DO RESOURCES FLOW TO PATENTING FIRMS? CROSS-COUNTRY EVIDENCE FROM MICRO DATA

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OECD
BETTER POLICIES FOR BETTER LIVES

Motivation

- Innovation contributes to aggregate productivity growth
- Innovation (patenting) has positive effects at firm level (e.g. Hall et al., 2005)
  - Balasubramanian and Sivadasan (BS - 2011) using US Census data for manufacturing for 1975-1997 find that increases in patent stock are associated with increases in firm size, scope, skill and capital intensity
  - Kogan et al. (2012) also find a strong stock market response to news about patents

Allocative efficiency

- **The flow of resources** across firms contributes to aggregate productivity growth.
- In turn, the **incentives to invest in patents and innovation** at the firm level are partly determined by the efficiency of resource reallocation mechanisms
- Very limited cross-country evidence .
- **Public policies** can significantly affect the degree of static and dynamic allocative efficiency (Bartelsman et al., 2013; Andrews and Cingano, 2012; Bravo-Biosca et al., 2013).

Our contributions

- We broaden BS's analysis using ORBIS firm-level data matched with PATSTAT
  - Up to 20 countries
  - Whole economy
- We address causality building an IV based on litigation data (preliminary)
- We look at patents granted by different offices; patent families; group-level patents
- We compare the different magnitude of these estimates across countries
- We assess the role of national policies and framework conditions in explaining cross-country differences

Key results

- A 10% increase in patent stock is associated with a 1% increase in labour, 1.3-1.5% increase in capital, 1.2% in turnover, 0.5% in value added
- the positive impact of patenting on firm size is likely to be causal (preliminary!)
- There are significant differences across OECD countries in the magnitude of these estimates
  - 4x-6x bigger in the US, SE, BE as compared to JP, FI, DN
- National framework conditions matter

Matched firm-patent data

- ORBIS: firm-level (balance sheet) commercial database, restricted to unconsolidated accounts
- PATSTAT: detailed information on patent applications for over 80 patent offices.
  - Main measure of patent stock: cumulative sum of EPO-PCT-USTPO granted patents since 1980, depreciated at 15% p.a.
- Matching ORBIS-PATSTAT: OECD HAN database
- Period of analysis: 2003-2010
- Size threshold: 20 employees in 2003 or at the time of first appearance if the dataset if >2003

Caveats on data

- ORBIS is a commercial databases which has some issues
  - Non representative at aggregate level
  - Likely a selected sample: need to assume that sample selection is uncorrelated with conditional (on size, country, sector, etc) patenting probability
- Patents are allocated to the firms based on fuzzy matching, we expect substantial measurement error
  - We restrict the analysis to countries where the matching ratio is good
- There is not a 1:1 correspondence between patents and innovation
- Measurement of policies is based on synthetic indicators (OECD and World Bank)

Descriptive evidence

	Non patentees			Patentees			Differ.
	Mean	Std Dev	Number	Mean	Std Dev	Number	
Log employment	4.005	0.001	3,178,153	5.053	0.002	215,842	1.048***
Log real capital stock	6.606	0.001	3,142,980	8.232	0.004	213,781	1.626***
Log real capital stock per employee	2.601	0.001	3,142,980	3.178	0.004	213,781	0.577***
Log total turnover	8.982	0.001	3,097,633	10.454	0.003	209,868	1.472***
Log labour productivity (turnover)	4.969	0.001	2,216,694	5.366	0.002	151,240	0.398***
Log labour productivity (value added)	3.645	0.001	3,069,738	4.073	0.002	207,706	0.428***

Base model

$$\ln(y_{ijct}) = \beta \bullet \ln(Patstock_{ijct} + 1) + \eta_i + \mu_{jct} + \varepsilon_{ijct}$$

where: y_{ijct} is log input/output for firm i, in industry j, country c in period t, $PatS_{ijct}$ is the patent stock (EPO, USTPO, PCT), η_i is a firm F.E., μ_{jct} are industry-country-year F.E.

