



# The Role of International and Domestic R&D Outsourcing for Firms' Innovativeness

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- Exchange of knowledge services constitutes an increasingly important channel of technology flows (Metters and Verma, 2008; Lai et al., 2009; Sener and Zhao, 2009)
- Costs and benefits of outsourcing can differ depending on the outsourcing location, the type of knowledge outsourced and firm characteristics.
- The Economist (2013): the high hidden costs of offshoring and the increasing foreign labour costs induce some firms to bring back some of their offshored production to their home countries.

We empirically study the relationship between **domestic** and **international outsourcing** and **innovativeness** (firm-level measures).

1. Does R&D outsourcing influence firms' innovativeness?
2. Do international and domestic R&D outsourcing influence firms' innovativeness in different ways?
3. Are these effects different between exporters and non-exporters.

## Related literature:

- **Service offshoring on employment:** Hijzen et al., *EcoJ* 2005; Liu and Trefler, NBER 2008; Crinò, *RES* 2010; Criscuolo and Garicano, *AER* 2010.
- **“Trade in tasks” on productivity:** Grossman and Rossi-Hansberg, *AER* 2008.
- **Technology sourcing:** Chung and Yeaple, *SMJ* 2008.
- **Complementarity or substitutability btw. innovation strategies:** Mohnen and Röller, *EER* 2005; Cassiman and Veugelers, *ManSci* 2006.

R&D outsourcing is a good study case: Input with the highest high-tech intensity → Large consequences.

**Two hypotheses** about the effects of R&D outsourcing on innovativeness:

R&D outsourcing can ...

- ... allow firms to specialize in core knowledge-intensive tasks (Braga and Willmore, 1991) → ↑ firms' innovation.
- ... reduce firms' absorptive capacities, crowding out firms' innovation (knowledge builds on itself). Important in the case of **international R&D outsourcing** → Erosion of national competences & losses of high-skilled jobs. ↓ firms' innovation

## **PITEC database:** Spanish CIS.

- around 12,800 firms every year.
- period 2004-2010.

For the analysis we consider only firms with innovation expenditures (more than 40,000 observations).

## **Dependent variables:**

- **Innovation (0/1).**
- **Process innovation (0/1); Product innovation (0/1).**
- **% of sales from products new to the market.**

## Main independent variables:

- **National R&D outsourcing:** Acquisitions of R&D outside the firm from national providers.
- **International R&D outsourcing:** Acquisitions of R&D outside the firm from foreign providers (**not belonging to the group**).

**Control variables:** Internal R&D, total R&D, exporter, size (employees), physical capital, belonging to a business group, intellectual property rights, innovation objectives, sources of information, obstacles to innovating, year, sector, regional dummies.

**Table 1: Descriptive statistics of the main variables**

	Non-outsourcers		Domestic Outsourcers		International outsourcers	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
<b>Innovativeness measures:</b>						
Innovations (0/1)	0.74	(0.44)	0.91	(0.29)	0.93	(0.26)
Product innovations (0/1)	0.54	(0.50)	0.75	(0.43)	0.81	(0.39)
Process innovations (0/1)	0.57	(0.50)	0.73	(0.44)	0.78	(0.42)
Sales from new products (logs.)	3.99	(6.33)	6.82	(7.26)	8.10	(7.54)
<b>Other variables:</b>						
Exporter (0/1)	0.53	(0.50)	0.66	(0.48)	0.79	(0.41)
Internal R&D intensity (logs.)	0.06	(0.24)	0.13	(0.39)	0.18	(0.48)
Total R&D intensity (logs.)	0.07	(0.26)	0.17	(0.45)	0.24	(0.54)
<i>Obstacles to innovation</i>						
Lack of finance (0/1)	0.68	(0.47)	0.62	(0.49)	0.61	(0.49)
Lack of personnel (0/1)	0.67	(0.47)	0.61	(0.49)	0.58	(0.49)
Lack of information (0/1)	0.59	(0.49)	0.52	(0.50)	0.51	(0.50)
Not needed (0/1)	0.75	(0.44)	0.74	(0.44)	0.78	(0.42)
Size (number of employees)	272	(1373)	328	(1507)	383	(1051)
<i>No. Observations</i>	47,855		17,349		2,460	

**23.4%** of companies that outsource R&D only to domestic providers; **0.7%** only to international providers, and **3.0%** to both national and international providers. For companies that outsource, domestic and international R&D outsourcing represents 26.9% and 12.7% of their total R&D expenditures, respectively. For the whole sample, R&D outsourcing accounts for 10.6% of total innovation expenditures.



