The Impact of Market Regulation and Distance to Frontier on Innovation and Productivity

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Motivation

- Lisbon strategy: make the EU the most competitive knowledge-based economy.
- Rationale: more product market competition (less regulation) should bolster innovation and thus productivity and (ultimately) economic growth.
- However, economic research (both theoretical and empirical) suggests that there remain ambiguities in the relationship between competition and innovation.
- The present research re-examines this relationship empirically, using an original application of the "CDM" econometric framework linking R&D, innovation and productivity.

Summary of the presentation

- Review of the (theoretical and empirical) literature on competition and innovation
- Econometric modelling and data: from the knowledge production function to the CDM framework
- Preliminary results
- Conclusion

Competition and innovation

- Post-Schumpeterian economics generally expect an inverted-U relationship between competition and innovation.

- This inverted-U relationship is supported in many empirical studies (e.g., Scherer, 1965, *AER*; Acs and Audretsch, 1987, *Rev. Econ. Statist*.; Cohen and Levin, 1989; Baldwin et al. 2002, Aghion et al. 2005).

- However, Boone (2001) explains that a non-monotone relation between competition and innovation does not necessarily imply, for a particular market, that an increase in the former improves firms' incentives to innovate (Boone, 2001, *IJIO*, p. 16).

The inverted-U relationship

- Aghion et al. (2005), *QJE,* model the aforementioned inverted-U relationship as resulting from a positive "escape competition" effect and a negative "Schumpeterian" effect

- They consider an economy w/ levelled ("neck-and-neck") and unlevelled industries

- Under the (critical) assumption of automatic catch-up by the follower in unlevelled industries, they show that the "escape competition" effect dominates in levelled industries whereas the "Schumpeterian" effect dominates in unlevelled ones

- In other words, in this framework, innovation tends to increase w/ competition in levelled industries, and to decrease w/ competition in unlevelled ones.

Distance to frontier

- Aghion et al. (2005)'s model predicts that the "escape competition" effect tends to be stronger in industries that are closer to the technological frontier.
- In other words, competition should increase innovation in industries that are closer to the technological frontier
- However, using OECD industry-level data, Amable et al. (2010) find that product market regulation tend to increase innovation in industries that are closer to the technological frontier
- They show that this empirical result, which contradicts the above prediction, can be theoretically grounded if one includes interactions between leader and follower’s innovation in Aghion et al. (2005)'s model.