- β is the estimated *sensitivity* of firm employment to the patent stock, relative to the country-industry-year average.
- Robustness/extensions
  - patent families, other patent offices, group-level patents, extensive/intensive margin, heterogeneous effects (young vs. old)

Base model: results

	Empl.	Capital Stock	Capital/ Empl.	Turnover	Value added
Patent stock (firm)	0.103***	0.135***	0.0316***	0.121***	0.0532***
	(0.007)	(0.012)	(0.009)	(0.009)	(0.008)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Country-nace2-year f.e.	Yes	Yes	Yes	Yes	Yes
Number of observations	2,513,056	2,477,119	2,477,119	2,449,575	1,549,659
Patent stock - Families (firm)	0.107***	0.153***	0.045***	0.111***	0.0628***
	(0.009)	(0.013)	(0.011)	(0.010)	(0.009)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Country-nace2-year f.e.	Yes	Yes	Yes	Yes	Yes
Number of observations	2,513,056	2,477,119	2,477,119	2,449,575	1,549,659

Robust standard errors in parenthesis clustered at firm level. Patent stock includes patents granted by the USTPO, the EPO, and the WIPO under the PCT convention. The patent stock is calculated as the log(X+1) where X is the cumulated number of granted patents since the 1980 depreciated at the rate 15% per year.

Group-level patents

	Emp	Capital Stock	Capital/ Empl.	Turnover	Value added
Patent stock (firm)	0.103***	0.135***	0.032***	0.121***	0.053***
	(0.007)	(0.012)	(0.009)	(0.009)	(0.008)
Patent stock (group)	0.005***	0.004***	-0.00137	0.0057***	0.003***
	(0.0005)	(0.001)	(0.0009)	(0.0006)	(0.0007)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Country-nace2-year f.e,	Yes	Yes	Yes	Yes	Yes
Number of observations	2,513,056	2,477,119	2,477,119	2,449,575	1,549,659

Note: Robust standard errors clustered at the firm level in parenthesis. Pat. stock includes patents granted by the USTPO, the EPO, and the WIPO under the PCT convention. The patent stock is calculated as the log(X+1) where X is the cumulated number of granted patents since the 1980 depreciated at the rate 15% per year.

Potential endogeneity

- Unobserved heterogeneity or omitted variables might drive the positive association between patenting and firms' activity, e.g.:
  - firms endowed with a more skilled workforce or better management might patent more, and at the same time grow more
  - reverse causality: firms that manage to attract more resources might be able to convey some of these resources into their patenting activity
- Measurement error may lead to attenuation bias

Addressing causality

- valid IV strongly correlated with patenting activity at firm level conditional on firm FEs
- IV for depreciated patent stock at the firm-year level based on litigation data
- Idea: the perceived exposure to litigation in technological fields in which a firm is specialized influences negatively the firm's propensity to patent
- Assumption: litigation risks does not affect the firm's activity through other channels

