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FIW

Seminar in International Economics
19 March 2015

The additionality effects of R&D tax credits across sectors: A cross-country microeconometric analysis

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This seminar series is an activity in the framework of FIW ('Forschungsschwerpunkt Internationale Wirtschaft'), which is a project designed to build a center of excellence in research on International Economics, funded by the Austrian Ministry of Science, Research and Economy (BMWFW).

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Background & questions

R&D tax incentives

- More than 20 OECD countries currently support private R&D investments through R&D tax incentives

- These are fiscal deductions that firms can claim if they are involved in R&D activities

- They are typically directed to all firms in the economy and hence let private agents decide what type of project to apply for (Hall and Van Reenen, 2000)

- Their effect is to reduce the costs of firms' R&D projects and/or expand their scale

The literature on R&D policy evaluation

- A recent microeconometric literature investigates whether and the extent to which R&D tax credits are effective

- Main focus: «**input additionality**»: The increase in R&D expenditures carried out by a supported firm *vis-a-vis* the (counterfactual) situation in which the firm is not supported

- Only few studies investigate instead «**output additionality**»: the increase in innovation output (new products, patents) consequent to the increased R&D spending generated by the policy

Heterogeneity of R&D policy impacts

- Most of these econometric studies typically focus on the *average* additionality effect, i.e. the mean impact of R&D tax credits in a large sample of firms in a given economy

- Very few studies examine how the additionality effect varies for different groups of firms (e.g. large vs. SMEs; firms in different sectors)

- There is limited attention to «**heterogeneity**» in the R&D policy evaluation literature

The sectoral dimension

- The literature on sectoral patterns of innovation points out that firms in different industries differ substantially in terms of the innovation strategy they adopt and the industrial dynamics conditions they face (Dosi, 1988; Malerba, 2005)

- It is therefore reasonable to ask whether the effects of R&D tax credits vary systematically by sector, and if so, why

- Two related branches of literature and two more specific dimensions are relevant to investigate this general question

Research question 1

- The literature on sectoral taxonomies originated by Pavitt (1984)

- Industries differ substantially in terms of their **R&D orientation**, i.e. the extent to which formal R&D activities represent the main innovation strategy adopted by innovative companies

- **Q1:** *How does the sector-specific R&D orientation affect the additionality effects of R&D tax credits – should we expect firms to be more responsive to R&D fiscal incentives in industries with high R&D orientation or rather in sectors with low average R&D intensity?*

Research question 2

- The literature on competition and innovation (Malerba and Orsenigo, 1996; Tang, 2006)

- Industries differ substantially in terms of the degree of market concentration and the competition conditions faced by innovative companies

- **Q2:** *How do sector-specific competition conditions affect the additionality effects of R&D tax credits – should we expect additionality effects to be stronger in more concentrated or in more competitive industries?*

Model & hypotheses

The empirical model

$$\Pr\{TC_{ij}\} = \alpha + \beta X_{ij} + \gamma RD_j + \delta C_j + \varepsilon_{ij} \qquad (1)$$

$$RD_{ij} = \mu + \eta TC_{ij} + \theta W_{ij} + \kappa RD_j + \lambda C_j + \zeta_{ij} \qquad (2)$$

$$IO_{ij} = \nu + \psi RD^{C}_{ij} + \pi \Delta RD_{ij} + \sigma Z_{ij} + \varphi RD_j + \omega C_j + \xi_{ij} \qquad (3)$$

where:

LHS: TC_{ij} (tax credit); RD_{ij} (R&D investments); IO_{ij} (innov. output)
Industry-level variables: RD_j (R&D orientation); C_j (concentration)

Hyp. 1: TC probability & R&D orientation

Firms' probability to receive a tax credit is greater:

- **In sectors with *higher* R&D orientation (H1a)**

Firms that have already invested previously in R&D will be more willing to apply to tax deductions in order to reduce the costs of their existing R&D projects and/or expand their scale

- **In industries with *lower* R&D orientation (H1b)**

Companies in low R&D intensity industries may apply to tax credits to achieve fiscal benefits and alleviate financial constraints rather than to increase their R&D investments in a permanent way

Hyp. 2: TC probability and concentration

Firms' probability to receive a tax credit is greater:

- **In sectors with *higher* concentration (H2a)**

Schumpeterian effect: Oligopolistic innovators in highly concentrated sectors have a greater incentive to apply to tax credits because they can more easily reap innovation rents

- **In industries with *lower* concentration (H2b)**

Escape competition effect: Firms in competitive markets find it attractive to apply to R&D fiscal incentives because they consider R&D an essential strategy to maintain their competitive position

Hyp. 3: IA and R&D orientation

Input additionality is stronger:

