When Do R&D subsidies Boost Innovation? Revisiting the Inverted-U Shape

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Motivation

- Private and social solution differ in R&D activity due to capital market imperfections (asymmetric information) and possible lack of collateral
- All Western countries intervene in technology markets: Most widely used instruments are the R&D subsidies next to fiscal incentives
- Our main concern is whether effectiveness of R&D subsidies is conditional on the level of product market competition.

Motivation (cont'd)

- Aghion, Dewatripont and Rey (1999) analyse in an agency model of external finance how competition combined with a threat of liquidation might work as a disciplinary device for non-profit maximizing managers fostering technology adoption.
  - *Result:* substitutability btw external finance and competition at low levels of external finance and complementarity btw external finance and competition at high levels of external finance
  - *Policy suggestion*: [...] THIS PAPER WILL TEND TO ARGUE AGAINST ANY FORM OF "(UNMONITORED) SUBSIDIES" TO THE EXTENT THAT THESE MIGHT HAVE THE PERVERSE EFFECT OF INCREASING MANAGERIAL SLACK AND THEREBY SLOWING DOWN TECHNOLOGICAL ADOPTION. (P. 826)

This paper

- We start from the Schumpeterian literature on growth (Aghion, Howitt, Harris and Vickers (2001)) and consider step-by-step model of innovation.
- We introduce R&D subsidies into the standard model and look at the interplay between competition and R&D subsidies directly
- Theory suggests that R&D subsidies accelerate the rate innovation at all levels of PMC, but less so at high degrees of competition
- Our empirical findings are broadly consistent with this.

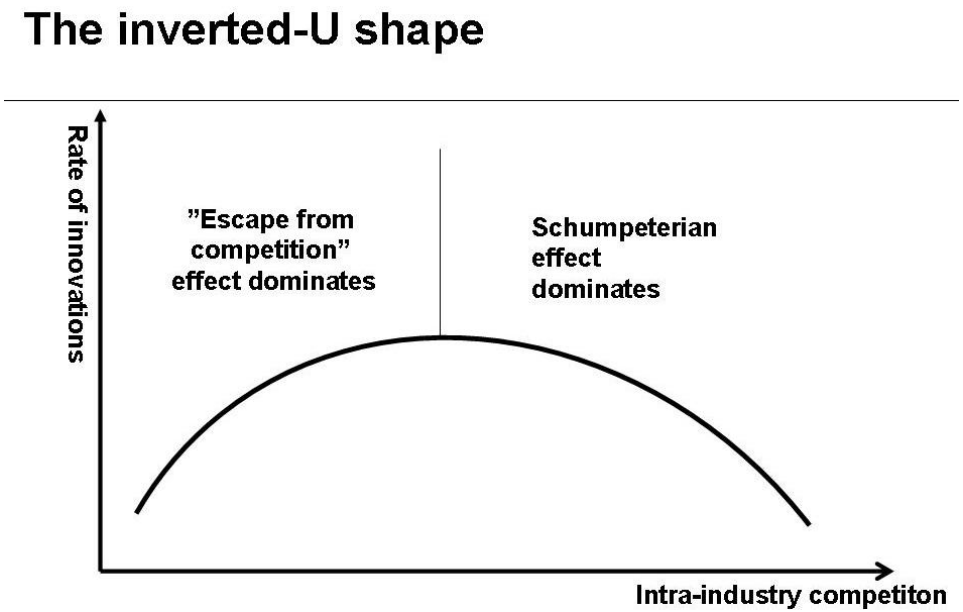
Road map

- Theoretical issues and hypothesis
- Data and empirical issues
- Results and policy implications