- **1<sup>st</sup> question: Are R&D outsourcers more innovative than non R&D outsourcers?**
- **2<sup>nd</sup> question: Have international and domestic R&D outsourcing different effects on innovativeness?**
- **3<sup>rd</sup> question: Are these effects different between exporters and non-exporters?**

# 1<sup>st</sup> question: Are R&D outsourcers more innovative than non R&D outsourcers?

$$Innovation = f(\gamma'x + \beta'z) + \varepsilon,$$

- **3 alternative measures of innovativeness.** The specific functional form for  $f$  and the distribution function of  $\varepsilon$  depend on the measure (probit, bivariate probit, generalized tobit...).
- **3 different specifications**
  - Whole sample and observed outsourcing status (with a one-period lag).
  - Instrumental variables (predicted outsourcing status).
  - Matched sample and observed outsourcing status (with a one period lag).
- **3 different econometric methods** for:
  - Non linear models
  - Linear probability models with fixed effects
  - Dynamic models

**Table 2: Are R&D outsourcers more innovative than non-R&D outsourcers?**

	<i>RE Probit</i>	<i>Bivariate Probit</i>		<i>RE OLS</i>
	Innovations	Product innovations	Process innovations	Sales from new products
	[1]	[2]	[3]	[4]
Outsourcer	0.029*** (0.002)	0.153*** (0.005)	0.121*** (0.005)	0.857*** (0.081)
<b><i>Control variables:</i></b>				
Exporter	0.020*** (0.003)	0.102*** (0.006)	0.050*** (0.005)	0.611*** (0.096)
Total R&D intensity	0.016*** (0.004)	0.072*** (0.009)	0.011 (0.007)	0.180 (0.112)
<b><i>Obstacles to innovation</i></b>				
- Lack of finance	-0.008*** (0.002)	-0.031*** (0.005)	-0.027*** (0.005)	-0.316*** (0.079)
- Lack of personnel	-0.002 (0.002)	-0.036*** (0.006)	-0.011** (0.006)	-0.233*** (0.082)
- Lack of information	-0.006*** (0.002)	-0.045*** (0.006)	-0.025*** (0.005)	0.032 (0.080)
- Not needed	-0.005*** (0.002)	-0.005 (0.006)	-0.016*** (0.006)	0.148* (0.083)
<i>No. observations</i>	44,654	44,654	44,654	32,733
<i>No. firms</i>	10,198			8,205

Note: **All regressions include 4 size dummies**, 15 industry dummies, 3 geographical dummies, and year dummies. Estimated standard errors are in parentheses. We report marginal effects at sample means \* Significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%. The dummy for being an outsourcer is included with two lags in columns [1] to [3] and with one lag in column [4].