- **In sectors with *higher* R&D orientation (H3a)**

Firms with ongoing R&D activities find it easier to increase their R&D investments by building upon and extending previous R&D projects (success-breeds-success and cumulativeness mechanism)

- **In industries with *lower* R&D orientation (H3b)**

Companies have greater scope for learning and catching up:
any given small increase in R&D spending induced by a tax credit will lead to a relatively larger increase in R&D intensity

Hyp. 4: IA and concentration

Input additionality is stronger:

- **In sectors with *higher* concentration (H4a)**

Same logic as H2a (*Schumpeterian effect*)

- **In industries with *lower* concentration (H4b)**

Same logic as H2b (escape competition effect)

Hyp. 5: OA and R&D orientation

Output additionality is stronger:

- **In sectors with *higher* R&D orientation (H5a)**

Since firms have higher R&D and technological capabilities on average, a given amount of additional R&D is more likely to lead to a stronger increase in innovation output

- **In industries with *lower* R&D orientation (H5b)**

Companies produce a lower amount of innovation output on average. Hence, any small increase in innovation output will represent a relatively larger output additionality effect

Hyp. 6: OA and concentration

Output additionality is stronger:

- **In sectors with *higher* concentration (H6a)**

Oligopolistic innovators are able to increase their innovation output relatively more than firms lagging behind the technological frontier due to cumulativeness and success-breeds-success mechanisms

- **In industries with *lower* concentration (H6b)**

If highly competitive markets are also characterized by high technological opportunities, a large number of innovators increase their technological output as a response to R&D tax credits

Data & methods

Data

- A panel of firm-level data for all manufacturing industries originated from the innovation surveys for three countries: Norway, France and Italy

- **Norway and France:** three waves of the CIS survey referring to the periods 2002-2004, 2004-2006 and 2006-2008, respectively

- **Italy:** three waves of the innovation survey called Unicredit / Efige (analogous to CIS), referring to the periods 2001-2003, years 2004-2006 and 2007-2009

Indicators (1): Dependent variables

- **TC**: R&D tax credit dummy (1 if firm is granted a R&D fiscal deduction in the period, 0 otherwise)

- **RD_INTENSITY**: R&D expenditures as a share of total turnover (0-100 scale)

- **TURN_NEW**: Share of turnover from new or improved products (0-100 scale)

Indicators (2): Control variables

- **SIZE**: Number of employees (log)

- **H_FINANCE_INT**: A categorical variable (0-3 scale): the extent to which firms consider the lack of *internal funding* an important factor hampering their innovative activities

- **H_FINANCE_EXT**: A categorical variable (0-3 scale): the extent to which firms consider the lack of *external funding* an important factor hampering their innovative activities

- **H_PERSONNEL**: A categorical variable (0-3 scale): the extent to which firms consider the lack of *qualified personnel* an important factor hampering their innovative activities

- **COOP**: Innovation cooperation dummy (1 if firm has had cooperation)

Indicators (3): Industry-level variables

- **Industry's R&D orientation:**
  Four dummy variables representing the sectoral groups identified by Pavitt's (1984) taxonomy: SS (specialized suppliers), SB (science-based), SI (scale intensive), and SD (supplier-dominated)
  => Each NACE 2 sector is assigned to a Pavitt group based on a previous classification table

- **Market concentration:**
  Two dummy variables: LC (low-concentration sectors) and HC (high-concentration industries)
  => Each NACE 2 sector is assigned to LC (or HC) if its Herfindahl concentration index (HHI) is below (or above) the median, for a given country and a given year

Methods

- A three-step estimation procedure based on Czarnitzki and Hussinger (2004) and Cerulli and Poti (2012)

- **Step 1:** We estimate the probability that a company receives a R&D tax credit (equation 1) – RE probit model – Sectoral group dummies

- **Step 2:** We estimate the input additionality parameter through a PSM approach (nearest-neighbor matching), separately for each sectoral group and each year => We split the R&D variable in two parts: (i) ΔRD_{ij} (TET estimated in step 2); (ii) RD^{C}_{ij} (counterfactual)

- **Step 3:** We estimate the output additionality parameter – RE linear model – Interactions between TET and sectoral group dummies

Identification issues

- **Three model specifications:**

1. Without lagged R&D regressor; whole sample

2. With lagged R&D regressor; only balanced panel sample

3. Without lagged R&D regressor; only innovative firms (Czarnitzki et al., 2011)

Results

Results for equation 1 (TC probability)

