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The Internationalisation of R&D and the Knowledge Production Function

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Motivation

❖ Cross country technological disparities:

- MNE as channel of international technology diffusion (Keller, 2010).
- Technological gap matters

❖ Internationalisation of R&D:

MNE as main producer of knowledge (Dunning and Lundan, 2008).

- Their R&D location is global (Bloom and Griffith, 2001; NSF, 2011).
- Their R&D production function uses internationally sourced knowledge (Criscuolo, Haskel and Slaughter, 2010; Veugelers and Cassiman, 2004).

- Explore the link between the internationalisation of R&D and the knowledge production function by looking at the knowledge inputs of firms acquired by foreign MNEs: **PRE and POST ACQUISITION**

Hypothesis

- Frame: Bi-directional knowledge flows: MNE (country) ↔ Affiliate (country)
- **Pre-acquisition:** acquired firms ≠ non-acquired firms
Motive for FDI:
 - Complementarities in the knowledge assets? (Nocke and Yeaple, 2008).
 - Targets are more active in innovation?
 - Targets use more intensively internally created knowledge?
- **Post-acquisition:** changes in knowledge inputs differ
 - Motives of acquisitions are reflected in post-acquisition restructuring of knowledge production function
 - Differences between MNEs at /below the technology frontier

■ Data and Methodology

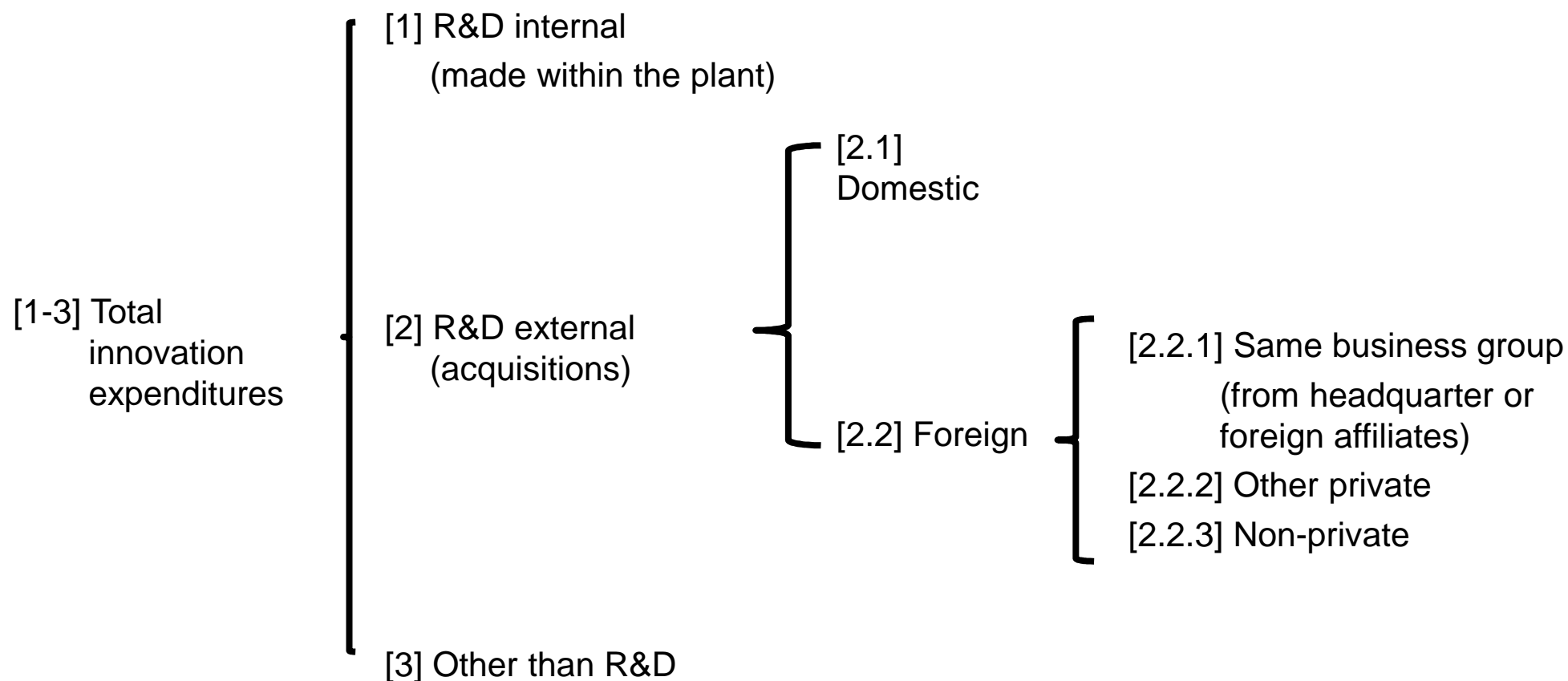
Data

- Database: PITEC 2004 – 2009 (Spanish Community Innovation Survey, CIS)
- Representative sample of innovative and non-innovative firms
- Data on key characters as :
 - Sales, employees etc...
 - Ownership and country of headquarters
 - Innovation activities:



Data and Methodology

Decomposition Innovation Expenditures



Data and Methodology

Operationalisation

- Definition of foreign acquisition