**Table 3: Robustness checks**

	Whole sample						Matched sample		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
<b>Part A. Dependent variable: Innovations</b>			<i>Instrumental variables procedures</i>						
<i>Estimation method</i>	<i>RE Probit</i>	<i>RE dynamic Probit</i>	<i>FE linear probability</i>	<i>RE Probit</i>	<i>RE dynamic Probit</i>	<i>FE linear probability</i>	<i>RE Probit</i>	<i>RE dynamic Probit</i>	<i>FE linear probability</i>
Outsourcer	0.029*** (0.002)	0.043*** (0.004)	0.031*** (0.004)	0.055*** (0.004)	0.069*** (0.005)	0.040*** (0.005)	0.006*** (0.002)	0.040*** (0.006)	0.029*** (0.008)
<i>No. observations</i>	44,654	44,273	44,654	44,654	44,273	44,654	10,496	10,454	10,496
<b>Part B. Dependent variables: Product and process innovations</b>			<i>Instrumental variables procedures</i>						
<i>Estimation method</i>	<i>Bivariate Probit</i>	<i>Dynamic bivariate Probit</i>	<i>FE linear probability</i>	<i>Bivariate Probit</i>	<i>Dynamic bivariate Probit</i>	<i>FE linear probability</i>	<i>Bivariate Probit</i>	<i>Dynamic bivariate Probit</i>	<i>FE linear probability</i>
Outsourcer									
- on product innovation	0.153*** (0.005)	0.071*** (0.008)	0.032*** (0.005)	0.281*** (0.006)	0.108*** (0.009)	0.043*** (0.005)	0.080*** (0.009)	0.072*** (0.013)	0.043*** (0.011)
- on process innovation	0.121*** (0.005)	0.037*** (0.007)	0.018*** (0.005)	0.178*** (0.005)	0.065*** (0.008)	0.028*** (0.006)	0.083*** (0.009)	0.080*** (0.013)	0.040*** (0.012)
<i>No. observations</i>	44,654	44,273	44,654	44,654	44,273	44,654	10,496	10,454	10,496
<b>Part C. Dependent variable: Sales from new products</b>			<i>Instrumental variables procedures</i>						
<i>Estimation method</i>	<i>RE OLS</i>	<i>RE dynamic OLS</i>	<i>FE linear model</i>	<i>RE OLS</i>	<i>RE dynamic OLS</i>	<i>FE linear model</i>	<i>RE OLS</i>	<i>RE dynamic OLS</i>	<i>FE linear model</i>
Outsourcer	0.857*** (0.081)	0.540*** (0.073)	0.431*** (0.092)	1.536*** (0.088)	0.871*** (0.082)	0.614*** (0.119)	0.610*** (0.147)	0.609*** (0.145)	0.516** (0.213)
<i>No. observations</i>	32,733	32,710	32,733	32,733	32,710	32,733	8,824	8,824	8,824

Note: The numbers in each cell correspond to the marginal effect of being an outsourcer in different estimates. All specifications include the same control variables as in column [1] of Table 2. RE and FE means firm-random effects and firm-fixed effects, respectively. In the dynamic model, lagged dependent variable and initial conditions are also included, although not reported here. Coefficients of column [1] correspond to those of Table 2. The instruments used in columns [4] to [6] as well as the diagnostic tests are shown in Appendix B. Estimated standard errors are in parentheses. \* Significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.



## 2<sup>nd</sup> question: Have international and domestic R&D outsourcing different effects on innovativeness?



### Main results:

- National outsourcing increases all types of firms' innovativeness.
- International outsourcing has a positive and significant effect only on process innovation.
- The relationship between national outsourcing and sales from new products is quite large varying from 57.9% to 89.1%.



**Table 6:**  
**The effects of being a domestic or international outsourcer on innovativeness for the randomized matched sample**

**Control variables:**  
 Exporter, Total R&D intensity, Obstacles to innovate, 4 size dummies, 15 industry dummies, 3 geographical dummies, and year dummies

	[1]	[2]	[3]
<b>Part A. Dependent variable: Innovations</b>			
<i>Estimation method</i>	<i>RE Probit</i>	<i>RE Probit dynamic Probit</i>	<i>FE linear probability</i>
National outsourcer	0.008*** (0.002)	0.025*** (0.005)	0.014** (0.007)
International outsourcer	0.003** (0.001)	0.010 (0.009)	0.000 (0.012)
<i>No. observations</i>	12,440	12,376	12,440
<b>Part B. Dependent variables: Product and process innovations</b>			
<i>Estimation method</i>	<i>Bivariate Probit</i>	<i>Dynamic bivariate Probit</i>	<i>FE linear probability</i>
<i>On product innovation</i>			
- National outsourcer	0.079*** (0.008)	0.051*** (0.011)	0.035*** (0.009)
- International outsourcer	0.057*** (0.014)	0.034* (0.020)	-0.007 (0.015)
<i>On process innovation</i>			
- National outsourcer	0.060*** (0.008)	0.046*** (0.011)	0.028*** (0.010)
- International outsourcer	0.078*** (0.014)	0.051** (0.020)	0.046*** (0.016)
<i>No. observations</i>	12,440	12,376	12,440
<b>Part C. Dependent variable: Sales from new products</b>			
<i>Estimation method</i>	<i>RE OLS</i>	<i>RE dynamic OLS</i>	<i>FE linear probability</i>
National outsourcer	0.637*** (0.138)	0.578*** (0.133)	0.457** (0.187)
International outsourcer	0.758*** (0.221)	0.506** (0.220)	0.373 (0.274)
<i>No. observations</i>	10,477	10,473	10,477