Marginal effects from RE probit

	Norway	Italy	France
SB	0.173 (9.75)***	0.020 (1.89)*	0.199 (9.79)***
SS	0.127 (7.65)***	0.021 (2.29)**	0.239 (11.53)***
SI	0.021 (1.57)	0.008 (1.12)	0.065 (3.55)****
LC	-0.040 (2.71)***	0.006 (0.89)	-0.059 (-3.98)***
SIZE	0.063 (12.75)***	0.017 (5.88)***	0.0917 (18.45)***
H_FINANCE_INT	0.019 (2.82)***	0.008 (2.29)**	0.022 (3.1)***
H_FINANCE_EXT	0.035 (5.00)***	0.006 (1.97)**	0.018 (2.66)***
H_PERSONNEL	0.033 (5.68)***	0.023 (8.63)***	0.015 (2.14)**
YEAR 2006	-0.094 (9.05)***	0.130 (12.69)***	.103 (8.33)
YEAR 2008	-0.123 (11.63)***	0.153 (14.22)***	-.116 (7.29)***
N	6779	9185	7346

Equation 2 (input additionality)
Norway

		SS	SB	SI	SD	LC	HC
Year 2004							
	ATT	8.048	5.166	3.708	2.796	4.059	7.765
	t-stat	(7.34)***	(2.48)**	(7.63)***	(4.22)***	(10.25)***	(5.33)***
	N untreated	131	114	428	606	1077	202
	N treated	132	89	179	219	494	125
	Median bias	2.3%	6.7%	3.3%	3.2%	2.5%	5.1%
Year 2006							
	ATT	9.468	11.046	5.291	4.776	6.831	9.095
	t-stat	(6.28)***	(4.74)***	(6.89)***	(5.10)***	(11.40)***	(4.81)***
	N untreated	239	113	620	1016	1770	218
	N treated	109	92	149	151	396	105
	Median bias	9.9%	6.8%	7.3%	1.2%	1.6%	7.5%
Year 2008							
	ATT	7.230	10.271	3.854	11.566	8.828	10.189
	t-stat	(4.54)***	(5.39)***	(5.12)***	(8.21)***	(10.20)***	(6.08)***
	N untreated	198	170	580	957	1591	300
	N treated	65	121	112	166	356	101
	Median bias	2.8%	5.0%	3.0%	1.3%	1.1%	2.1%

Results for equation 2 (input additionality) Italy

		SS	SB	SI	SD	LC	HC
Year 2004							
	ATT	4.576	3.234	3.110	0.972	2.141	5.766
	t-stat	(2.88)**	(2.12)**	(2.61)***	(2.56)**	(3.80)***	(2.58)**
	N untreated	396	301	842	1163	2,004	698
	N treated	25	18	35	30	88	20
	Median bias	4.8%	2.3%	1.1%	2.0%	2.0%	7.5%
Year 2006							
	ATT	-1.354	-0.857	-0.418	-0.323	-0.498	-0.750
	t-stat	(-3.65)***	(-1.91)*	(-3.40)***	(-1.31)	(-3.05)***	(-3.35)***
	N untreated	561	352	1063	1173	2280	869
	N treated	73	44	178	183	327	151
	Median bias	7.8%	3.3%	2.1%	2.2%	1.5%	2.0%
Year 2008							
	ATT	4.532	6.231	5.977	3.634	4.765	6.539
	t-stat	(4.86)***	(5.69)***	(8.08)***	(6.68)***	(11.66)***	(6.07)***
	N untreated	294	195	886	903	1682	596
	N treated	101	73	153	143	369	101
	Median bias	3.0%	2.1%	1.3%	2.6%	2.4%	5.2%

Results for equation 2 (input additionality) France

		SS	SB	SI	SD	LC	HC
Year 2004							
	ATT	2.393	3.52	1.60	0.434	1.29	2.989
	t-stat	(3.7)***	(4.83)***	(2.75)***	(0.66)	(3.74)***	(5.49)***
	N untreated	333	457	852	711	1347	976
	N treated	207	270	296	150	429	494
	Median bias	3%	1.9%	2.4%	1.4%	2.1%	1.9%
Year 2006							
	ATT	2.67	3.47	0.57	-.107	0.254	3.009
	t-stat	(4.06)***	(6.16)***	(1.36)	(-0.24)	(0.72)	(6.68)***
	N untreated	191	278	522	738	1115	614
	N treated	208	324	319	217	522	546
	Median bias	2.7%	2.5%	0.3%	0.5%	1%	2.1%
Year 2008							
	ATT	2.062	4.145	1.297	0.449	1.35	4.04
	t-stat	(3.03)***	(5.21)***	(2.02)**	(1.06)	(2.5)**	(4.83)***
	N untreated	93	221	318	288	549	306
	N treated	54	113	106	59	180	119
	Median bias	1.2%	3.4%	8.1%	3.7%	2.8%	0.9%

Results for equation 3 (output additionality)

RE linear model (only main regressors reported in the table)