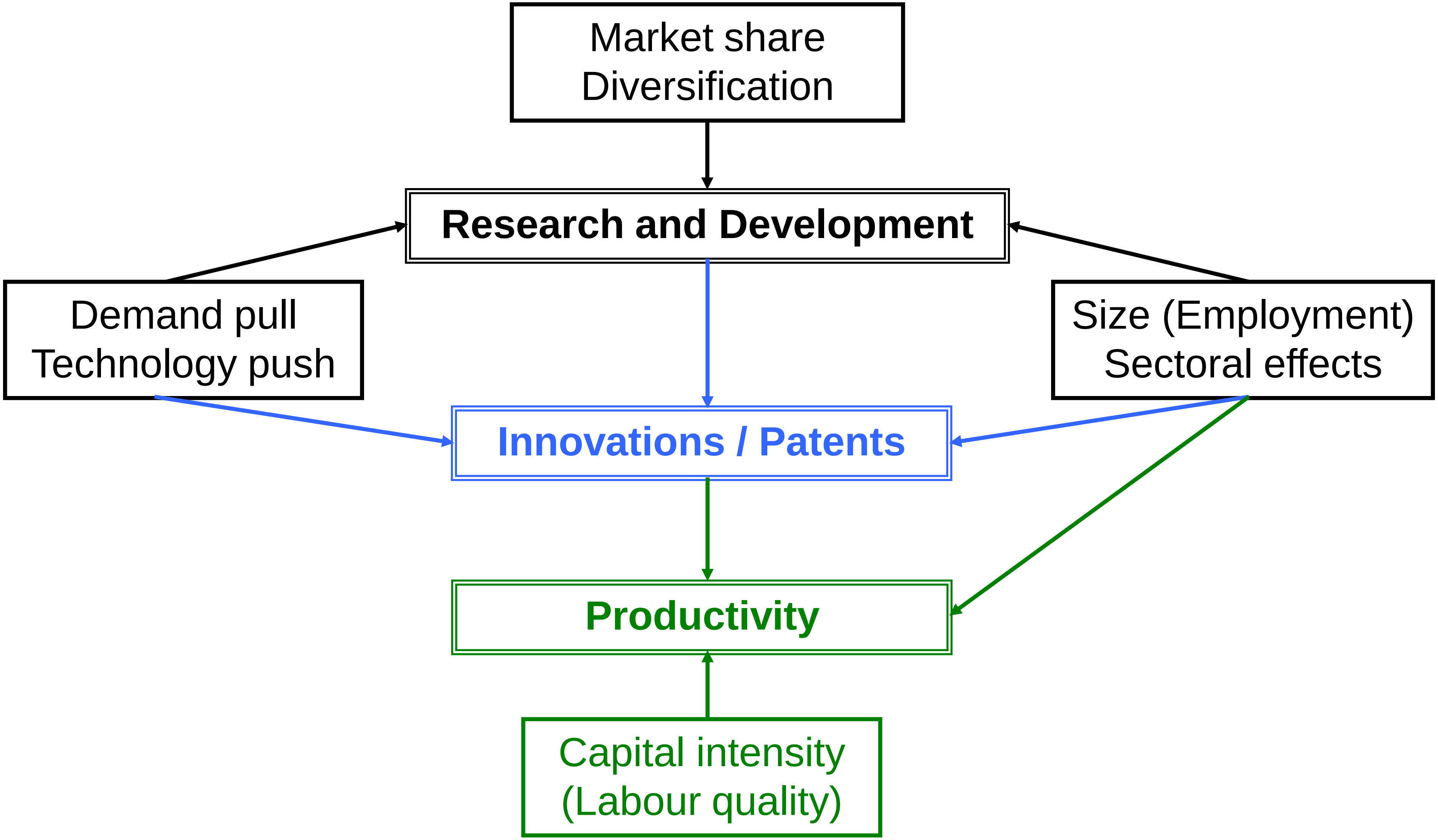
What we do

- We check whether Amable et al. (2010)'s conclusions, derived from the estimation of a knowledge production function, still hold in a broader framework linking R&D, innovation and productivity.
- The so-called "CDM" model (from Crépon, Duguet, Mairesse, 1998, *Econ. Innov. New Tech*) provides such a framework, primarily for firm-level data.
- We adapt the specification of this model to a panel of industries similar to the one used in Amable et al. (2010), to re-examine how product market regulation and distance to frontier influence the R&D – Innovation – Productivity relationship.

What we find

- A positive effect of product market regulation on R&D expenditures in industries that are closer to the world technological frontier
- A positive effect of R&D expenditures on innovation (measured by patenting intensity) in the leading industries
- A positive (negative/insignificant) effect of patenting on productivity in the leading (laggard) industries.

The original CDM model (firm-level)



Applications of the CDM model

Reference	Data	Specification	Estimation
Crépon, Duguet, Mairesse, 1998, *Econ. Innov. New Tech.*	Cross section (CIS)	Type II Tobit + linear/count models	LIML + ALS
Griffith, Huergo, Peters, Mairesse, 2006, *Oxford Rev. Econ. Pol.*	Cross section (CIS)	Type II Tobit + Probit + linear model	LIML
Benavente, 2006, *Econ. Innov. New Tech.*	Cross section (CIS-type)	Type II Tobit + ordered Probit + linear model	LIML + ALS
Chudnovsky, Lopez, Pupato, 2006, *Res. Pol.*	Panel data	Logit w/ FE + multinomial Logit + linear models w/ FE	LIML
OECD, 2009	Cross section (CIS-typ)	Type II Tobit + linear models	LIML
Raymond *et al.*, 2009, CIRANO WP	Panel data	RE multivariate Tobits	FIML

Our application

- So far, the "CDM" model has been estimated on microeconomic data only.

