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Competitive pressure determinants and innovation at the firm level

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1. MOTIVATION

- **Does competitive pressure fosters innovation?**

- **Theoretical and empirical inconclusive results on the relationship between competition and innovation.**

  - **Negative relationship:** "Schumpeterian effect" (1943).
  - **Positive relationship**: "Escape competition effect" (Arrow, 1962)

  - **Inverted-U shape relationship:** Aghion *et al*. (QJE, 2005)
  - **U-shape relationship**: Tishler and Milstein (IJIO, 2009).

- **Inconclusive results.**

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1. MOTIVATION

- **Traditional measures in empirical work:** concentration and/or PCM.
- **Drawbacks** of traditional measures: there is not a simple relationship between measures of competition and market structure
  - Enhanced competition may increase or decrease PCM and/or concentration.
- **Alternative** measures of competition: **the fundamentals of competitive pressure unambiguously related to competition**: product substitutability, market size, entry costs.
- **AIM of this paper:** to test the relation between fundamentals of competitive pressure and incentives to introduce product and process innovation.

1. MOTIVATION

- **THEORETICAL FRAMEWORK: VIVES (JINDEC, 2008)**
- It provides a general framework with robust results on the effect of **competitive pressure** indicators on **innovation**.
- Encourages the use of **fundamentals of competitive pressure** for empirical work: degree of product substitutability, market size, entry costs.
- Changes in the fundamentals of competitive pressure **affect differently to product and process innovation incentives**.
  - Process innovations are cost reducing:
    - Changes in competition increasing **per-firm output** encourage cost reduction investment (**process innovation**).
  - Product innovations are demand enhancing:
    - Changes in competition increasing **post innovation rents** encourages **product innovation**.

THEORETICAL PREDICTIONS:

The main 3 theoretical predictions in Vives (2008)

	Product innovation	Process innovation
1.***Product Substitutability*** ↑ Prod. Subst. → ↑ Comp.	-	+
2. ***Market size*** ↑ Market Size → ↑ Comp.	+, -	+
3. ***Entry costs*** ↓ Entry Costs → ↑ Comp.	+	-

2. THE DATA

Survey of Business Strategies (ESEE), a panel data set for Spanish manufacturing firms, period 1990-2006.

- annual survey representative of Spanish manufacturing classified by industrial sectors and size categories.
- provides exhaustive information at the firm level on a number of production and market issues, including innovation activities.

UNCTAD TRAINS statistics, to obtain export and import tariffs per industry-year, period 1990-2006.

Sample: 14,855 observations, corresponding to an unbalanced panel of 1,821 firms.

DEPENDENT VARIABLES:

Product innovations **:**

"Indicate if during year t the firm obtained product innovations (either completely new products or with so important modifications that they are different to those produced in the past)".

Process innovations**:**

"Indicate if during year t the firm introduced some important modification of the production process ".

EXPLANATORY VARIABLES :

VARIABLES MEASURING COMPETITIVE PRESSURE:

(I) Product Substitutability. 2 variables:

✓**Advertising over sales ratio**

- Potential endogeneity problem.
- Use Dorfman-Steiner condition: $\left(\frac{Adver.}{Sales}\right) = f\,(price\ elasticity)_{(-)}$

- INSTRUMENTAL VARIABLES:

- change in prices following price changes in domestic competitors.
- change in prices following price changes in foreign competitors.

✓**After-sales services to clients.**

EXPLANATORY VARIABLES :

VARIABLES MEASURING COMPETITIVE PRESSURE:

(II) Market size:

- ✓**Expansive market.**
- ✓**Export tariffs per industry-year (UNCTAD Statistics).**

(III) Entry Costs:

- ✓**Set-up costs (Sutton, 1991).**
- ✓**Cost of introducing a new product.**
- ✓**Import tariffs per industry-year (UNCTAD Statistics).**

CONTROL VARIABLES: size, age, industry and time dummies.

