

More of the same or something different?
Technological originality and novelty in public
procurement-related patents

Emilio Raiteri



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- In this work I aim at assessing the degree of novelty of patents induced by public procurement contracts between the US federal government and private corporations
- While substantial amount of studies investigated the originality of specific kind of patents no work has focused on procurement related patents
- This work tries to fill this gap, using both traditional measures based on patent citations and new variables based on patent classification
- Outline: 1.Theoretical framework and hypothesis; 2.Data and Method; 3.Results; 4. Preliminary conclusions

1.Theoretical framework

Innovative public procurement as a 'de facto' technology policy

- Demand-pull hypothesis: Schmookler (1962) and Kaldor (1966).
- The demand side approach has regained attention and also the debate on the role of public demand in fostering innovation has been revitalized
- Innovative Public Procurement defined as purchasing activities carried out by public agencies that lead to innovation
- IPP is increasingly acknowledged as an actual innovation policy both from scholars and politicians
- Theoretical side: Edquist (2000), Edler and Georghiou (2007)
- Growing empirical evidence: Aschhoff and Sofka (2009), Guerzoni and Raiteri (2015)
- Political side: OECD (2011, 2013), European Commission (2007, 2010, 2011)

Public Procurement and radical innovations

Historical studies on technological change in the U.S.:

- Federal procurement for purposes of national defense fostered fundamental technological advances in key industries such as semiconductors, computers and aircraft (Nelson, 1982; Levin, 1982; Mowery, 2012; Carlaw & Lipsey, 2014):
- Ruttan (2006): Defense related procurement had a major impact for the emergence and diffusion of every GPTs developed in the U.S., from mass-production to satellite communications

Raiteri (2014) → econometric evidence through patent data

- IPP can increase the pervasiveness of given technologies by stimulating additional innovations in the application sectors
- Receiving a citation from a patent related to public procurement rises the degree of generality of the cited patent compared to the counterfactual situation in which that citation did not arrive

What's special in procurement-related innovative output?

- Public procurement stimulates the same kind of technological change that the private sector would produce in the absence of public demand?

Is it just more of the same?

- Edquist(2000); Edler (2007) enlarging (lead) markets → critical mass and network effects
- Mowery (2012): scale of US procurement programs → success

Or is it also something different?

- Defense-related R&D explores a different portion of the technological spectrum
- Development of a technology as an evolutionary tree → some branches will be actually explored some others ignored (David, 1988)
- Business R&D explores only a portion of the variety distribution of a technology
- Public demand is able to absorb the uncertainty related to profitability (Mazzucato, 2013) and to increase diversity

Procurement-related innovative output

“The essence of the exploitation is the refinement and extension of existing competences, technologies, and paradigms. Its returns are positive, proximate, and predictable. The essence of exploration is experimentation with new alternatives. Its return are uncertain, distant, and often negative”. March (1991)

- Business R&D → exploitation → refinements of existent technologies
- Procurement R&D → exploration → new combinations
- hyp: Private firm involved in PP contracts should produce innovative output that is more exploratory in nature with respect to what they would do in the absence of public demand

Aim of the paper:

- Test this hypothesis by looking at patents (proxy for innovation output)
- There is abundant literature that tries to assess the degree of novelty of specific patents, in particular university patents (Trajtenberg et al., 1997; Thursby et al., 2008; Czarnitzki et al. 2009; Guerzoni et al. , 2014)
- No work investigated the degree of novelty in procurement-related patent and this work aim to fill the gap

Why Patents?

Patent citations and technical change as a cumulative process

- Citations 'paper trail' of the linkages between an innovation and its technological 'antecedents' and 'descendants'
- Measure originality of patents by looking at the extent to which citations to prior art are spread across different technological fields → Originality Index (Trajtenberg et al. 1997)

Patent classification and innovation as a combinatorial process

- Different technological classification assigned to a patent → combination of technological capabilities (Strumsky et al., 2010)
- The characteristics of the combinations provide info about the degree of novelty of the patents (Akcigit et al., 2013; Youn et al., 2014)

Formal Hypothesis:

- A patent related to public procurement will have a higher degree of originality and novelty compared to the counterfactual situation in which it was induced by a private research project

