uncertainty in terms of commercial and technological success in the markets.*
- **Impact of an invention:**
  - *Positive impact of forward citations weighted inventions on firm performance.*
  - *Breakthrough inventions have even stronger impact.*
- **Multi-field usability of an invention:**
  - *Positive impact of general invention strategy on firm-level private returns*

What is next?

- **Extension of analysis:**
  - Sectoral analysis
  - Sub-samples according to firms' characteristics and regions
- **Endogeneity and simultaneity issues:**
  - Estimations using two-stage least squares and GMM for panel data models

Thank you for your attention!

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