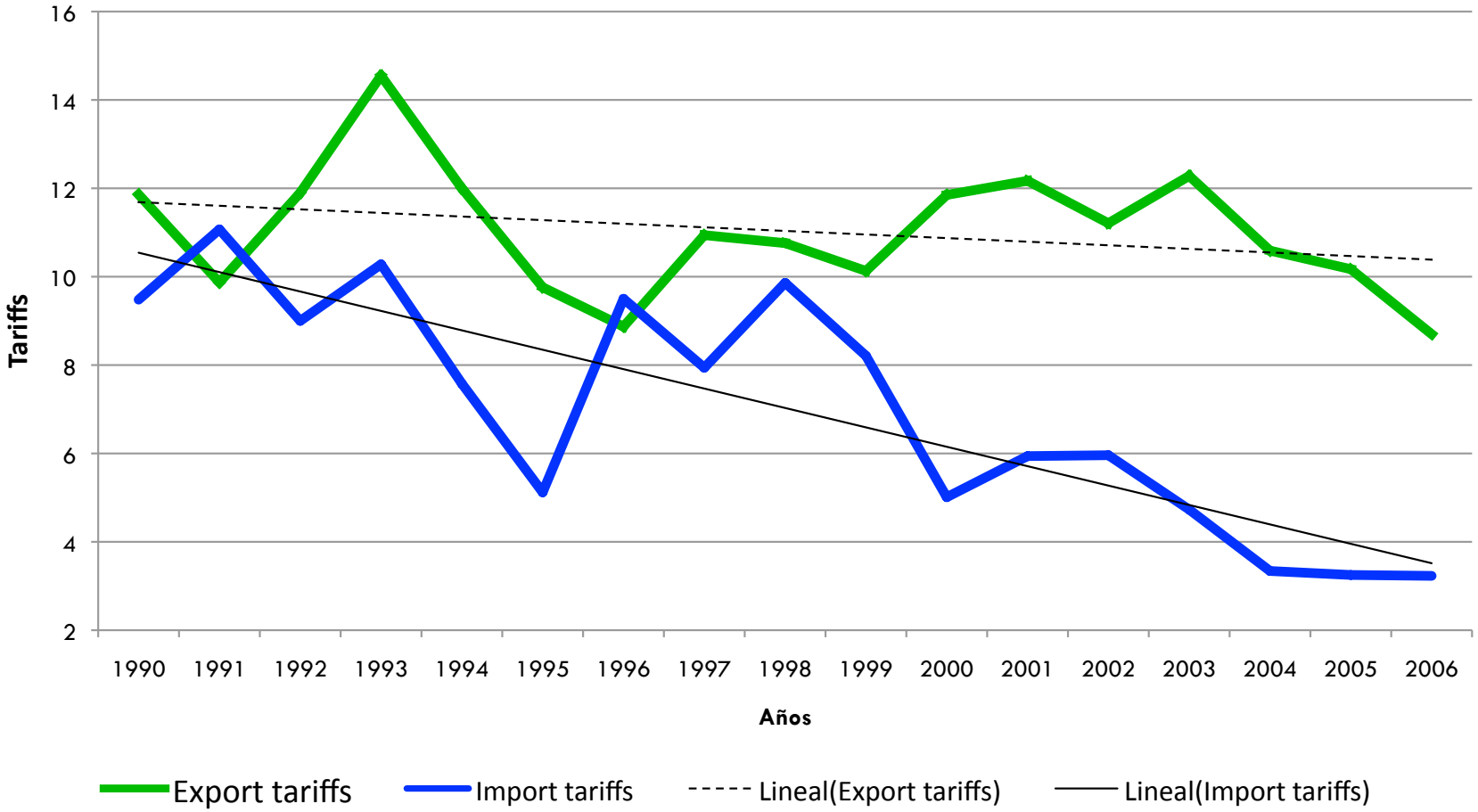
Table 1. Sample

	N° Observations (%)	N° Firms (%)
TOTAL	14,855	1,821
INNOVATING	5,594	474
	(37.65 %)	(26.03 %)
ONLY PRODUCT INNOVATION	1,482	133
	(26.49 %)	(28.06%)
BOTH PRODUCT & PROCESS INNOVATION	1,646	174
	(29.42 %)	(36.70%)
ONLY PROCESS INNOVATION	2,466	167
	(44.09 %)	(35.24%)