- Only firms continuously active in innovation
- Final data set:
 - Panel of 4,295 continuous innovators
 - Firms once acquired and dislocated headquarter abroad after acquisition
 - Firms not acquired
- Definition of “frontier” MNEs:
 - JUG: Japan, Germany, USA vs. “non-frontier”
- 189 acquisitions: 67 JUG – 122 non-JUG

Data and Methodology

Methodology

Pre-acquisition characteristics of the target firm & post-acquisition changes in the target firm:

- Pre-acquisition:
 - Probit models
- Post-acquisition:
 - Difference-in-difference regression (DiD)
 - Controlling for selection: Constructing a counterfactual of matched non-acquired firms (Propensity Score Matching Approach)
 - Add to the DiD model a set of interaction terms to study differences between MNEs (JUG versus non-JUG)

Determinants of foreign acquisitions

Regression No.	Sample Full sample (iii)	Full sample (iv)	JUG vs. non- acquired (v)	Non-JUG vs. non- acquired (vi)	JUG vs. non- JUG (vii)
<i>Log(Number of patents)</i>	-0.0002 (0.000)	-0.0002 (0.000)	-0.0000 (0.000)	-0.0002 (0.000)	0.0019 (0.002)
<i>Log(internal R&D)</i>	0.0013*** (0.000)	0.0013*** (0.000)	0.0003 (0.000)	0.0009*** (0.000)	-0.0060 (0.013)
<i>Log(external R&D)</i>	-0.0004*** (0.000)	-0.0004*** (0.000)	-0.0002*** (0.000)	-0.0002** (0.000)	-0.0012 (0.003)
<i>External same business group/external R&D</i>	0.0001 (0.000)				
<i>External same business group dummy</i>	0.0479** (0.022)	0.0731*** (0.021)	0.0234* (0.013)	0.0574*** (0.020)	-0.0618 (0.039)
<i>Labour productivity</i>	0.0031*** (0.001)	0.0031*** (0.001)	0.0014*** (0.000)	0.0017*** (0.000)	0.0152 (0.018)
<i>Export dummy</i>	0.0016 (0.001)	0.0016 (0.001)	0.0003 (0.001)	0.0012 (0.001)	-0.0261 (0.050)
<i>Observations</i>	13,527	13,527	13,295	13,397	362

Note: Size dummies omitted for presentation. The coefficients refer to marginal effects calculated at sample means. All regressions include region and year dummies.

