

Innovation process: an analysis of European CIS data

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Preliminary results

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(ANR-19-CE26-0008-01)

Mannheim 16-17 March 2023

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Introduction and motivation

- **Innovation** : plays a crucial role as an economic engine.
- **Innovation process** : studying the link between input and output innovations

A lot of studies use the **Community Innovation Survey (CIS)** :

- **Main source** of statistics on business innovation in Europe :
 - to study the determinants of innovation,
 - the complementarity between the types of innovation,
 - the environmental benefit...
- Currently **available on a broad time** scale :
 - Ranging from 1998 to 2018.
 - Firms in each member State of the European Union.

Introduction and motivation (continued)

Our contribution consists of a version of the **CDM model** (Crépon, Duguet, Mairesse 1998).

Many studies use the CDM model : but this work concerns a **single country**, or a comparison between **two countries** or between **two waves** of surveys...

→ **We go further by benefiting from 8 waves and 9 countries.**

- to compare between countries and over time.
- We have countries that have not been much studied in the literature.

Related literature

Crépon, Duguet, Mairesse (1998) : CIS0 (France)

- Use the number of patents or sales of innovative products.
- Estimation : Asymptotique Least Squares.
- Positive effect of R&D on innovation and of innovation on productivity.

Mairesse Mohnen Kremp (2005) : CIS3 (France)

- Use sales of innovative products (continuous measure).
- Estimation : two generalized Tobit.
- Positive effect of R&D on innovation and of innovation on productivity.

Parisi et al (2005) : Italian manufacturing firm

- Use product and process innovation (discret measure)
- Estimation : Bivariate Probit
- Positive effect of R&D on product innovation (not on process innovation).
- Positive effect of Process innovation on productivity.

Related literature

Griffith, Huergo, Mairesse, Peters (2006) : CIS3 (FR, DE, ES, UK)

- Use product and process innovation (discrete measure).
- Bivariate Probit.
- Positive effect of R&D on product and process innovation.
- Positive effect of product innovation on productivity but not process innovation.

Hajjem, Garrouste, Ayadi (2015) : CIS6 (France)

- Use product, process, marketing and organisational innovation (discret).
- Estimation : Multivariate Probit.
- Positive effect of R&D on all of types of innovation.
- Positive effect of marketing and organisational innovation on productivity.
- Negative effect of product innovation on productivity.

→ From this overview, we see that there is degree of heterogeneity in the findings according to specification.

Intuition of the CDM model

CDM = Crépon, Duguet, Mairesse (1998)

⇒ original empirical approach in order to clarify the stages of the innovation process.

STEP 1 : Firms invest in R&D.

STEP 2 : R&D expenditures generate (**or not**) innovations

STEP 3 : Innovative firms improve their productivity.

Research return is therefore the result of **two processes** :

- a research-innovation link,
- an innovation-productivity link.

Model

$$\left\{ \begin{array}{l} (1) \quad Rd_i = \sum_k x_{1i}^k b_1^k + u_{1i} \\ (2) \quad \ln(R_i) = \sum_k x_{2i}^k b_2^k + u_{2i} \\ (3) \quad Id_i = Rd_i \beta_3 + \sum_k x_{3i}^k b_3^k + u_{3i} \\ (4) \quad \ln(I_i) = \ln(R_i) \gamma_4 + \sum_k x_{4i}^k b_4^k + u_{4i} \\ (5) \quad \ln(Y_i) = \ln(I_i) \gamma_5 + \sum_k x_{5i}^k b_5^k + u_{5i} \end{array} \right. \quad (1)$$

- Rd_i and $\ln(R_i)$ are respectively probability and intensity of R&D.
- Id_i and $\ln(I_i)$ are respectively probability and intensity of innovation.
- $\ln(Y_i)$ is the performance of the firm i .
- $x_{.i}$ five vectors of k covariates.
- $b., \beta.$ and $\gamma.$ the parameters, and $u_{.i}$ five error terms.

→ Estimation by maximum likelihood :

- two Type II tobit models [eq(1-2) and eq(3-4)],
- and one linear regression for [eq(5)].

Sample and variables

Use the **European Community Innovation Survey (CIS)** by Eurostat :

- Harmonized survey that covers firms in each EU Member State in several waves (= three years).

Our sample (500 000 firms) :

- 8 waves from 1998 to 2016, and 9 countries : (Bulgaria, Czech Republic, Estonia, Spain, Hungary, Lithuania, Portugal, Romania, Slovakia)

Our dependant variable :

- $\ln(R_i)$ → R&D intensity : the logarithm of the ratio of continuous R&D expenditure to the turnover.
- $\ln(I_i)$ → Innovation intensity : the logarithm of the share of sale of new product in turnover.
- $\ln(Y_i)$ → Firm's performance : approximated by the growth of turnover over the period.