Table 2. Export and Import Tariffs

	Export Tariffs				Import Tariffs			
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
1990	11.86	7.06	0.52	44.31	9.48	7.59	1.87	73.01
1991	9.87	6.57	0.42	63.51	11.07	8.45	4.1	70.58
1992	11.90	6.84	0.53	48.07	9.00	7.08	2.84	64.91
1993	14.55	6.81	0.35	43.60	10.28	8.85	3.58	66.22
1994	12.00	5.20	2.52	31.67	7.58	7.18	1.60	67.46
1995	9.76	4.03	0.81	18.44	5.12	4.19	1.28	43.15
1996	8.87	5.29	0.57	52.04	9.50	9.32	3.53	70.48
1997	10.94	4.60	0.58	24.19	7.94	9.20	2.10	60.13
1998	10.76	5.62	0.76	33.11	9.86	15.95	1.55	98.63
1999	10.13	7.53	1.91	72.66	8.21	8.13	1.56	58.06
2000	11.85	6.73	0.45	42.99	5.01	5.77	1.18	42.37
2001	12.17	18.32	0.26	186.16	5.94	5.83	0.30	34.05
2002	11.21	8.43	0.12	75.55	5.96	5.72	1.55	33.94
2003	12.28	23.02	1.31	226.81	4.73	5.15	0.76	29.47
2004	10.59	15.54	0.84	153,6	3.34	3.77	0.03	30.21
2005	10.17	6.85	0.17	56.56	3.25	3.67	0.03	28.96
2006	8.70	4.71	0.023	28.86	3.23	3.64	0.02	27.52

Figure 1: Export and import tariffs, 1990-2006



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3. MODEL SPECIFICATION & ECONOMETRIC PROCEDURE

We observe 3 firms' Innovation statuses: (percentages of firms' observations)

Introduce only product innovations (8.6%)

Introduce only process innovations (15.1%)

Introduce both product and process innovations (10.0%)

We estimate 3 Probit Models (Instrumental variables techniques)

$$y_{it} = \begin{cases} 1 & if \quad \mu_t + \beta_{CP} CP_{it} + \beta_C C_{it} + \varepsilon_{it} \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

Where CP stands for competitive pressure variables and C are control variables

4. ESTIMATING RESULTS

(i) First question:

Is it valid to use the Price-Cost Margin as a measure of market competition?

(ii) Main results:

Competitive pressure and innovation incentives

Table 3. Price Cost Margin

Product sustitutability **↑ Prod. Subst. → ↑ Comp.**

	Model I	Model II	Model III
Advertising/Sales **Expected sign: (+)**	0.0034***	0.0036***	0.0040***
	(0.0009)	(0.0009)	(0.0009)
After-sales services **Expected sign: (+)**	-0.0293***	-0.0083	-0.0057
	(0.0066)	(0.0065)	(0.0073)
Time dummies	No	Yes	Yes
Industry dummies	No	No	Yes
N. Obs.	14,743	14,743	14,741
Adjusted R^2	0.0125	0.0782	0.0943

All regressions include firms' age and size.