- However, if the "knowledge production function" can be applied to various economic units (Mairesse and Mohnen, *AER*, 2002), the same must be true of the "CDM" model.

- Applying the CDM model to a panel of industries:
  - requires one to rethink the choice of variables
  - limits missing observations problems
  - allows one to specify the model using three linear equations
  - allows one to use FE estimation

Data sources

- EU KLEMS data on output, input and productivity measures (http://www.euklems.net; O'Mahony and Timmer, 2009).
- Data on patenting from EUROSTAT
- Regulation proxies computed by the OCDE
- R&D stock provided by EUKLEMS-Linked data (O'Mahony et al., 2008)
- We keep a balanced panel of 13 industries observed across 13 countries (i.e. 169 industry-country) over 24 years (1980-2003)

The EUKLEMS industry panel

- Unit of analysis: industry-country *i*, observed at time *t* :

Industry	
Code	**Name**
15-16	Food, Beverages and Tobacco
17-19	Textile, Leather and Footwear
20	Wood, Wood and Cork Products
21-22	Pulp and Paper, Printing and Publishing
23	Coke, Refined Petroleum and Nuclear Fuel
24	Chemicals and Chemical Products
25	Rubber and Plastic
26	Other Non-Metallic Minerals
27-28	Basic Metal and Fabricated Metal
29	Machinery
30-33	Eletrical and Optical Equipment
34-35	Transport Equipment
36-37	Other Manufacturing, Recycling

Country
Australia
Denmark
Finland
France
Germany
Ireland
Italy
Japan
Netherlands
Spain
Sweden
United Kingdom
USA

Key variables

- **R&D intensity:** R&D stock on total (employees) hours worked
- **Patenting intensity:** # of patents on total hours worked
- **TFP:** computed based on value-added

- **MHS:** # of Medium/High Skill labour hours worked in the industry
- **ext:** patenting externalities (patenting intensity in other industries-countries)
- **regimp:** importance of product market regulation (OECD Index)

Econometric modelling

- According to Aghion et al. (2005), what matters is the difference between pre- and post-innovation rents: "*competition may increase the incremental profits from innovating, and thereby encourage R&D investments aimed at "escaping competition"* ".
- To take this into account, we specify an econometric model in which product market regulation impacts R&D but not the output of the innovation process.
- We let R&D affect the output of the innovation process (measured by patenting intensity), which in turn may affect TFP

Specification and estimation

- Our model is specified as a three equation system:

$$\begin{cases} \ln RD_{it} = \alpha_0 + \alpha_1 \ln ext_{it} + \alpha_2 \ln MHS_{it} + \alpha_3 \ln regimp_{it} + \nu_{1t} + u_{1i} + \omega_{1it} \\ \ln patents_{it} = \beta_0 + \beta_1 \ln RD_{it} + \beta_2 \ln ext_{it} + \beta_3 \ln MHS_{it} + \nu_{2t} + u_{2i} + \omega_{2it} \\ \Delta \ln TFP_{it,t-1} = \gamma_0 + \gamma_1 \ln patents_{it-1} + \gamma_2 \ln patents_{it-2} + \gamma_3 \ln patents_{it-3} + \nu_{3t} + u_{3i} + \omega_{3it} \end{cases}$$

with ν_{kt} = year FE, u_{ki} = individual FE, ω_{kit} = error term (k = 1,2,3). Note that *RD* = R&D intensity and *patents* = patenting intensity.

- The first two equations are estimated as an IV system with FE

- The third equation is estimated as an additional FE regression using the predicted value of patenting intensity as a covariate (standard errors are bootstrapped).

Measuring distance to frontier

- We estimate the above system separately for industries that are closer to the world technology frontier (hereafter "leaders") and for those that are further away from the frontier (hereafter "followers")
- We define "leaders" as industries where the TFP is above a certain quantile of the global TFP distribution (Q50, Q60, Q75)
- We define "followers" as industries where the TFP is below a certain quantile of the global TFP distribution (Q50, Q40, Q25)
- In what follows, we take as our benchmark the estimates obtained with the definition of leaders/followers based on Q50.