Effects of Foreign Acquisition on Innovation Expenditures of Targets

- Technologically intensive countries: Germany, Japan and US
- Compare results to those when we use:
 - 10 most R&D intensive (OECD, BERD/GDP): Israel, Sweden, Japan, Finland, Switzerland, US, Denmark, Germany, Austria, Hong Kong.
 - Eurostat scoreboard technological leaders: Israel, Sweden, Japan, Finland, Switzerland, US, Denmark, Germany, UK
 - 5 Least technologically intensive: Portugal, Brazil, Mexico, Poland, India (6 acquisitions after matching)
- General result:

As we expand the set of technologically intensive countries the results change.



Effects of Foreign Acquisition on Innovation Expenditures of Targets

Innovation Expenditures Regression No.	Total (i)	Internal R&D (ii)	External R&D (iii)	External Domestic (iv)	External Foreign (v)	External Foreign Same Bus. Group (vi)
Panel A: Top 10 and non-top 10 in terms of BERD as percentage of GDP						
Top 10						
<i>Year of acquisition</i>	-0.002 (0.048)	-0.404*** (0.084)	0.634** (0.233)	0.348 (0.207)	0.397 (0.323)	0.583*** (0.148)
<i>One year after acquisition</i>	-0.151*** (0.042)	-0.464*** (0.144)	-0.648 (0.430)	-1.145*** (0.328)	0.118 (0.512)	0.477*** (0.148)
Panel B: Technological leaders and non-leaders (Source: European Commission)						
Technological Leader						
<i>Year of acquisition</i>	-0.003 (0.045)	-0.353*** (0.086)	0.574** (0.227)	0.333* (0.192)	0.350 (0.304)	0.519*** (0.165)
<i>One year after acquisition</i>	-0.093 (0.061)	-0.365** (0.149)	-0.677* (0.381)	-1.106*** (0.339)	0.096 (0.468)	0.417** (0.163)
Panel C: 5 least technologically intensive countries						
Least Techno Intensive						
<i>Year of acquisition</i>	1.360*** (0.160)	1.413 (1.591)	-4.208** (1.701)	-4.357** (1.846)	-0.957 (0.733)	0.238 (0.364)
<i>One year after acquisition</i>	0.733** (0.321)	1.198*** (0.343)	-1.874*** (0.646)	-2.062*** (0.666)	1.317** (0.522)	0.148 (0.128)

Note: Size dummies, export dummy and relative corporate tax omitted for presentation. Variables are in logs. All regressions include region, sector and year dummies.

Summary

Internationalisation of R&D and impact on the knowledge production function: Role of complementarities in knowledge assets?

Pre-acquisition:

- Knowledge inputs used by acquired firms differ significantly from non-acquired firms.
- Cherry-picking of those with best internal R&D capabilities.
- No evidence of significant differences between MNEs
- Suggests complementarities as motive for FDI

Summary

Post-acquisition:

- Investor's origin has impact on target's knowledge production function
- Change in geographic location of knowledge production
- 3 groups of MNEs
 - Technologically intensive:
 - ↓ Total innovation expenditures, ↓ internal R&D , ↑ external R&D from the group.
 - Technology transfer
 - Complementary knowledge assets.
 - Technologically similar: No change
 - Technologically un-intensive:
 - ↑ Total innovation expenditures, ↑ internal R&D, ↓ external R&D
 - Technology sourcing.



BACK UP

AGENDA

- Motivation
- Research hypothesis
- Data and Methodology
- Effects of foreign acquisitions on the structure of R&D-sourcing of target firms depending on investor's country of origin
- Summary

Motivation

- Bandick(2010): No relocation of R&D from Sweden to MNE's country of origin
- Bertrand(2009): Positive effects from foreign acquisitions on the level of R&D spending and its subcomponents in French firms
- Stiebale/Reinze(2011): No positive effects of cross-border M&A on innovational activities in target firms
- Do not look at foreign acquisitions in general – differentiate by country of origin
- Javorcik/Spatareanu(2011): Influence of investor's origin on vertical spillovers
- Chen(2011): Influence of investor's origin on target firm's performance:
Lower labor productivity increase when acquired by developing countries than by domestic
- Griffith, Harrison and Van Reenen(2006):
 - Target firms' productivity changes has outwards effects on investors' performance
 - Spillovers bigger the greater the technology gap (sectoral comparison)