Table 3. Price Cost Margin

Market Size	**↑ Market size → ↑ Comp.**		
	Model I	Model II	Model III
Expansive Market **Expected sign: (-)**	0.0471***	0.0354***	0.0347***
	(0.0064)	(0.0063)	(0.0063)
Export Tariffs **Expected sign: (+)**	0.0016***	0.0007	-0.0007
	(0.0006)	(0.0006)	(0.0007)
Time dummies	No	Yes	Yes
Industry dummies	No	No	Yes
N. Obs.	14,743	14,743	14,741
Adjusted R^2	0.0125	0.0782	0.0943
All regressions include firms' age and size.			

Table 3. Price Cost Margin

Entry Costs **↓ Entry Costs → ↑ Comp.**

	Model I	Model II	Model III
Set-up costs **Expected sign: (+)**	0.0123	0.0087	-0.0505***
	(0.0121)	(0.0118)	(0.0153)
Import Tariffs **Expected sign: (+)**	-0.0016***	0.0019***	0.0010
	(0.0005)	(0.0005)	(0.0008)
Cost of introducing a new product **Expected sign: (+)**	-0.0017	-0.0086***	-0.0041
	(0.0017)	(0.0017)	(0.0034)
Time dummies	No	Yes	Yes
Industry dummies	No	No	Yes
N. Obs.	14,743	14,743	14,741
Adjusted R^2	0.0125	0.0782	0.0943

All regressions include firms' age and size.

MAIN RESULTS: MODEL SPECIFICATION

3 categories (*k*) of innovating firms (per year t):

k=1: Firms introducing product innovations (only).
k=2: Firms introducing product innovations (only).
k=3: Firms introducing both product and process innovations.

$$\text{Prob}\,(\text{firm } i \in k)$$

Probit Models (Instrumental Variables in 2 stages)

Table 4. PROBITS (Instrumental Variables)

(Lower) Product sustitutability ↓ Prod. Subst. → ↓ Comp.

Theoretical Prediction: Product (+) Process (-)

	Model I			Model II			Model III		
	Product (only)	Product+ Process	Process (only)	Product (only)	Product+ Process	Process (only)	Product (only)	Product +Process	Process (only)
Advertising/Sales	**0.0620*** **	0.0800***	**-0.0468*** **	**0.0637*** **	0.0833***	**-0.0456*** **	**0.0647*** **	0.0825***	**-0.0571*** **
	(0.0114)	(0.0104)	**(0.0105)**	**(0.0114)**	(0.0104)	**(0.0105)**	**(0.0179)**	(0.0169)	**(0.0188)**
After-sales services	**0.2089*** **	0.1577***	**-0.1576*** **	**0.1998*** **	0.1479***	**-0.1742*** **	0.0213	0.0644*	**-0.1042*** **
	(0.0322)	(0.0304)	**(0.0301)**	**(0.0324)**	(0.0307)	**(0.0304)**	(0.0380)	(0.0353)	**(0.0346)**
Time dummies	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	No	No	Yes	Yes	Yes
N. Observations	14,855	14,855	14,855	14,855	14,855	14,855	14,853	14,853	14,853

All regressions include firms' age and size.

Table 4. PROBITS (Instrumental Variables)

Market Size ↑ Market size → ↑ Comp.

Theoretical predictions: Product (+ or -) Process (+)

	Model I			Model II			Model III		
	Product (only)	Both	Process (only)	Product (only)	Both	Process (only)	Product (only)	Both	Process (only)
Expansive Market	-0.0157	0.1899***	**0.1908*** **	-0.0194	0.1876***	**0.1765*** **	0.0042	0.1760***	**0.1586*** **
	(0.0321)	(0.0289)	**(0.0276)**	(0.0328)	(0.0295)	**(0.0281)**	(0.0340)	(0.0303)	**(0.0292)**
Export Tariffs	**-0.0124*** **	-0.0060*	**-0.0060** **	**-0.0108*** **	-0.0044	**-0.0062* **	**-0.0116** **	-0.0010	-0.0016
	(0.0038)	(0.0032)	**(0.0030)**	**(0.0042)**	(0.0033)	**(0.0033)**	**(0.0053)**	(0.0039)	(0.0037)
Time dummies	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	No	No	Yes	Yes	Yes
N. Obs.	14,855	14,855	14,855	14,855	14,855	14,855	14,853	14,853	14,853

All regressions include firms' age and size.

