The Contribution of Academic Knowledge to the Value of Inventions

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Outline

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Economic impact of academic knowledge

- Transfer of academic knowledge to industry leads to economically valuable outcomes
  - Evidence of positive effect of expenditure in academic research on
    - Productivity growth
    - Firms' innovation performance
- Not much evidence on: how does academic knowledge contribute to the development of **economically valuable inventions?**

  → **What characteristics of the process of university-industry knowledge transfer lead to more valuable inventions?**

  - Difficulty in finding appropriate data

The value of inventions

- Proxy variables that capture the extent to which **patents** are used and therefore economically valuable:
  - forward patent citations
  - patent opposition and renewal
  - company start-up activity
  - probability to get a patent granted
  - composite indicators
  - **targeted surveys asking respondents to provide estimates of the monetary value of their patents**
    - Few examples: Scherer and Harhoff (2000),(Gambardella, Harhoff and Verspagen, 2005 (PatVal)

Determinants of invention value: what do we know

- Distribution of patent value is highly skewed
- Value of patents closely associated to: forward patent citations, geographical scope of protection of a patent, family size, amount of backward patent citations
- Value distributions of corporate and academic patents are similar
- Company-owned academic patents more valuable than university-owned ones (in terms of forward citations, probability of being used)

Lack of specific focus on

- Features of university-industry knowledge transfer as determinants of the value of (non-academic) inventions

Academic knowledge's contribution to invention value

- We expect the value of inventions that benefit from academic knowledge to be influenced by:
  - Inventor characteristics (age, field of work, "absorptive capacity")
  - Firm characteristics (size, sector, research intensity)
  - Features of the knowledge transfer channel used
    - Possibility to convey tacit knowledge
    - Possibility to generate more "radically new" inventions
      - Situations in which universities contribute basic theoretical advances
      - Channels of knowledge transfer that allow for exploratory search rather than exploitation of existing knowledge
      - Channels of knowledge transfer that integrate diverse sources

PIEMINV (2009/10):

- Survey of industrial inventors (at least one EPO patent application between 1998 and 2005) resident in the Italian region of Piedmont
- 2,583 inventors, 938 valid responses (36%)
  - General information about the inventors and their inventive activity
    - Age, gender, education, mobility, inventive / patenting behaviour
  - University-industry interactions
    - Importance of university knowledge in the development of inventions; relative importance / effectiveness of different interaction channels
  - Economic impact of university knowledge
- Additional sources:
  - Information about the firms' for which inventors worked (769 inventors)
  - Information about inventors' patents (902 inventors)

The inventors: some general characteristics

- Mean age: 48
- 8.2% women, lower mean age (41)
- Younger inventors (under-40s) on average more educated
  - 76.5% tertiary degree (vs 59.3% sample average)
  - 6% PhD (vs 3.72% sample average)
- Low educational and career mobility:
  - 79.8% attended primary and secondary school in the region
  - 30.9% have only worked for one company
  - 8.2% have had more than five different employers
  - more educated inventors are more mobile
- 40% of inventors work in large firms (>250 employees)
- Most frequent technology classes: Mechanical Engineering (34%), Electricity (25.6%)

The inventors' use of academic knowledge

- **Contribution of university knowledge** to inventions:
  - 66.3%: no contribution
  - 24.4%: contributed to less than the 50% of their inventions
  - 9.3%: contributed to more than the 50% of their inventions
  - Contribution varies by technological area
- **Most important channels** used to access academic knowledge
  - Academic articles, publications, conferences (50%-60%)
  - Recruitment of university graduates and student trainees (36%-40%)
  - Formal collaborations with the university institutions and consultancies with individual researchers (about 25%)
  - Informal interactions (27%)
  - Joint supervision of students (27%)
  - Others (5-20%)