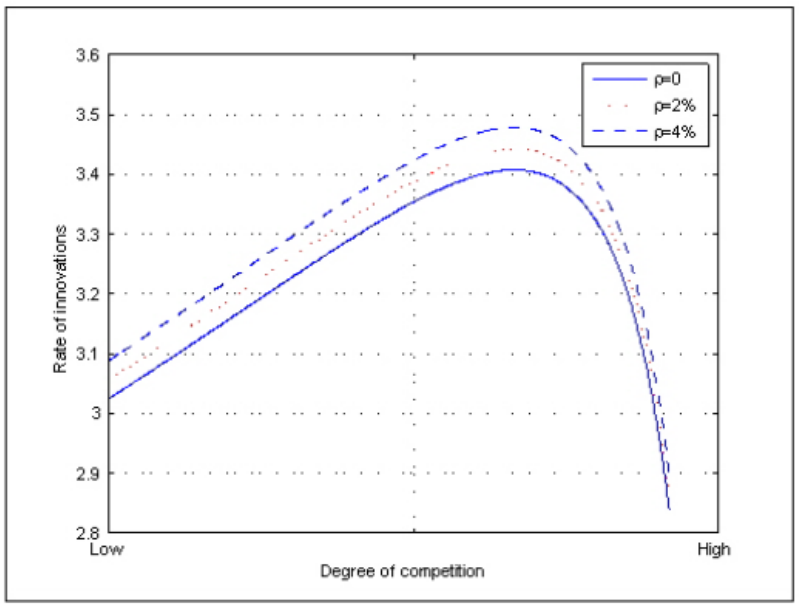
Theory background

- Industrial Organization and Schumpeterian Growth Theory:
- Schumpeter (1934)
  - Kamien and Schwartz (1974), Tirole (1988), ch. 10
  - Aghion, Harris, Howitt and Vickers (2001)
- "New" hypothesis: An inverted-U shaped relationship between competition and innovations

The inverted-U shape



Inverted-U shape with R&D subsidies



- ρ denotes subsidy. For $\rho = 2\%(4\%)$ firms receive a proportional subsidy which lowers the innovation costs by $2\%(4\%)$.

Theoretical predictions

- An inverted-U relationship between product market competition and the average rate of innovation
- R&D subsidies accelerate the rate innovation at all levels of PMC
- The Schumpeterian effect becomes more pronounced as R&D subsidies are introduced

Empirical issues

- Measurement issues
- The data
- Methods
- Results

Measurement

- INNOVATION intensity with patent counts (NBER patent data)
- COMPETITION with the industry level Lerner index
- R&D SUBSIDIES with the direct industrial R&D grants to product development admitted by the national technology agency (TEKES)

Endogeneity issues

- The Lerner index is potentially endogenous (fixed costs instead of variable costs driving the variation)
  - Instrumental variables: EU Single Market Program pre-1993 =0 and post-1992 period=1. Non-sensitive industries=0, sensitive=1
  - Investigations by Competition Authority. industry dummy variables codified as 0 when no investigation during that year and 1 when and investigation was made (190 investigations in manufacturing industries). investigations not necessarily leading to remedial action
  - Privatizations of 9 big publicly owned companies in 8 two-digit industries. Industry dummies, pre-privatization =0 and post-privatization=1

The Data

- We merged the data on R&D subsidies (TEKES register of financial decisions) with the NBER patent data file and plant level and firm level data sets from the Business Structures Unit (BSU) at Statistics Finland
- Data sets included from the BSU :
  - Accounting data (firm level), productivity and competition data (plant level), R&D panel (firm level) + key data containing all Finnish USPTO patent numbers and company codes enabling matching the NBER patent data to Finnish firm level data

The Data (cont'd)

- The final sample contains 3340 observations of 1487 manufacturing firms between years 1990 and 2001
- Industry classification based on two-digit SIC code
- Competition measure on industry level while patents and R&D subsidies on firm level

Econometric methods

- Exponential quadratic specification (Poisson)
- Interactions between competition and R&D subsidies

$$E\left[p_{ijt} \mid c_{jt-1}, \rho_{ijt-1}, x_{ijt-1}\right]$$
$$= \exp(\alpha + \beta_1 c_{jt} + \beta_2 \left(c_{jt-1}\right)^2 + \beta_3 \rho_{ijt-1} + \beta_4 c_{jt-1}\rho_{ijt-1}$$
$$+ \beta_5 \left(c_{jt-1}\right)^2 \rho_{ijt-1} + x'_{ijt-1}\gamma + \tau_t + \eta_j).$$

- i for firms, j for industries and t for time.
- c for patents, ρ for R&D subsidy, x for firm covariates and τ and η for time and fixed effects.
- Theory predictions: $\beta_1 > 0$, $\beta_2 << 0$. $\beta_3 > 0$, $\beta_5 < 0$.