Table 4. PROBITS (Instrumental Variables)

Entry Costs ↑ Entry Costs → ↓ Comp.

Theoretical Prediction: Product (-) Process (+)

	Model I			Model II			Model III		
	Product (only)	Both	Process (only)	Product (only)	Both	Process (only)	Product (only)	Both	Process (only)
Set-up costs	**-0.1783*** **	-0.1244**	**0.2270*** **	**-0.1675** **	-0.1189*	**0.2533*** **	-0.0585	-0.0009	**0.1231***
	(0.0688)	(0.0606)	**(0.0502)**	**(0.0700)**	(0.0616)	**(0.0513)**	(0.0941)	(0.0797)	**(0.0685)**
Import Tariffs	**-0.0051***	-0.0080***	**0.0046***	**-0.0084*** **	-0.0116***	0.0018	0.0092**	-0.0022	0.0045
	(0.0029)	(0.0026)	**(0.0024)**	**(0.0032)**	(0.0028)	(0.0026)	(0.0040)	(0.0038)	(0.0035)
Costs of introducing a new product	**-0.0208** **	-0.0079	**0.0330*** **	**-0.0171***	-0.0049	**0.0416*** **	**-0.0363***	-0.0338*	0.0161
	(0.0087)	(0.0082)	**(0.0077)**	**(0.0088)**	(0.0083)	**(0.0078)**	**(0.0208)**	(0.0189)	(0.0174)
Time dummies	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	No	No	Yes	Yes	Yes
N. Observations	14,855	14,855	14,855	14,855	14,855	14,855	14,853	14,853	14,853

All regressions include firms' age and size.

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Table 4. PROBITS (Instrumental Variables)

Instrumental Variables: results from 1st stage and dignostic tests.

Fisrt Stage Estimates of Advertising/Sales	Model I	Model II	Model III
Price changes following domestic competitors' price changes	0.0414*** (0.0084)	0.0420*** (0.0084)	0.0418*** (0.0084)
Price changes following foreign competitors' price changes	0.0308*** (0.0118)	0.0325*** (0.0118)	0.0335*** (0.0119)
Ajusted R^2	0.238	0.238	0.239

Instrumental variables diagnostic tests	Product (only)	Both	Process (only)	Product (only)	Both	Process (only)	Product (only)	Both	Process (only)
Wald test of endogeneity X^2 (r)	6.59***	26.57***	9.88***	7.26***	6.59***	29.72***	9.15***	2.90***	5.67***
(p-value)	(0.0102)	(0.0000)	(0.0017)	(0.0070)	(0.0102)	(0.0000)	(0.0025)	(0.0880)	(0.0172)
Sargan test of overid. restr. (Lee, 1992) $X^2_{(1)}$	0.115	0.101	0.724	0.077	0.115	0.015	0.755	0.023	1.071
(p-value)	(0.7348)	(0.7506)	(0.3949)	(0.7819)	(0.7348)	(0.9011)	(0.3850)	(0.8793)	(0.3008)

5. CONCLUSIONS

1. Traditional measures of market power such as PCM can be misleading.
2. The relevance of using in empirical papers the "fundamentals" of competitive pressure (product substitutability, market size and entry costs).
3. Market competition may be captured by different indicators.
4. Results consistent with Vives (2008) predictions: different sources of competitive pressure have differentiated effects on product or process innovation.
5. Results not distinguishing between product and process can be misleading.