	Norway	Norway	Italy	Italy	France	France
TET • SS	0.653 (5.29)***		0.771 (1.799)*		0.717 (6.22)***	
TET • SB	0.554 (6.54)***		0.623 (2.570)**		0.449 (5.14)***	
TET • SI	0.819 (4.46)***		0.604 (1.924)*		0.437 (2.89)***	
TET • SD	0.698 (7.85)***		0.456 (1.910)*		0.555 (3.11)***	
TET • LC		0.654 (9.28)***		0.635 (2.567)**		0.490 (4.29)***
TET • HC		0.447 (3.33)***		0.568 (2.195)**		0.517 (6.31)***
RD_COUNTER	0.797 (5.82)***	0.258 (1.75)*	0.736 (2.766)***	0.765 (2.899)***	0.489 (4.46)***	0.465 (4.52)***
SIZE	0.551 (3.00)***	0.559 (3.14)***	0.679 (3.170)***	0.674 (3.218)***	-0.249 (-1.75)	-0.247 (-1.71)
COOP	9.137 (12.13)***	9.570 (12.53)***	5.923 (5.872)***	5.909 (5.178)***	8.353 (12.38)***	8.358 (11.97)***
Test of equality of coefficients of interaction variables	2.57	1.84	0.59	0.04	5.63	0.05
N	7046	7025	9185	9185	9093	9093

Summary and conclusions

Summary of hypotheses tests

	Norway	**Italy**	**France**	**Supported hypothesis**
Hypothesis 1 (probability to receive a TC)	Stronger in SB and SS	Stronger in SB and SS	Stronger in SB and SS	H1a: Greater probability in sectors with higher R&D orientation
Hypothesis 2 (probability to receive a TC)	Stronger in HC	Not significant	Stronger in HC	H2a: Greater probability in sectors with higher concentration
Hypothesis 3 (input additionality)	Stronger in SB and SS	Stronger in SB, SS and SI	Stronger in SB and SS	H3a: stronger additionality in sectors with higher R&D orientation
Hypothesis 4 (input additionality)	Stronger in HC in model 1 (mixed results in models 2 and 3)	Stronger in HC	Stronger in HC	H4a: stronger additionality in sectors with higher concentration
Hypothesis 5 (output additionality)	Stronger in SI (but differences across industries are not significant)	Stronger in SB, SS and SI (but differences across industries are not significant)	Stronger in SS and SD (but differences across industries are not significant)	Results differ across countries, and hypothesis tests are not significant
Hypothesis 6 (output additionality)	Stronger in LC (but differences across industries only significant in model 3)	Stronger in LC (but differences across industries are not significant)	Stronger in HC (but differences across industries are not significant)	Results differ across countries, and hypothesis tests are not significant

Two main findings (1)

- **On the role of the industry-specific R&D orientation:**

- Firms in sectors with a higher R&D orientation are on average more responsive to fiscal incentives than companies in industries where formal R&D is not the main innovation strategy.

- This pattern refers to both firms' propensity to apply to tax credits, and the related input additionality impacts

Two main findings (2)

- **On the role of sector-specific competition conditions:**

- Enterprises in high-concentration industries are more responsive to R&D fiscal incentives (higher propensity to apply and stronger input additionality)

- This may be due to the greater incentives that oligopolistic producers have to strengthen their market leadership by investing in innovation activities, and/or cumulativeness and persistence effects

Implications for policy

- Tax credits programmes tend to foster the growth of R&D investments relatively more in companies that have already strong technological capabilities

- This drives up the average R&D intensity of the economy, which is one major objective of this type of R&D policy in the first place

- However, this cumulative dynamics also leads to increasing polarization between market leaders and firms lagging behind the technological frontier, thus reinforcing market gaps and concentration levels over time

Future research

- This result is far from conclusive, though, since some recent studies indicate instead that it is companies in low-tech sectors and firms with liquidity constraints that benefit the most from R&D tax credits (Yohei, 2013)

- Before drawing well-founded policy implications, therefore, future research should produce much more extensive and systematic empirical evidence on the extent and reasons of cross-industry diffences in additionality effects

Thanks!

Appendix

Correspondence between NACE 2 and Pavitt's sectors

***Specialized suppliers manufacturing*:**
Machinery and equipment; medical, precision and optical instruments

***Science-based manufacturing*:**
Chemicals; office machinery and computers; electrical machinery and apparatus; radio, TV and communication equipment

***Scale-intensive manufacturing*:**
Rubber and plastic products; other non-metallic mineral products; basic metals; fabricated metal products; motor vehicles; other transport equipment

***Supplier-dominated goods*:**
Food and beverages; textiles; wearing; leather; wood and related; pulp and paper; printing and publishing; furniture; recycling