Covariates : size of firm, share of market, group, cooperation and fixed effects...

Descriptives Statistics

Selection extend :

- CIS3 contains the largest share of firms without innovation activity (71.22%).
- Other CIS waves quite similar (contain on average 60% of firms without innovation activity).

Innovation sample :

- Innovative firms are more likely to be part of a group (39.5% versus 21.3%).
- Innovative firms are more engaged in R&D (52% versus 5%).
- Innovative firms cooperate more (38.1% versus 4%).
- Innovative firms sell more on the international market (67.3% versus 40.1%) .
 - Less difference for the local and national market.

Main results

VARIABLES	(1)	(2)	(3)	(4)	(5)
SAMPLE	R&D (proba)	R&D (log)	Innov (proba)	Innov (log)	Perform (log)
	Full	R&D>0	Full	Innov>0	Full
[50;249] employees (dummy)	0.005 [0.0074]	-0.19* [0.0102]	0.135*** [0.0056]	-0.071*** [0.0157]	0.019*** [0.0029]
≥ 250 employees (dummy)	0.115*** [0.0115]	0.170*** [0.0160]	0.227*** [0.0086]	-0.099*** [0.0226]	0.021*** [0.0041]
Group (dummy)	0.117*** [0.0067]	0.113*** [0.0085]	0.088*** [0.0060]	0.010 [0.0131]	-0.003 [0.0029]
Market share (log)	0.129*** [0.0026]	-0.317*** [0.0039]			
National market (dummy)	0.455*** [0.0111]				
International market (dummy)	0.927*** [0.0109]				
Cooperation (dummy)			1.103*** [0.0071]		
R&D probability (dummy)			1.529*** [0.0175]		
R&D intensity (log)				0.226*** [0.0210]	
Innovation intensity (log)					0.024*** [0.0014]
Observations			504 660		

Wald chi2(443) = 205484.42 | Prob > chi2 = 0.0000

Standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Results by countries and by waves

COUNTRY	BG	CZ	EE	ES	HU	LT	PT	SK*
R&D intensity (log) (on innovation intensity (log))	-0.105 [0.1293]	0.512*** [0.06821]	0.417*** [0.2109]	0.152*** [0.0229]	0.347 [0.2478]	0.913*** [0.1495]	0.437*** [0.0080]	0.418*** [0.1905]
Innovation intensity (log) (on performance (log))	0.026*** [0.0043]	0.028*** [0.0038]	0.054*** [0.0078]	0.012*** [0.0021]	0.037*** [0.0054]	0.023*** [0.0086]	0.032*** [0.0035]	0.028*** [0.0095]
Observations	98 518	41 278	12 441	197 244	31 486	14 110	42 947	14 945

With waves and sectors fixed effects
 Standard errors in brackets
 *** p<0.01, ** p<0.05, * p<0.1

WAVE	CIS3 (1998-2000)	CIS4 (2002-2004)	CIS6 (2004-2006)	CIS8 (2006-2008)	CIS10 (2008-2010)	CIS12 (2010-2012)	CIS14 (2012-2014)	CIS16 (2014-2016)
R&D intensity (log) (on innovation intensity (log))	0.138 [0.1173]	0.236*** [0.0699]	0.284*** [0.0643]	0.275*** [0.0558]	0.192*** [0.0492]	0.145*** [0.0552]	0.203*** [0.0549]	0.241*** [0.0546]
Innovation intensity (log) (on performance (log))	0.036*** [0.0088]	0.039*** [0.0048]	0.034*** [0.0041]	0.019*** [0.0036]	0.020*** [0.0038]	0.022*** [0.0040]	0.011** [0.0045]	0.021*** [0.0034]
Observations	19 521	43 611	61 267	68 453	63 795	59 881	57 660	63 836

With country and sector fixed effects
 Standard errors in brackets
 *** p<0.01, ** p<0.05, * p<0.1

Conclusion

Conclusion :

- We find a **positive effect** of R&D intensity on innovation intensity.
- We find a **positive effect** of innovation intensity on performance.
- We find a certain **heterogeneity** between countries and over time.

Extensions :

- Add control variables : for exemple financial support.
- Testing alternative estimation methods and sensitivity analysis.
- Add other types of innovation and check the complementarity.
- Integrate the innovation process with the impact of anti-competitive regulations on the labor market.

Thank you for your attention !