2.Data and method:

Quasi-experimental framework:

- Patent as the unit of analysis
- Focus variable: Originality and novelty of the patent
- Compare originality and novelty between a group of treated and group of control patent
- A patent will be assigned to the treated group if it considered as 'related to public procurement'
- The control group will be instead carefully constructed to approximate the counterfactual situation in which the treated patents do not receive the treatment

Data and sample:

1. NBER patent data project

- Patents granted by the USPTO in the period 1976-2006 and citation data.
- Provide detailed information about each patent: primary tech code, backward and forward cites, # claims, assignee, app. and grant. year
- From this dataset I extract all the priority filings assigned to private firms, applied for between 1985-2004 → 813,780

2. Google-USPTO Bulks Downloads

- The **U.S. Patent Grant Master Classification File** contains all the primary and secondary classification information on all patent issued by the USPTO from 1790

3. USPTO Full-text and Image Database

- It offers the full text of every patent granted from 1976 → **Government Interest field**

Treatment variable

Treated patents

- A patent is put into the treatment group if it has been induced by a procurement contract between a private firm and a federal department or agency of the U.S. Government

Patent rights under government contracts (from 1983):

- F.A.R. 27.3: The Government shall have an irrevocable license to any invention of a contractor made in the performance of work under a Government contract
- F.A.R. 52.227: In applying for a patent the contractor must add a government interest statement → USPTO Fulltext Database

This invention was made with Government support under Contract/Grant [x] awarded by the Department [y]. The U.S. Government has certain rights in the invention

Patent related to public procurement

- Deem a patent as related to public procurement if includes this statement and if the word 'contract' is mentioned → **7,993 treated patents**

1) Originality measure:

- Trajtenberg et al. (1997) developed the Originality Index [0,1] :

$$\Omega_i = [N_i / (N_i - 1)] \left(1 - \sum_{j=1}^J N_{ij}^2 / N_i \right) \quad (1)$$

- It is computed on the basis of the degree of concentration of backward citations across patent classes (3-digit level)
- The larger Ω the broader are the technological roots of the underlying research

Drawbacks:

- Loss of observations if cites made < 2
- Assumes that patent classes are equidistant from one another
- Backward-looking measure: provide little information about the capabilities that had to be combined to create a new product or process

Innovation as a combinatorial process:

- Schumpeter(1911), Arthur(2009): recombination → one of the principal sources of technological novelty
- Strumsky et al.(2011, 2012): technology codes assigned to patents can characterize the nature of the recombination process

Technology codes:

- USPTO's tech codes are a set of consistent definitions of technological capabilities spanning 200 years of inventive activity
- Assigned to a patent on the basis of the claims included in a patent, composed by a technology class (470) and a subclass (150,000)
- Each patent should have a unique primary code but there are no limits as to how many codes it could have
- Our sample: > 90% at least 2 tech codes, avg. 4.4
- Patents → combination of technological capabilities

Youn et al.(2014): Novelty and technology codes

- Inventions arises from re-use of existing combinations, new recombination of existent tech capabilities, or combinations that involves new capabilities
- Process of invention is almost entirely driven by novel combinations (60%) of existing tech codes and refinements using existing combinations (40%)
- New combinations can be **narrow** or **broad** on the basis of the codes' technological distance (same technology class, 3-digit)
- The notions of broad and narrow technological combinations allows to assess how novel a patent is

Novelty and Procurement related patents

- Procurement related patent should embody more **novel** combinations than refinements
- Procurement related patent should embody more **broad** novel combinations than narrow

Outcome Variables II

Novelty (Youn et al., 2014)

$$\text{Novelty} = \begin{cases} 1 & \text{if a patent embodies a novel combination of tech codes} \\ 0 & \text{if a patent embodies an old combination} \end{cases}$$

Breadth (Youn et al., 2014; Trajtenberg et al., 1997)

$$\text{LOW_Breadth} = \begin{cases} 1 & \text{if combines codes from different patent classes at the 3-dgt level (440)} \\ 0 & \text{otherwise} \end{cases}$$

$$\text{MED_Breadth} = \begin{cases} 1 & \text{if combines codes from different patent classes at the 2-dgt level (37)} \\ 0 & \text{otherwise} \end{cases}$$

$$\text{HIGH_Breadth} = \begin{cases} 1 & \text{if combines codes from different patent classes at the 1-dgt level (6)} \\ 0 & \text{otherwise} \end{cases}$$