## 3<sup>rd</sup> question: Are these effects different between exporters and non-exporters?

**Table 5: The effects of being a domestic or international outsourcer on innovativeness depending on exporting status (randomized matched sample)**

	[1]	[2]	[3]
<b>Part A. Dependent variable: Innovations</b>			
<i>Estimation method</i>	<i>RE</i>	<i>RE</i>	<i>FE</i>
	<i>Probit</i>	<i>dynamic</i>	<i>linear</i>
National outsourcer & - exporter	0.0061** (0.002)	0.024*** (0.006)	0.020** (0.009)
- non-exporter	0.0045** (0.001)	0.021*** (0.006)	0.002 (0.012)
International outsourcer & - exporter	0.0025** (0.001)	0.007 (0.011)	-0.005 (0.013)
- non-exporter	0.0022 (0.001)	0.017 (0.013)	0.015 (0.021)
<i>No. observations</i>	12,440	12,376	12,440

**Table 5 (cont.)**

<b>Part B. Dependent variables: Product and process</b>			
<i>Estimation method</i>	<i>Bivariate</i>	<i>Dynamic</i>	<i>FE</i>
	<i>Probit</i>	<i>bivariate</i>	<i>linear</i>
<i>On product innovation</i>			
National outsourcer &			
- exporter	0.078*** (0.010)	0.056*** (0.013)	0.042*** (0.011)
- non-exporter	0.073*** (0.012)	0.038** (0.015)	0.020 (0.015)
International outsourcer &			
- exporter	0.064*** (0.016)	0.015 (0.024)	-0.020 (0.016)
- non-exporter	0.033 (0.027)	0.071** (0.029)	0.031 (0.026)
<i>On process innovation</i>			
National outsourcer &			
- exporter	0.047*** (0.010)	0.035** (0.014)	0.028** (0.012)
- non-exporter	0.076*** (0.013)	0.062*** (0.016)	0.028* (0.016)
International outsourcer &			
- exporter	0.097*** (0.015)	0.048** (0.023)	<b>0.046***</b> (0.018)
- non-exporter	0.022 (0.028)	0.064* (0.034)	0.044 (0.028)
<i>No. observations</i>	12,440	12,376	12,440



**Table 5 (cont.)**

	[1]	[2]	[3]
<b>Part C. Dependent variable: Sales from new products</b>			
<i>Estimation method</i>	<i>RE OLS</i>	<i>RE</i>	<i>FE</i>
National outsourcer &			
- exporter	0.645*** (0.163)	0.541*** (0.157)	0.509** (0.215)
- non-exporter	0.626*** (0.236)	0.660*** (0.221)	0.330 (0.322)
International outsourcer &			
- exporter	0.549** (0.245)	0.269 (0.244)	0.328 (0.301)
- non-exporter	1.528*** (0.446)	1.356*** (0.433)	0.530 (0.532)
<i>No. observations</i>	10,477	10,473	10,477

Notes: All regressions include 4 size dummies, 15 industry dummies, 3 geographical dummies and year dummies. All specifications include the same control variables as in column [1] of Table 2. Estimated standard errors are in parentheses. We report marginal effects at sample means \* Significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

- R&D outsourcing increases firm's innovativeness.
  - Probability to innovate rises by 0.6-6.9%
  - Product innovation: 3.2%
  - Process innovation: 1.8%
- Different effects of national & international outsourcing:
  - Product innovation increases mostly with domestic outsourcing
  - Process innovation increases with both.
- Heterogeneity depending on exporting status:
  - International outsourcing only influences exporter's process innovation.