Building the IV

- $IV_{it} = \sum_k share_{ikt_0} * Litig\_prop_{kt}$

  Where

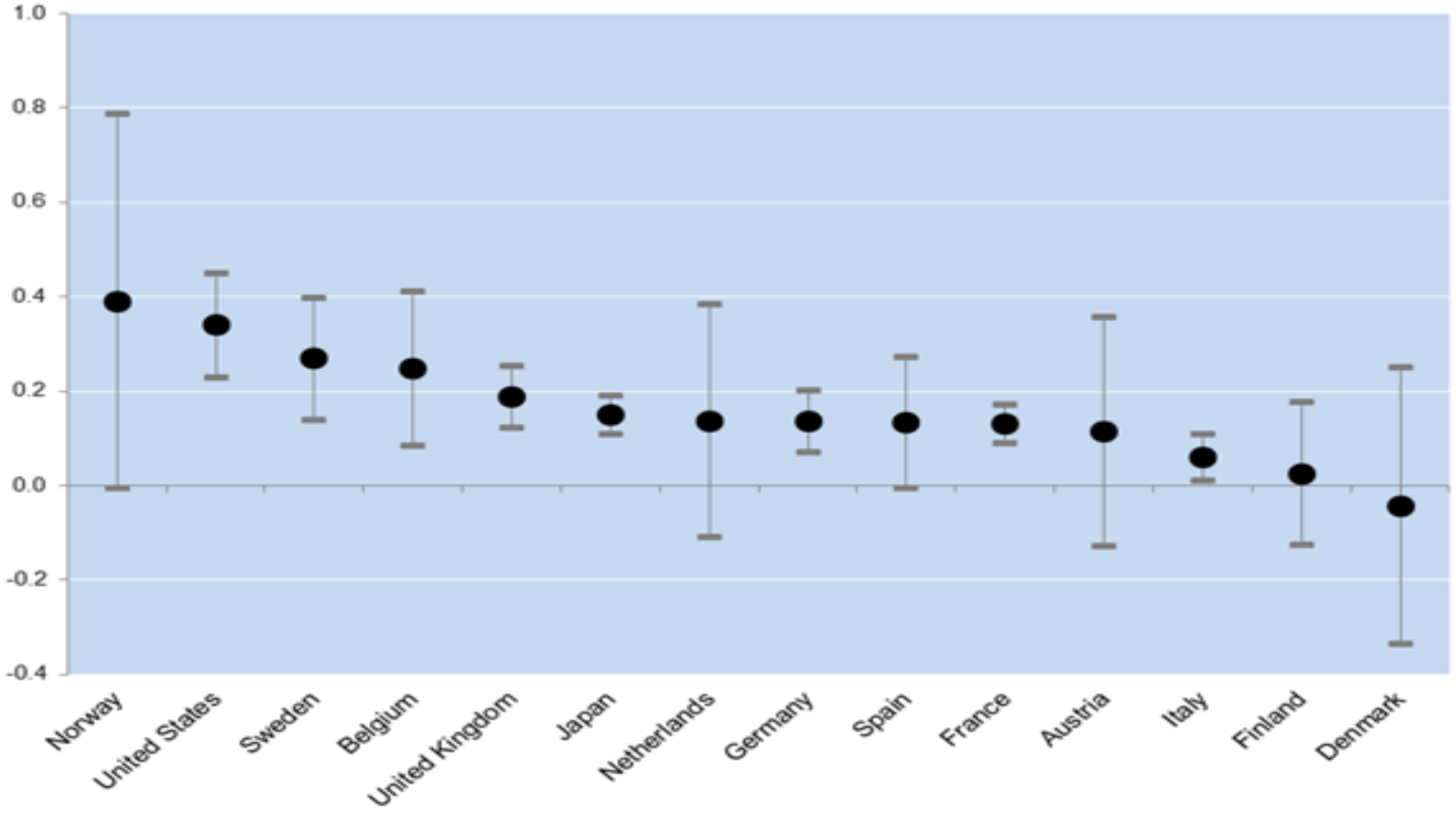
  - *Litig_prop* is the share of patents litigated in a given year in all patents applied for in the same years
  - *share* is the firm-level share of patents in each 4-digit IPC class *k* before 2003 relative to all firm patents

- Litigation data comes from a commercial database maintained by Darts-IP, used in Graham and van Zeerbroeck (2011)

IV results are in line with OLS estimates

	Employment	Capital Stock	Capital/ Empl.	Turnover	Value added
Patent stock (firm)	0.625**	0.779**	1.113*	0.178	0.625**
	(0.278)	(0.372)	(0.600)	(0.381)	(0.278)
Firm fixed effects	YES	YES	YES	YES	YES
Country-year fixed effects	YES	YES	YES	YES	YES
Number of observations	72,905	72,700	72,700	70,929	40,809
FIRST STAGE (Dependent variable: Patent stock)					
Patent litigation propensity	-1.788***	-1.76***	-1.763***	-1.74***	-1.157**
	(0.384)	(0.384)	(0.384)	(0.397)	(0.481)
Kleibergen-Paap Wald F	21.64	21.02	21.02	19.24	5.785
OLS ESTIMATION					
Patent stock (firm)	0.0973***	0.126***	0.0294***	0.099***	0.0518***
	(0.0075)	(0.0118)	(0.0098)	(0.009)	(0.008)

Country-specific OLS effects (capital)



Note: Country-specific sensitivity of employment to patent family stock, obtained by interacting the patent stock variable with a full set of country dummies. Bars report 10% confidence intervals.