Data and Methodology

Decomposition Innovation Expenditures

R&D Internal	1.	In-house or Intramural R&D: Creative work undertaken within an enterprise on an occasional or regular basis in order to increase the stock of knowledge and its use to devise new and improved goods, services and processes.
R&D External	2.	Acquisition of R&D or Extramural R&D: Firm purchases of creative work on an occasional or regular basis in order to increase the stock of knowledge and its use to devise new and improved goods, services and processes from other companies (including other enterprises within your group) or public and private research organisations
R&D External Domestic	2.1	
R&D External Foreign	2.2	
R&D External Foreign Same Business Group	2.2.1	R&D acquisitions abroad from companies that belong to the same business group
R&D External Foreign other Private	2.2.2	R&D acquisitions abroad from companies that are legally independent and do not belong to the same business group
R&D External Foreign Non-private	2.2.3	R&D acquisitions abroad from public administration, universities, non-profitable organizations and other international organizations
Innovation Expenditures other than R&D	3.	Acquisition of machinery, equipment and software: Acquisition of advanced machinery, equipment and computer hardware or software to produce new or significantly improved goods, services, production processes, or delivery methods. Acquisition of external knowledge: Purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organisations.
		Expenditures on design functions for the development or implementation of new or improved goods, services and processes. Expenditure on design in the R&D phase of product development should be excluded.
		Internal or external training for your personnel specifically for the development and/or introduction of innovations.
		Expenditures on all activities concerning market preparation and introduction of new or significantly improved goods and services, including market research and launch advertising.

Table 2: Number of acquisitions distinguishing by headquarter of the MNE

	Number of acquisitions before matching (i)	Number of acquisitions after matching (ii)	BERD as % of GDP (average 2004-2009) (iii)	JUG countries (iv)	Top 10 BERD countries (v)	Technological leaders (vi)	Above Spain in BERD (vii)
Israel	2	2	3.54		√	√	√
Sweden	3	2	2.62		√	√	√
Japan	3	3	2.58	√	√	√	√
Finland	2	1	2.52		√	√	√
Switzerland	8	7	2.17		√	√	√
USA	33	27	1.87	√	√	√	√
Denmark	2	2	1.80		√	√	√
Germany	31	23	1.79	√	√	√	√
Austria	1	1	1.76		√		√
Hong-Kong	1	1	1.58		√		√
Luxembourg	8	5	1.33				√
France	25	19	1.32				√
Belgium	8	7	1.29				√
Canada	4	4	1.08				√
United Kingdom	12	6	1.08			√	√
Netherlands	16	11	0.96				√
Slovenia	1	1	0.97				√
Czech Republic	1	0	0.90				√
Norway	3	2	0.85				√
Spain			0.66				
Italy	17	15	0.58				
Portugal	3	3	0.52				
Brazil	1	1	0.49 ^(a)				
Mexico	1	1	0.18				
Poland	2	1	0.17				
India	1	0	n/a				
Total	189	154					

Note: Period 2004-2009. (a) Data of Brazil are for the year 2006. BERD as % of GDP data come from OECD database. Columns (iv) to (vii) refer to different classifications of technologically leading countries and technologically non-leading countries. Source for column (vi) European Commission Scoreboard (2009).