# Auxiliary tables



**Table B.1:  
Characteristics  
of R&D  
outsourcers**

	[1]	[2]	[3]	[4]	[5]
Innovations		0.059*** (0.005)			
Product innovations			0.055*** (0.004)		0.033*** (0.005)
Process innovations			0.041*** (0.004)		0.040*** (0.004)
Sales from new products				0.004*** (0.000)	0.003*** (0.000)
Exporter	0.058*** (0.004)	0.055*** (0.004)	0.052*** (0.004)	0.053*** (0.004)	0.051*** (0.004)
Sectoral patents	0.207*** (0.010)	0.204*** (0.010)	0.201*** (0.010)	0.203*** (0.010)	0.200*** (0.010)
Business group	0.014*** (0.005)	0.014*** (0.005)	0.013*** (0.005)	0.013*** (0.005)	0.013*** (0.005)
Public support	0.208*** (0.004)	0.206*** (0.004)	0.201*** (0.004)	0.202*** (0.004)	0.199*** (0.004)
Internal R&D intensity	0.063*** (0.007)	0.064*** (0.007)	0.063*** (0.007)	0.064*** (0.007)	0.064*** (0.007)
<i>Innovation objectives</i>					
- Pull demand	0.071*** (0.005)	0.061*** (0.005)	0.052*** (0.005)	0.057*** (0.005)	0.049*** (0.005)
- Push costs	-0.001 (0.004)	-0.006 (0.004)	-0.010** (0.004)	-0.000 (0.004)	-0.010** (0.004)
<i>Sources of information</i>					
- Internal	0.025*** (0.004)	0.019*** (0.004)	0.017*** (0.004)	0.020*** (0.004)	0.016*** (0.004)
- Suppliers	-0.014** (0.006)	-0.015** (0.006)	-0.016** (0.006)	-0.015** (0.006)	-0.016** (0.006)
- Institutional	0.164*** (0.006)	0.164*** (0.006)	0.165*** (0.006)	0.163*** (0.006)	0.164*** (0.006)
- Other	0.053*** (0.006)	0.048*** (0.006)	0.047*** (0.006)	0.050*** (0.006)	0.046*** (0.006)
<i>No. Observations</i>	54,212	54,212	54,212	54,212	54,212

**Table C.1: Balancing tests: Difference of means**

Variables	Mean		% bias		t-test	
	Treated	Control	% bias	Reduction	t-value	p-value
Product innovations	0.73	0.73	-1.30	95.90	-0.410	0.685
Process innovations	0.60	0.58	4.80	83.70	1.460	0.143
Sales from new products	6.72	6.59	2.00	94.40	0.600	0.549
Exporter	0.41	0.40	1.40	93.30	0.430	0.665
Business group	0.19	0.19	4.30	66.40	1.510	0.131
Sectoral patents	0.27	0.30	-5.50	-366.00	-1.670	0.095
Public support	0.73	0.72	2.40	96.70	0.740	0.462
Internal R&D intensity	0.33	0.33	-1.60	95.30	-0.530	0.598
<i>Innovation objectives</i>						
- Pull demand	0.69	0.70	-0.60	98.50	-0.180	0.859
- Push cost	0.39	0.38	3.40	83.60	1.010	0.313
<i>Sources of information</i>						
- Internal	0.67	0.66	1.30	96.10	0.420	0.677
- Suppliers	0.42	0.43	-1.20	94.80	-0.360	0.716
- Institutional	0.27	0.27	0.00	100.00	0.000	1.000
- Other	0.56	0.59	-5.90	83.00	-1.790	0.074

**Table C.2: Balancing test: Overall measures of covariate balancing**

	Mean abs.	% mean bias	Median abs.	% median bias	Pseudo R <sup>2</sup>	LR-test*	
	std. bias	reduction	std. bias	reduction		Chi <sup>2</sup>	p>Chi <sup>2</sup>
before matching	20.83		20.54		0.124	1359	0.000
after matching	2.74	86.8%	2.00	90.2%	0.007	34.17	0.063