The effect of policies

$$y_{ijct} = \beta \cdot PatS_{ijct} + \gamma \cdot PatS_{ijct} * Policy_{ct} + \varphi \cdot PatS_{ijct} * Out\_FDI_{ct} +$$
$$+ \theta \cdot PatS_{ijct} * GDP_{ct} + \eta_i + \mu_{jct} + \varepsilon_{ijct}$$

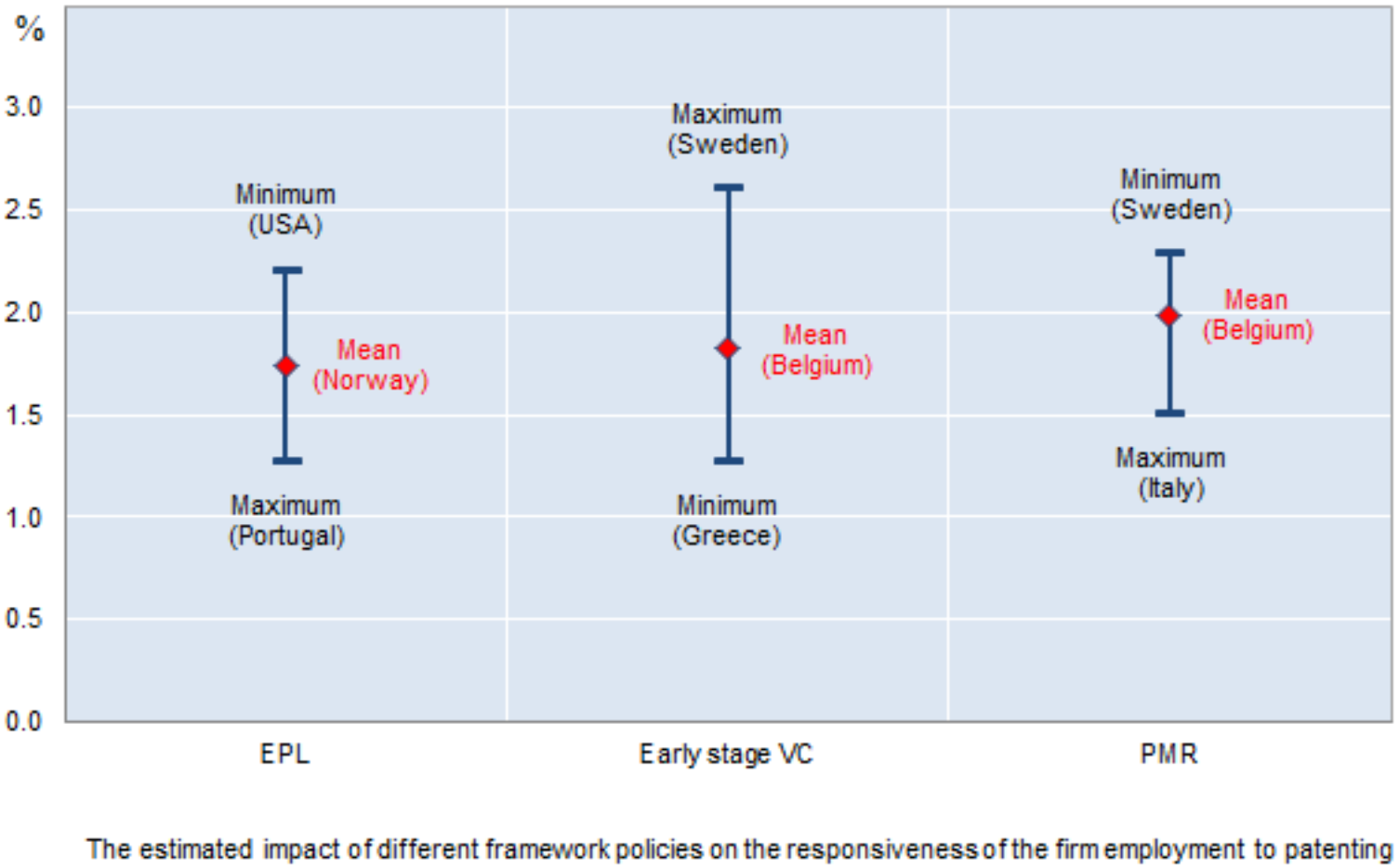
- results suggest that sensitivity of employment or capital to patent stock changes is higher in economies characterised by:
  - Less stringent EPL and bankruptcy legislation
  - A better investors protection
  - More efficient judicial systems
  - More developed seed and early stage venture capital markets
- The effect is generally much stronger for young firms
- Robust to controlling for openness (outward FDI) and size (GDP)