Table 1: Descriptive statistics

	All acquired firms			Acquired firms from JUG countries			Acquired firms from non-JUG countries			Never acquired
<i>Year</i>	<i>t-1</i>	<i>t</i>	<i>t+1</i>	<i>t-1</i>	<i>t</i>	<i>t+1</i>	<i>t-1</i>	<i>t</i>	<i>t+1</i>	
<i>Total Innovation Expenditure (log)</i>	13.44 (1.56)	13.35 (1.59)	13.23 (1.47)	13.13 (1.62)	13.22 (1.68)	13.07 (1.67)	13.61 (1.50)	13.43 (1.54)	13.31 (1.36)	12.45 (1.56)
% of total innovation expenditure on...										
Internal R&D	73.78 (32.72)	68.60 (34.77)	71.36 (36.15)	77.74 (31.97)	68.40 (36.42)	63.40 (40.02)	71.61 (33.06)	68.71 (33.98)	75.47 (33.47)	73.45 (31.02)
External R&D	12.89 (23.61)	14.62 (25.37)	14.38 (28.46)	10.06 (22.89)	13.49 (25.79)	12.82 (28.40)	14.45 (23.95)	15.23 (25.22)	15.19 (28.61)	11.43 (20.83)
Non-R&D innovation	14.50 (25.84)	16.78 (28.50)	14.26 (27.91)	13.94 (26.79)	18.10 (29.65)	23.78 (35.86)	14.80 (25.44)	16.05 (27.94)	9.34 (21.38)	15.98 (26.85)
<i>Total External R&D Expenditure (log)</i>	5.36 (6.12)	5.71 (6.13)	4.93 (6.02)	4.28 (5.89)	5.48 (6.11)	4.66 (5.93)	5.96 (6.18)	5.84 (6.16)	5.08 (6.09)	4.89 (5.62)
% of external R&D on...										
External domestic	71.77 (40.41)	69.87 (42.14)	75.30 (40.11)	59.39 (45.32)	57.83 (46.70)	60.18 (47.12)	76.73 (37.53)	76.19 (38.45)	82.66 (34.52)	93.81 (20.00)
External foreign	28.23 (40.41)	30.13 (42.14)	24.70 (40.11)	40.61 (45.32)	42.17 (46.70)	39.82 (47.12)	23.27 (37.53)	23.81 (38.45)	17.33 (34.52)	6.19 (20.00)
<i>Total External Foreign Expenditure (log)</i>	2.21 (4.82)	2.34 (4.85)	1.68 (4.20)	2.20 (4.79)	2.76 (5.26)	2.17 (4.64)	2.23 (4.85)	2.12 (4.62)	1.42 (3.96)	0.69 (2.69)
% of external foreign R&D on...										
External foreign same business group	58.62 (48.39)	69.59 (44.87)	72.27 (43.88)	54.17 (49.81)	76.84 (40.43)	80.01 (39.99)	61.05 (48.61)	64.64 (47.94)	65.94 (47.76)	5.41 (21.38)
External foreign other private firms	35.50 (46.92)	27.71 (43.55)	12.73 (31.39)	29.17 (45.02)	16.49 (34.70)	8.88 (26.65)	38.95 (48.61)	35.36 (47.94)	15.87 (35.77)	74.19 (41.90)
External foreign non-private firms	5.88 (23.88)	2.70 (16.44)	15.00 (36.63)	16.67 (38.92)	6.67 (25.82)	11.11 (33.33)	0.00 (0.00)	0.00 (0.00)	18.18 (40.45)	20.41 (38.65)
Number of firms	189	189	144	67	67	48	122	122	96	4,106

Note: The symbol *t-1* means one year before acquisition; *t* means in the year of the acquisition; and *t+1* means one year after acquisition. JUG countries are Japan, USA and Germany. All variables are in logarithms except number of patents. We show means. Standard deviations are in parenthesis.

Data and Methodology

Propensity Score Matching (PSM)

- Matching method based on Rubin (1979), Rosenbaum/Rubin(1983,1985)
- Application:
 - Determination of Propensity Score for acquisition by eq. (1)
 - Matching method: „Caliper Matching with Replacement“
 - Matching within year and industry
- Balancing is satisfied
- After matching our final sample consists of
 - 302 firms with 159 acquisitions and 148 untreated firms.
 - 55 acquisitions from frontier
 - 104 acquisitions from non-frontier countries