Metholodology: constructing a measure of invention value

- Respondents were asked to consider two of their inventions (patented or not)
  - Highest contribution from university knowledge
  - Highest economic impact
- And provide, for each of them, information about
  - Whether the two inventions were the same (or not)
  - Monetary value of the invention (in thousand euro, at current prices)
    - *“Suppose that, on the day in which the invention was completed (or, if the invention has been patented, on the day in which the patent was granted) a potential competitor had expressed an interested in purchasing it: what is the minimum price that the invention’s owner would have asked for it?”*
  - Share of sales due to invention

- We build **relative measures of invention value**
  - Whether invention with highest contribution from university knowledge is also that with highest economic impact (*uniecon*)
    - 25.4% of inventions with highest contribution from university knowledge also had highest economic impact (excluding inventors who had only one invention)
  - Value of invention with highest contribution from university knowledge relative to value of invention with highest economic impact (*ratio*)
    - We are interested in the contribution of academic knowledge to the value of inventions, rather than in the value of inventions per se
    - Lack of comparability of invention values across inventors (highly subjective)
    - Possible situations in which respondents have used the wrong unit of measurement

	Highest contribution from university knowledge <u>and</u> highest economic impact (%)	**Highest contribution from university knowledge, <u>not</u> highest economic impact (%)**
Number of inventions	54	158
Employer at time of invention		
Business	**82.35**	**79.87**
University	0	5.37
PRO	3.92	2.68
Government	1.96	0
Charity	1.96	3.36
Self Employed	9.8	8.72
Source of funding		
University	12	14.05
Venture Capital	0	0.83
Company	78	81.82
Both university and company	**10**	**3.31**
Source of idea		
Master	1.85	5.73
PhD	1.85	1.27
University R&D	3.7	10.83
Company operations / market research	**11.11**	**8.92**
Company internal R&D	**57.41**	**41.4**
Previous collaboration with university	**12.96**	**10.19**
Other	11.11	21.66

	Highest contribution from university knowledge <u>and</u> highest economic impact (%)	Highest contribution from university knowledge, <u>not</u> highest economic impact (%)
Number of inventions	54	158
Months of work that led to invention		
Less than 6	28.85	30.65
Between 7 and 12	32.69	38.71
Between 13 and 24	**26.92**	**21.77**
Between 25 and 36	**7.69**	**6.45**
More than 36	**3.85**	**2.42**
Use of invention		
Commercialized	**60.47**	**34.55**
Licensed or sold to third parties	0	1.82
Not used	**27.91**	**47.27**
Used internally	4.65	4.55
Used to block others from patenting	0	1.82
Yet to be commercialized	6.98	10
Patent protection		
Patented	92.59	72.15
Not patented	**7.41**	**27.85**

Empirical strategy

- Is the relative value of the invention with the highest contribution from university knowledge affected by certain characteristics of knowledge transfer process, firm and inventor?
- Control for selection bias:
  - some inventor / firm features influencing the relative value of invention are also likely to influence the probability to have a contribution from university knowledge
  - Similar results with alternative specifications of the selection variable
    - 1 if at least some of the inventor’s inventions have benefited from university knowledge
    - 1 if inventor uses at least one of the possible knowledge transfer channels indicated
    - 1 if inventor has collaborated with university institution or individual university professor

Variables: selection equation

variable	description
select	1 if at least some of the inventor's inventions have benefited from university knowledge
hedu	Inventor has Masters or PhD
workuni	Whether the inventor has ever worked at a university
age	Age of inventor
age2	Age squared
male	Male inventor
pat9805	Number of inventor's EPO patent applications between 1998 and 2005
size2	Size of inventor's firm (between 10 and 49 employees)
size3	Size of inventor's firm (between 50 and 250 employees)
size4	Size of inventor's firm (more than 250 employees)
foreign	Inventor's firm not based in Italy
	Most common technology class in inventor's patent portfolio:
proceng	process engineering
instr	instruments
chem	chemicals
pharma	pharmaceutical
mech	Industrial engineering
consumer	Consumer goods