The effect of policies: results

Policy	Employment	Capital
Enforcing contracts cost	– ***	– **
Closing business cost	– **	– **
Product market regulation	– *	–
Empl. protection legislation	– ***	– *
Stock market capitalization	+ **	+ **
Early stage finance	+ **	+ ***
Expansion finance	=	+ *

Note: the table reports the sign of the coefficient of the patent stock interacted with the policy variable. Regressions are run separately.

Change in firm employment associated with a 10% change in the patent stock



The estimated impact of different framework policies on the responsiveness of the firm employment to patenting

Note: the chart shows that the sensitivity of firm employment to changes in the patent stock varies according to the policy and institutional environment.

Robustness/extensions

- Heterogeneous effects
- Alternative measures of patent stocks (families, national offices, etc.)
- Group-level patents
- Intensive/extensive margins only
- Natural values rather than log+1
- Effects of policies with country-sector diff-in-diff
- Propensity score matching analysis of first-time patentees

Thanks for your attention

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ADDITIONAL SLIDES

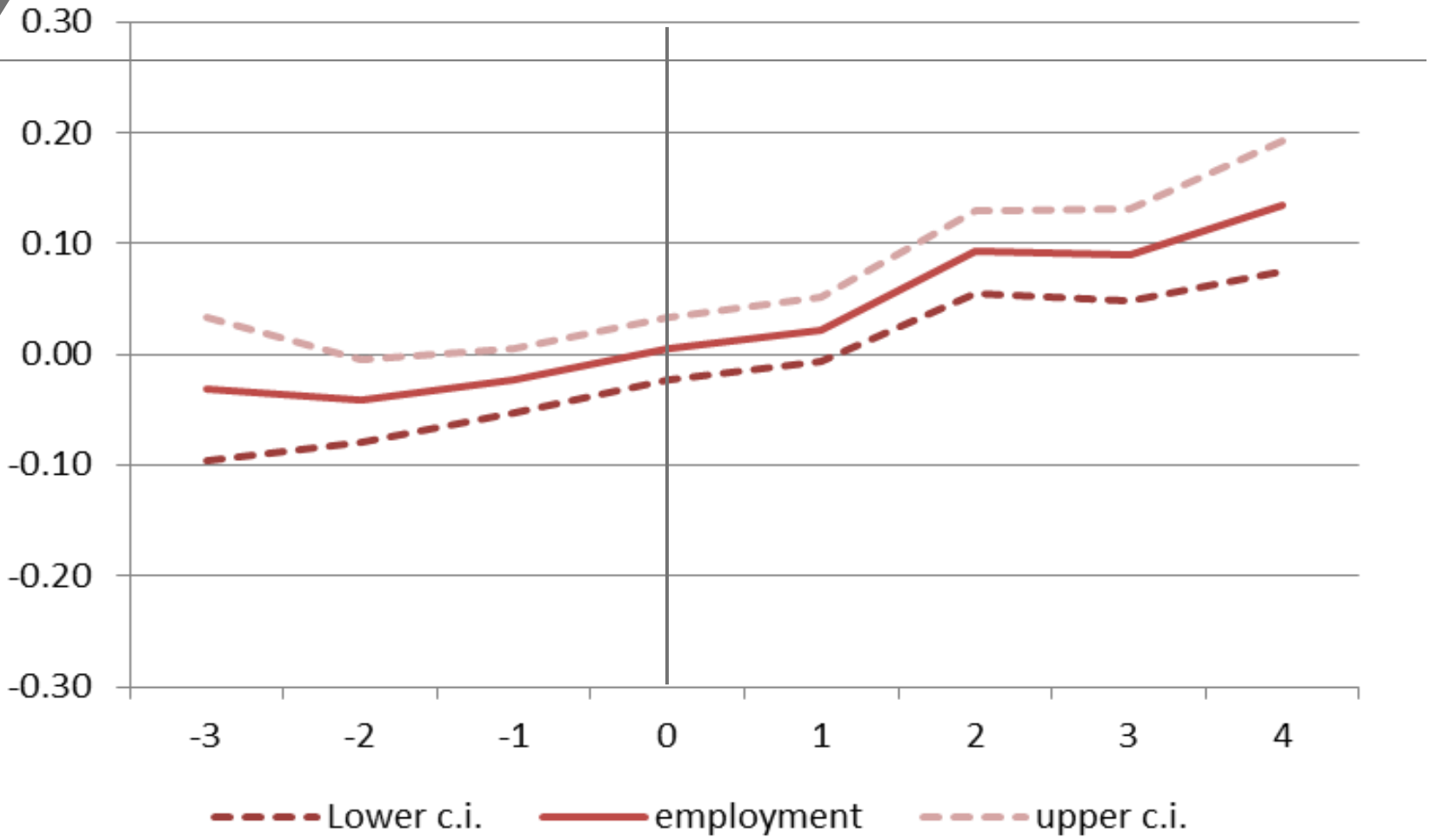
Propensity score matching

- Following B&S (2011), we implement a matching exercise aimed at
  - Assessing the extensive margin effect
  - establishing the timing of the patent effect
  - testing for "pre-treatment" differences
- We match every patentee with the "most similar" non-patentee within the same year, 3-digits sector, and country.
  - Similarity based on treatment propensity estimated on employment, capital, and turnover the year before the 1st patent