Endogeneity issues

- Taking simple difference in averages between treated and not treated patents would lead to biased results → selection bias
- Mitigation: build a control group of patents similar to the ones in the treated group along several dimensions

'Hybrid matching'

- P-score estimated through a probit regression of the T variable on a vector of patents' characteristics: Application year, Patent class (2-digit), Application-Grant lag, Backward citations avg. lag # of backward citation (log), # forward and backward citation, claims (log), Patent stock in 2006 (log)
- Exact matching on the 20 *Application Year Dummies*, and on 36 *Technological subcategory dummies*
- 36x20 matrix: in each cell treated patents are then matched to suitable control patents exploiting the p-score.

Matching quality

2-sample t-test for significant differences of covariate means (Originality)

ORIGINALITY	NOT MATCHED			MATCHED		
	N.T.	T.	Diff.	N.T.	T.	Diff.
App_grant_lag	2.239	2.252	0.013	2.220	2.236	-0.016
log_#_claims	2.660	2.689	0.029**	2.683	2.689	-0.006
log_#_cites_rec	1.617	1.563	-0.054***	1.584	1.564	0.020
log_#_cites_made	2.278	2.154	-0.124***	2.166	2.156	0.010
log_pat_stock	5.942	6.490	0.548***	6.470	6.488	-0.018
log_avg_lag	2.035	2.063	0.028***	2.069	2.062	0.007
App_year dum	-	-	Yes	-	-	0
Tech_Class_dum	-	-	Yes	-	-	0
N	741,041	7,272		20,946	7,254	

2-sample t-test for significant differences of covariate means (Novelty)

NOVELTY	NOT MATCHED			MATCHED		
	N. T.	T.	Diff.	N.T.	T.	Diff.
App_grant_lag	2.211	2.229	0.018	2.211	2.227	0.016
log_#_claims	2.636	2.663	0.028**	2.668	2.663	-0.005
log_#_cites_rec	1.607	1.557	-0.050***	1.579	1.557	-0.022
log_#_cites_made	2.132	2.001	-0.131***	2.014	2.002	-0.012
log_pat_stock	5.913	6.495	0.582***	6.513	6.494	-0.018
App_year dum	-	-	Yes	-	-	0
Tech_Class_dum	-	-	Yes	-	-	0
3N	805,786	7,999		23,143	7,990	

3. Results

Outcome	Sample	Treated	Controls	Diff	S.E.	T-stat
Originality	Unmatched	.5783	.5382	.0401***	.003	10.76
	Matched	.5785	.5418	.0366***	.004	8.73
Novel	Unmatched	.7811	.7605	.0205***	.004	4.3
	Matched	.7813	.7712	.0100*	.005	1.86
Low_Breadth	Unmatched	.6375	.6328	.0046	.006	0.77
	ATT	.6375	.6300	.0075	.007	1.06
Med_Breadth	Unmatched	.5302	.4946	.0355***	.006	5.60
	Matched	.5301	.5019	.0282***	.007	3.84
High_Breadth	Unmatched	.4056	.3422	.0633***	.006	10.53
	Matched	.4057	.3552	.0504***	.008	7.03

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- Procurement induced patents are on average more original than controls
- There are more patents including both novel and broader combinations among procurement induced patents than controls
- The difference is increasing with the breadth of the novel combinations

4. Conclusions

Preliminary conclusion

- Results confirms initial hyp: patents related to public procurement have a higher degree of originality and embody both more novel and broader combinations compared to controls patents

Policy perspective

- Schumpeterian demand policies that pay attention to the technological composition of public procurement as an effective tool to increase the variety of existing technologies, through recombination
- Relevant in this era in which recombination and in particular distant recombination appears to become harder and harder

Limitations

- Patent as a proxy for the output of innovative activities: subset of the innovation universe
- Matching methods vulnerable to potential bias introduced by selection on unobserved variables

Thank you for your attention! [emilio.raiteri@epfl.ch]