Data and Methodology

Characteristics of Acquisition – Propensity Score determination

■ Probit Model

$$Acquisition_{it} = \begin{cases} 1 & \text{if } \alpha + X'_{it-1}\beta + \gamma_i + \varepsilon_{it} > 0 \\ 0 & \text{if } \alpha + X'_{it-1}\beta + \gamma_i + \varepsilon_{it} \leq 0. \end{cases} \quad \text{Eq. (1)}$$

■ Vector X:

- Expenditures for internal R&D
- Expenditures for external R&D
- Dummy for having ex-ante R&D imports from within the group
- Firm size (number of employees)
- Labour productivity
- Dummy for exports
- Region and year dummies

Data and Methodology

Propensity Score Matsching (PSM)

- Fundamental evaluation problem
- Matching method based on Rubin (1979), Rosenbaum/Rubin(1983,1985)
 - The effect of treatment for a firm $\tau_i = Y_i(1) - Y_i(0)$
 - Average Treatment Effect
 $\tau_{ATT} = E[\tau|D = 1] = E[Y(1)|D = 1] - E[Y(0)|D = 1]$
 - Average outcome value of the untreated $E[Y(0)|D = 0]$
 - “Selection Bias” Problem
 - Solution: Matching

Methodik: PSM & DID

Propensity Score Matching (PSM) - II/II

- Matching assumptions:
 - Conditional Independence Assumption $(Y_i(1); Y_i(0)) \perp D_i | X$
 - Common Support Assumption $P[D = 1|X] < 1$
- Propensity Score $P(X) \equiv Pr(D = 1|X) = E[D|X]$,
 - Conditional Independence Assumption $(Y_i(1); Y_i(0)) \perp D_i | P(X)$
- Application:
 - Determination of Propensity Score for acquisition by eq. (1)
 - Matching method: „Caliper Matching with Replacement“

Data and Methodology

„Balancing Hypothesis“

Table 5: Balancing test

a) For each ex ante covariate

Variable	Mean		%bias	% Bias Reduction	t-test	
	Treated	Control			t	p-value
<i>Log(internal R&D)</i>	11.91	12.52	-17.0	13.4	-1.50	0.134
<i>Log(external R&D)</i>	4.81	4.93	-2.1	75.4	-0.18	0.859
<i>External same business group dummy</i>	0.08	0.05	14.6	74.8	1.39	0.166
<i>Labour productivity</i>	12.32	12.29	3.7	94.7	0.36	0.722
<i>Size <50 employees</i>	0.19	0.19	0.0	100	0.00	1.000
<i>Size 50-99 employees</i>	0.18	0.21	-8.7	-463.7	-0.72	0.471
<i>Size 200-499 employees</i>	0.22	0.21	1.7	95.4	0.14	0.891
<i>Size >500 employees</i>	0.18	0.12	17.6	55.3	1.43	0.155
<i>Export dummy</i>	0.79	0.86	-14.5	60.5	-1.50	0.135

b) Overall measures of covariate balancing

	Mean abs. std. bias	% mean bias reduction	Median abs. std. bias	% median bias reduction	Pseudo R ²	LR test	
						X ²	p> X ² *
<i>Before matching</i>	39.53		37.68		0.145	279.08	0.000
<i>After matching</i>	8.88	77.53%	8.74	76.80%	0.020	8.49	0.486

Note: *Likelihood-ratio test of the joint insignificance of all regressors.

Data and Methodology

Estimation Equation

$$Y_{it} = \delta + \varphi Acq_{it} \cdot JUG + \tilde{\varphi} Acq_{it-1} \cdot JUG + \gamma Acq_{it} \cdot NonJUG + \tilde{\gamma} Acq_{it-1} \cdot NonJUG + Z_{it}' \phi + \vartheta_{it},$$

- Firm-fixed-effects estimation
- Y_{it} various measures for innovation expenditures
- Acq_{it} , dummy equal to 1 in the year of the acquisition
- Acq_{it-1} , dummy equal to 1 if acquisition in the year before
- Z_{it} set of controls
- Regional, year and sector dummies