Benchmark results: leaders

	log R&D intensity	log patenting intensity	TFP growth
log ext	0.351***	0.482***	—
	(0.071)	(0.08)	
log MHS	0.349***	0.994***	—
	(0.06)	(0.063)	
log regimp	0.802***		—
	(0.087)		
log RDint	—	0.634***	—
		(0.103)	
log patents $_{t-1}$ (predicted)	—	—	-0.017
			(0.017)
log patents $_{t-2}$ (predicted)			-0.027
			(0.026)
log patents $_{t-3}$ (predicted)			0.050**
			(0.024)
Constant	3.066***	-6.663***	0.037***
	(0.312)	(0.34)	(0.013)
Year dummies	Yes	Yes	Yes

Benchmark results: followers

	log R&D intensity	log patenting intensity	TFP growth
log ext	0.287***	0.887***	—
	(0.101)	(0.115)	
log MHS	0.881***	1.201***	—
	(0.072)	(0.244)	
log regimp	-0.370***		—
	(0.115)		
log RDint	—	-0.003	—
		(0.263)	
log patents $_{t-1}$	—		0.063**
(predicted)			(0.025)
log patents $_{t-2}$			0.023
(predicted)			(0.041)
log patents $_{t-3}$			-0.071*
(predicted)			(0.039)
Constant	-1.348***	-5.326***	-0.070**
	(0.416)	(0.343	(0.036)
Year dummies	Yes	Yes	Yes

Closer to the frontier…

	>Q50	>Q60	>Q75
Effect of log regulation on log R&D intensity	0.802***	0.804***	1.011***
	(0.087)	(0.091)	(0.118)
Effect of log R&D int on log patenting	0.634***	0.716***	0.866***
	(0.103)	(0.113)	(0.117)
Effect of patenting at t-1 on TFP growth	-0.017	0.024	0.008
	(0.017)	(0.023)	(0.01)
Effect of patenting at t-2 on TFP growth	-0.027	-0.057	-0.005
	(0.026)	(0.046)	(0.013)
Effect of patenting at t-3 on TFP growth	0.050**	0.045	0.007
	(0.024)	(0.035)	(0.009)

Further away from the frontier…

	<Q50	<Q40	<Q25
Effect of log regulation on log R&D intensity	-0.370***	-0.374***	-0.084
	(0.115)	(0.132)	(0.186)
Effect of log R&D int on log patenting	-0.003	-0.458	-2.38
	(0.263)	(0.375)	(6.064)
Effect of patenting at t-1 on TFP growth	0.063**	0.172***	0.012
	(0.025)	(0.061)	(0.018)
Effect of patenting at t-2 on TFP growth	0.023	-0.011	-0.033
	(0.041)	(0.062)	(0.021)
Effect of patenting at t-3 on TFP growth	-0.071*	-0.095**	0.033**
	(0.039)	(0.045)	(0.014)

Main findings

- Using a panel of industries, we examined the impacts of:
  - product market regulation on R&D
  - R&D on innovation
  - innovation on TFP growth
- A separate analysis for industries that are closer to / further from the world technology frontier reveals that:
  - Product market regulation has a positive (negative) impact on R&D expenditures closer to (further away from) the frontier
  - In "leader" industries, innovation intensity increases with R&D intensity, and feeds the growth of TFP

Conclusions

- We find the expected virtuous circle between R&D, innovation and economic growth
- However, our results suggest that the way distance to frontier affects the relationship between competition and R&D expenditures remains ambiguous
- In particular, our preliminary results show a positive effect of product market regulation on R&D closer to the technology frontier

Further research and implications

- We need to conduct extended robustness checks of our results (e.g., GMM, simultaneous estimation)
- Provided that they are robust, they suggest that deregulation should not be expected to systematically improve the R&D effort
- This would be in line with some industry-specific studies (e.g. Jasmab and Pollitt, *Res. Pol.,* 2008)
- Therefore, deregulation as a policy instrument should be considered on a case-by-case basis rather than systematically.