Results - Inverted-U relationship

Dependent variable: Patents	I FE Poisson	II FE Poisson Smith-Blundell 2-step
Competition	48.5	24.6
s.e	(46.5)	(70.1)
Competition squared	-24.2	-14.1
s.e.	(25.9)	(37.1)
Firm and industry dummies	yes	yes
Observations	1271	1510

Results (cont'd)

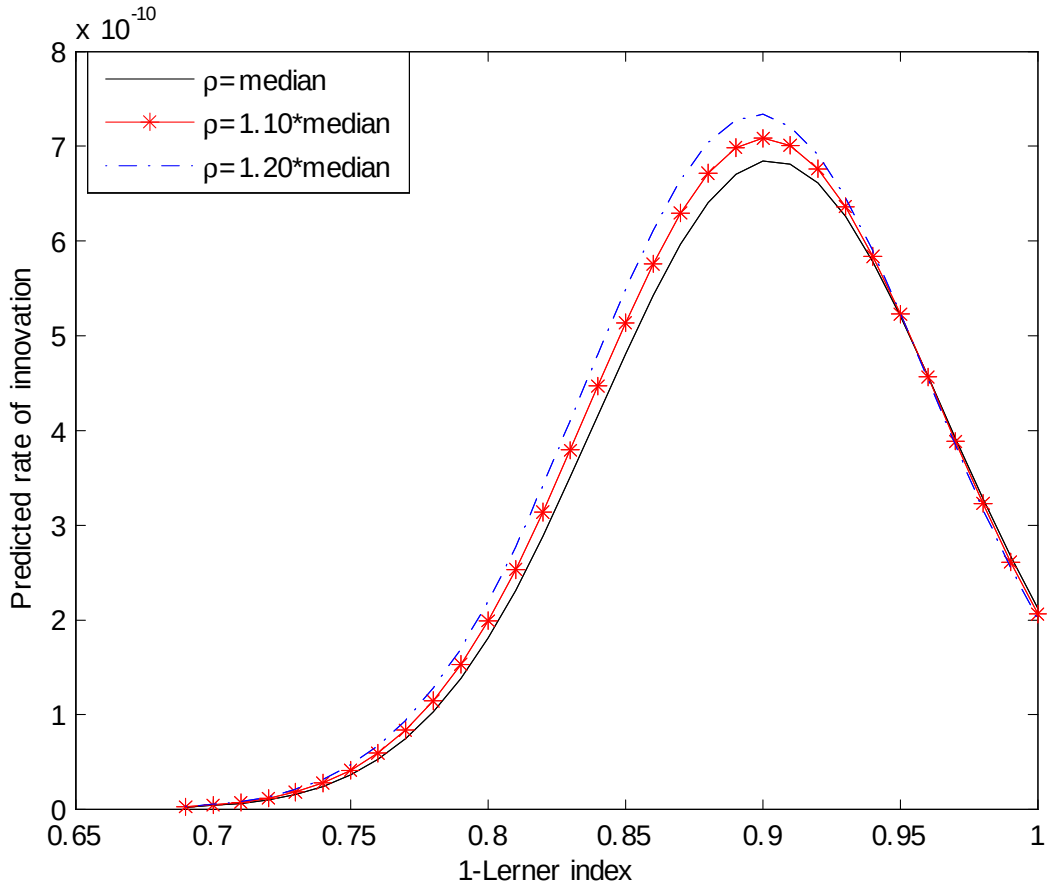
Dep variable: patents	I FE Poisson	II FE Poisson Smith-Blundell
Competition	148.2 (38.5)	232.3 (149.2)
Competition squared	-79.6 (21.4)	-125.4 (78.9)
R&D subsidy	9.9 (5.1)	25.3 (19.9)
R&D subs×competition	-10.6 (5.5)	-26.8 (21.7)
R&D subs ×competition sq.	-0.07 (0.18)	-0.16 (0.7)
Firm and industry dummies	yes	yes
Observations	854	835

Power of the instruments

First stage regression:	Competition
partial R-squared	0.15
F-test (df)	36.6(20)***

First stage regression:	Competition squared
partial R-squared	0.17
F-test (p-value)	41.8(20)***

Simulation of exponential quadratic specification



Conclusions - R&D

- R&D subsidy should accelerate innovation at different degrees of competition, but this effect should become smaller when competition is fierce.
- R&D subsididy therefore enhances the Schumpeterian effect of competition
- At low levels of profitability (due to fierce competition) R&D subsidies do not have the desired effect
  - in line with the Aghion et al. (1999) model where leverage and competition have a complementary effect on effort at high levels of external finance