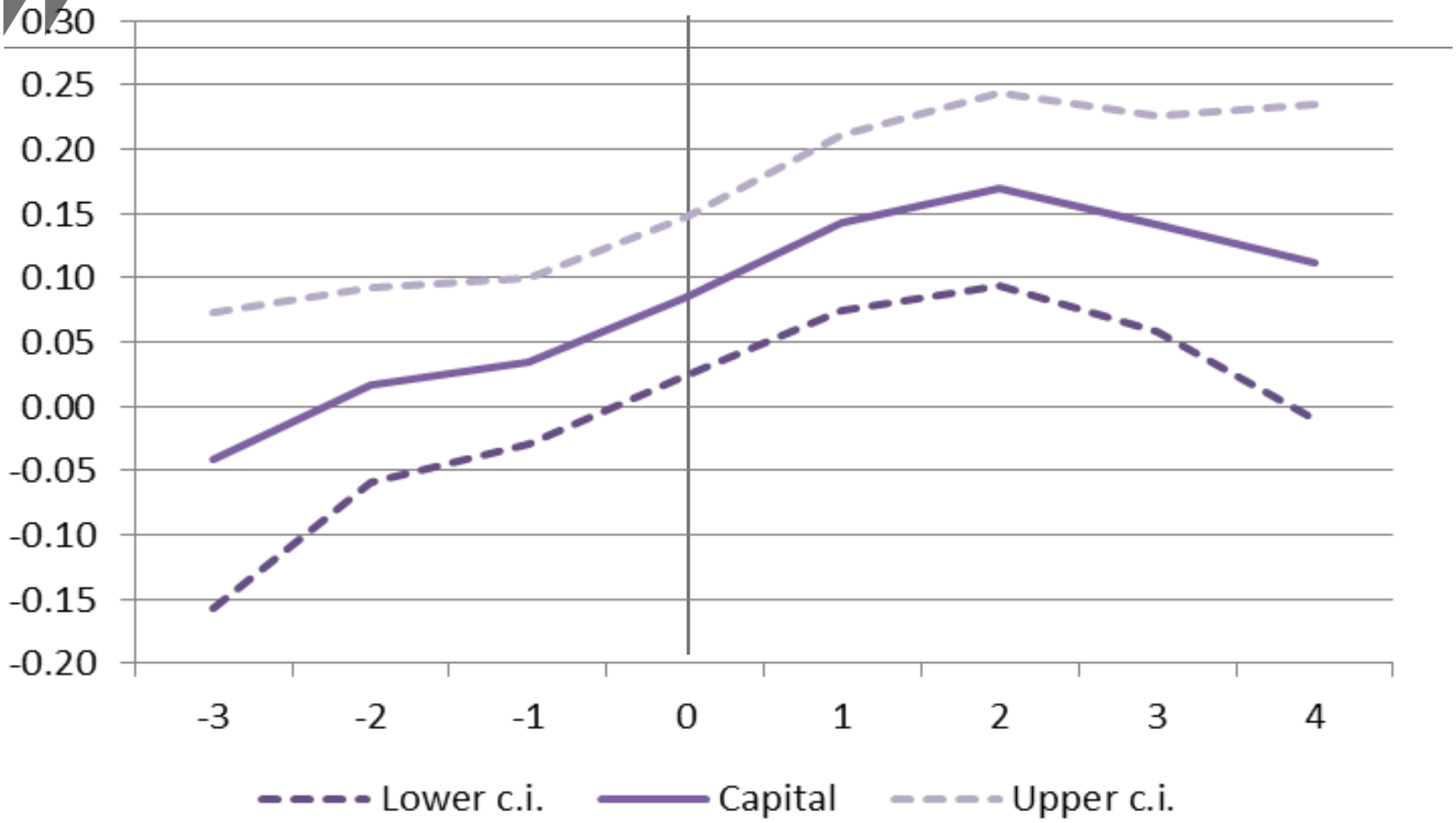
Propensity score matching: results

	Employment	Capital	Turnover
Patentees dummy x first patent year – 3	-0.0314	-0.0419	0.0540
	(0.0391)	(0.0702)	(0.0531)
Patentees dummy x first patent year – 2	-0.0421*	0.0173	0.0161
	(0.0230)	(0.0462)	(0.0239)
Patentees dummy x first patent year – 1	-0.0235	0.0350	0.0358*
	(0.0175)	(0.0397)	(0.0194)
Patentees dummy x first patent year	0.00522	0.0855**	0.0581***
	(0.0170)	(0.0377)	(0.0194)
Patentees dummy x first patent year + 1	0.0223	0.143***	0.0982***
	(0.0176)	(0.0419)	(0.0216)
Patentees dummy x first patent year + 2	0.0922***	0.169***	0.154***
	(0.0230)	(0.0455)	(0.0259)
Patentees dummy x first patent year + 3	0.0899***	0.142***	0.129***
	(0.0256)	(0.0508)	(0.0299)
Patentees dummy x first patent year + 4	0.134***	0.112	0.128***
	(0.0358)	(0.0747)	(0.0475)
Year fixed effects	YES	YES	YES
Index year fixed effects	YES	YES	YES
Number of observations	9,233	9,233	9,233

Propensity score matching: employment



Propensity score matching: capital



Country-sector diff-in-diff

- based on the assumption that some industries have 'naturally' higher exposure to a given policy than other industries
- the term (lnPatS*P) is interacted with a relevant index of sectoral exposure (E) to the policy at hand, to form a triple interaction term in the following model:

$$\ln Y_{isct} = \sum_j \delta_1^j \ln(PatS_{isct}) * P_{ct}^j * E_s^j + \delta_2 \ln(PatS_{isct}) * C_c + \delta_3 \ln(PatS_{isct}) * S_s$$
$$+ \eta_i + \mu_s + \gamma_c + \rho_t + \varepsilon_{isct}$$

- includes country (C) and sector (S) dummies (C); firm fixed effects; sector, country and year fixed effects; the parameter of interest is δ_1
- Results are confirmed