Variables: main equation

variable	description
	Nature of interaction between inventor and university that gave rise to the invention
collabo	Collaboration between the inventor and a university
reser	Collaboration with a single university researcher
inst	Collaboration with a university research team
	Type of academic knowledge that the inventor considers most important for the development of his/her inventions
theories	Scientific theorems and principles
contact	Information about other relevant sources of knowledge / about other organisations
uno	Solutions to technological problems / methodologies, techniques and instruments / support to prototyping
	Features of invention that are likely to affect the value of the invention
latestage	1 if invention was not at an early stage of development
easy	1 if invention was not difficult to apply to new product development
	Some of the variables also included in selection equation:
	age, age2, pat9805, size2, size3, proceng, instr, chem, pharma, mech, consumer

	select	uniecon			
collabo		0.395*			
reser			0.554**	0.568**	0.490*
inst			0.192	0.095	0.140
latestage				0.547**	0.459*
easy					0.378
theories		0.574**	0.607***	0.637***	0.601**
contact		0.217	0.212	0.255	0.241
uno		0.158	0.179	0.228	0.271
age	-0.083*	-0.111	-0.104	-0.105	-0.108
age2	0.001**	0.001	0.001	0.001*	0.001*
pat9805	0.050**	0.013	0.014	0.010	0.011
size2	-0.553**	0.017	-0.031	-0.059	-0.062
size3	-0.567**	0.429	0.373	0.338	0.265
size4	-0.328*	0.080	0.070	0.057	0.009
proceng	-0.434**	-0.389	-0.423	-0.552	-0.628
instr	0.279	-0.033	0.007	-0.053	-0.092
chem	0.058	0.145	0.108	0.142	0.144
pharma	0.370	-0.460	-0.489	-0.502	-0.456
mech	-0.242*	-0.004	-0.029	-0.109	-0.148
consumer	-0.630**	-0.562	-0.622	-0.635	-0.595
hedu	0.410***				
workuni	0.634***				
male	0.250				
foreign	-0.011				
Constant	1.244	1.367	1.097	0.634	0.597
athrho		-0.159	-0.107	0.109	0.150
		(0.551)	(0.555)	(0.611)	(0.613)

Probit model with sample selection

Number of obs: 694

Censored obs: 506

Uncensored obs: 188

Robust standard errors

*** p<0.01, ** p<0.05, * p<0.1

	select	ratio			
collabo		0.088			
reser			0.217**	0.192**	0.157
inst			-0.097	-0.133	-0.141
latestage				0.190*	0.199*
easy					0.097
theories		0.169*	0.189**	0.201**	0.195**
contact		0.049	0.020	0.036	0.034
uno		0.227	0.266	0.245	0.250
age	-0.056	-0.033	-0.031	-0.017	-0.013
age2	0.001	0.000	0.000	0.000	0.000
pat9805	0.026	-0.005	-0.019	-0.022	-0.025
size2	-0.363	-0.126	-0.164	-0.191	-0.221
size3	-0.462	-0.270	-0.289	-0.331*	-0.358*
size4	-0.480**	-0.273*	-0.262*	-0.324**	-0.366**
proceng	-0.061	-0.180	-0.141	-0.195	-0.205
instr	0.502**	0.023	0.040	0.024	0.036
chem	0.175	0.005	0.007	0.046	0.094
pharma	0.537	-0.457**	-0.470***	-0.565***	-0.583***
mech	0.088	0.105	0.092	0.112	0.115
consumer	-0.193	-0.242	-0.237	-0.197	-0.172
hedu	0.653***				
workuni	0.748***				
male	0.680**				
foreign	0.096				
Constant	-0.583	0.770	0.782	0.375	0.239
athrho		0.850*	0.715**	0.822**	0.855**
		(0.464)	(0.325)	(0.323)	(0.376)

Probit model with sample selection

Number of obs: 594

Censored obs: 506

Uncensored obs: 88

Robust standard errors

*** p<0.01, ** p<0.05, * p<0.1

Some remarks

- Inventions that have benefited from direct collaborations with university, particularly with individual researchers, are more economically valuable
  - Remain significant even when controlling for industrial applicability of invention
- Inventions that mostly benefit from university knowledge consisting of theories and scientific principles are more likely to be economically valuable
- Further developments?

Thank you!

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