THANK YOU

Table 5. PROBITS (Instrumental Variables)

(Low) Product Sustitutability

Theoretical Prediction: Product (+) Process (-)

	Model I		Model II		Model III	
	Product (only or both)	Process (only)	Product (only or both)	Process (only)	Product (only or both)	Process (only)
Advertising/Sales	0.0968***	-0.0468***	0.1008***	-0.0456***	0.1055***	-0.0571***
	(0.0094)	(0.0105)	(0.0094)	(0.0105)	(0.0154)	(0.0188)
After-sales services	0.2288***	-0.1576***	0.2172***	-0.1742***	0.0521*	-0.1042***
	(0.0268)	(0.0301)	(0.0270)	(0.0304)	(0.0313)	(0.0346)
Time dummies	No	No	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	Yes	Yes
N. Obs.	14,855	14,855	14,855	14,855	14,853	14,853

All regressions include firms' age and size.

Table 5 . PROBITS (Instrumental Variables)

Market Size

Theoretical Prediction: Product (+/-) Process (-)

	Model I		Model II		Model III	
	Product (only or both)	Process (only)	Product (only or both)	Process (only)	Product (only or both)	Process (only)
Expansive Market	0.1289***	0.1908***	0.1233***	0.1765***	0.1263***	0.1586***
	(0.0259)	(0.0276)	(0.0264)	(0.0281)	(0.0273)	(0.0292)
Export Tariffs	-0.0110***	-0.0060**	-0.0090***	-0.0062*	-0.0063	-0.0016
	(0.0030)	(0.0030)	(0.0032)	(0.0033)	(0.0039)	(0.0037)
Time dummies	No	No	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	Yes	Yes
N. Observations	14,855	14,855	14,855	14,855	14,853	14,853

All regressions include firms' age and size.

Table 5. PROBITS (Instrumental Variables)

Entry Barriers

Theoretical Prediction: Product (-) Process (+)

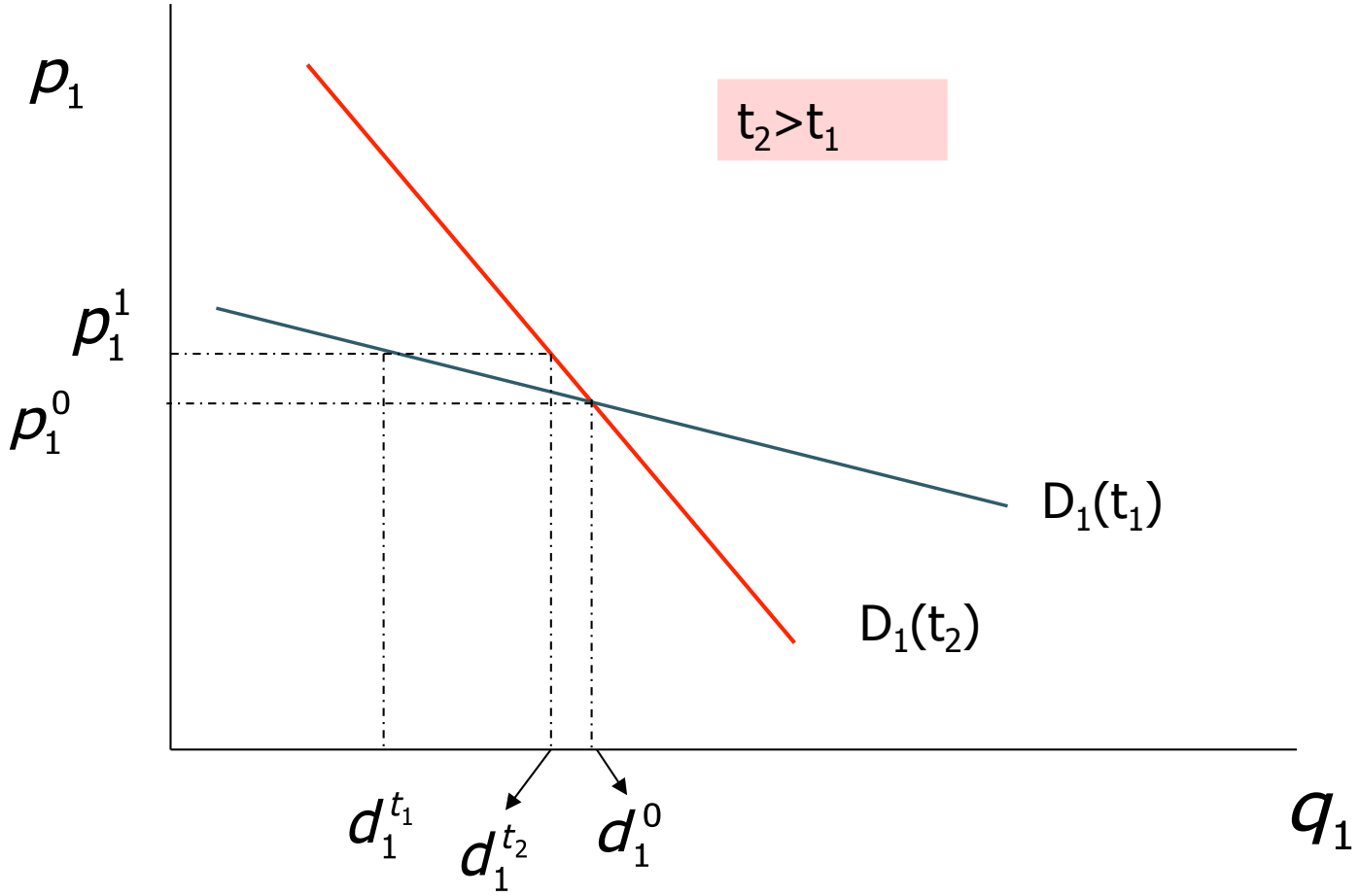
	Model I		Model II		Model III	
	Product (only or both)	Process (only)	Product (only or both)	Process (only)	Product (only or both)	Process (only)
Set-up costs	-0.1974***	0.2270***	-0.1864***	0.2533***	-0.0392	0.1231*
	(0.0538)	(0.0502)	(0.0547)	(0.0513)	(0.0717)	(0.0685)
Import Tariffs	-0.0091***	0.0046*	-0.0134***	0.0018	0.0037	0.0045
	(0.0023)	(0.0024)	(0.0025)	(0.0026)	(0.0033)	(0.0035)
Costs of introducing a new product	-0.0178**	0.0330***	-0.0134*	0.0416***	-0.0430***	0.0161
	(0.0072)	(0.0077)	(0.0073)	(0.0078)	(0.0165)	(0.0174)
Time dummies	No	No	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	Yes	Yes
N. Observations	14,855	14,855	14,855	14,855	14,853	14,853

All regressions include firms' age and size.

DESCRIPTIVE STATISTICS:

Table 2. Percentage of firms engaged in innovation activities

Year	Product innovation only	Process innovation only	Both	No innovation
1991	8.6	15.2	11.8	64.5
1992	10.0	14.5	11.7	63.8
1993	8.8	15.3	11.0	64.9
1994	9.1	15.2	10.9	64.9
1995	9.7	15.2	10.5	64.6
1996	9.1	13.7	10.4	66.8
1997	9.6	16.5	11.8	62.2
1998	9.5	19.2	10.6	60.7
1999	9.2	17.2	11.1	62.5
2000	9.5	17.4	10.7	62.4
2001	6.8	17.0	7.8	68.4
2002	6.8	13.4	8.1	71.6
2003	6.2	10.4	7.3	76.0
2004	6.8	11.1	7.8	74.4
2005	7.4	12.7	8.6	71.3
2006	7.9	15.4	6.5	70.3
Total period	8.6	15.1	10.0	66.4



Mayor t (mayor diferenciación de producto), menor elasticidad de demanda (menor sensibilidad de la demanda a cambios en precios)